laws

MDPI

Article

Commercial Use of Satellite Remote Sensing Data and Civil Liability

Young-Ju Kim

Department of International Trade, Pusan National University, Busan 46241, Republic of Korea; yjkim333@pusan.ac.kr

Abstract: This paper explores the civil liability issues arising from the commercial use of satellite remote sensing data, a rapidly growing sector in the space industry. With the increasing reliance on satellite data for various applications, such as agriculture, disaster response, and climate monitoring, legal challenges have emerged, particularly concerning the accuracy and commercialization of satellite data. The study examines the concept and characteristics of satellite remote sensing, focusing on the legal relationships between data providers, users, and third parties. It analyzes the legal framework regulating this business across different jurisdictions, including the United States, Canada, Germany, France, and Japan. Key issues addressed include liability for inaccurate data, licensing agreements, and the rights and obligations of parties involved in satellite data transactions. Through this analysis, the paper offers legal and institutional recommendations to support the development and stability of the commercial satellite data industry, contributing to the establishment of a comprehensive legal framework for the space sector.

Keywords: satellite remote sensing; Earth observation data; commercialization; data accuracy; data access; licensing agreements; civil liability

Citation: Kim, Young-Ju. 2024. Commercial Use of Satellite Remote Sensing Data and Civil Liability. *Laws* 13: 77. https://doi.org/10.3390/laws13060077

Academic Editor: Patricia Easteal

Received: 13 October 2024
Revised: 2 December 2024
Accepted: 3 December 2024
Published: 4 December 2024

1. Introduction

The commercial use of satellite data can be broadly categorized into three distinct business areas: satellite communication business utilizing communication satellite information, satellite remote sensing business using observation satellite information, and satellite navigation business based on navigation satellite information. Each sector has developed as an independent domain. Among these, satellite remote sensing, which employs artificial satellites to observe the Earth's surface and monitor various natural phenomena and human activities, has seen a rapid expansion of its applications due to advancements in science and technology, as well as the growth of the commercial space industry.

In general, "remote sensing" refers to the acquisition of information about distant objects without direct contact. The essence of remote sensing lies in detecting the shape and attributes of objects from a distance without physical contact between the observer and the observed object (Hobe 2019; Ito 2011). Hence, satellite remote sensing involves using artificial satellites to observe the Earth's surface from outer space (Emery and Camps 2017), with "earth observation", such as identifying the geopolitical positioning of various regions, the status of natural resources, and climate change, being a representative form of remote sensing (Tronchetti 2015).

By examining the Earth's surface, humanity can predict the geopolitical positioning of various regions, assess the state of natural resources, and monitor climate change. For instance, through platforms like Google Maps, individuals can easily identify geographical locations on the opposite side of the globe, and the structure and composition of natural resources for industrial development can be discerned. Additionally, this technology allows for more effective responses to unexpected natural disasters or climate anomalies (Zannoni 2019). These are results derived from the analysis of data acquired through satellite remote sensing activities.

Satellite data obtained through remote sensing provides valuable information across various fields, including agriculture, climate change, disaster response, and resource exploration, significantly contributing to modern society's infrastructure development and industrial growth. However, the growing satellite remote sensing business has also introduced new legal challenges concerning the commercial use of satellite data. Legal liability may arise at various stages, such as acquiring, processing, and selling satellite data as commercially valuable information. That is, throughout the process of Earth observation by artificial satellites, data acquisition, processing, and commercialization, legal issues may emerge concerning data processing and analysis, the rights and obligations between data providers and users, and potential damage to third parties. Of particular significance is the accuracy of the satellite data, as legal liability for damages caused to data users or third parties due to inaccurate satellite information is emerging as a key legal issue in the commercial use of satellite data.

In such a context, a detailed legal analysis of the commercial use of satellite data and the associated civil liability structure is required. However, the legal framework for this business remains unclear. This paper aims to systematically analyze the civil liability issues between parties arising from the commercial use of satellite remote sensing. To this end, it will first examine the concept and characteristics of the satellite remote sensing business, review the domestic legal framework regulating this area, and provide an in-depth analysis of the structure of commercial satellite data use, focusing on the rights, obligations, and liabilities of the parties involved. Specifically, the study will explore the general legal relationships and respective liability structures of satellite data providers, users, and third parties in commercial satellite data transactions.

Through this analysis, the paper seeks to elucidate the structure and characteristics of civil liability in commercial satellite remote sensing and offer legal and institutional implications to enhance the development and legal stability of the space industry, contributing to the establishment of a legal framework for the space business.

2. Overview of Satellite Remote Sensing Business

2.1. Concept of Satellite Remote Sensing

Remote sensing is used in a broad sense but can be classified into various types depending on the form of sensing and the entity conducting the operation (Lyall and Larsen 2024). Broadly, it can be divided into two categories: (1) passive and active sensing based on the sensing method and (2) aerial and satellite remote sensing based on the means of sensing. The classification according to the sensing method refers to how sensing devices are utilized, which can be further divided into passive and active remote sensing. Passive sensing involves collecting and analyzing electromagnetic waves or other radiation naturally emitted by an object. A representative example of this is photography. In contrast, active sensing involves emitting electromagnetic waves or other signals towards the target object and analyzing the reflected or diffracted signals to acquire information. The radar system utilizing Synthetic Aperture Radar (SAR) is a typical example of active sensing (Pettorelli 2019).

Remote sensing based on the means of sensing can be classified into (1) aerial remote sensing, conducted within Earth's atmosphere using aircraft, and (2) satellite remote sensing, conducted from space using artificial satellites outside Earth's atmosphere. Aerial remote sensing has been practiced since before the development of aircraft, using hot air balloons and other means, whereas satellite remote sensing originated with the launch of the Soviet Union's first artificial satellite, Sputnik 1 (Спутник-1), in 1957. Although satellite remote sensing began later than aerial remote sensing, it now surpasses aerial remote sensing in terms of scope, precision, cost, and efficiency. The term "remote sensing" is often used interchangeably to refer to Earth's observation from space using artificial satellites (Lyall and Larsen 2024).

Legal issues related to satellite remote sensing have been highlighted for many years, with comprehensive international discussions already taking place at the United Nations

level in the 1970s (Hopkins 1977; de Saint-Lager 1983; Diederiks-Verschoor 1984; Oosterlinck 1984; Christol 1987; Salin 1992a; Markowitz 2001). In 1986, the United Nations adopted the "Principles Relating to Remote Sensing of the Earth from Outer Space", and since the 1980s, spacefaring nations, led by the United States, have established domestic legal frameworks to regulate satellite remote sensing.

As of 2024, the only countries that have attempted to establish domestic legal frameworks for satellite remote sensing are the United States, Canada, Germany, France, and Japan.

2.2. Characteristics of the Satellite Remote Sensing Business

2.2.1. Acquisition of Satellite Data

To acquire data through satellite remote sensing, a satellite must be positioned in a specific orbit (Staelin and Kerekes 1996). Typically, remote sensing is conducted in two types of orbits: the geostationary equatorial orbit (GEO) and the low Earth orbit (LEO). The altitude of the orbit determines the scale of the objects that can be observed, with lower altitudes allowing for the observation of smaller objects. A key technological factor in satellites used for remote sensing is the spatial resolution, which determines the ability to modify and identify the object being sensed. Spatial resolution refers to the degree to which images or data of a target object can be represented in spatial terms (Johnston 2012). This capacity to distinguish between spatial differences is referred to as resolving power. Consequently, the higher the resolving power of the observation device, the higher the spatial resolution, which allows for clearer identification of detailed information about the object (Licor 2007). In addition to spatial resolution, technical characteristics such as temporal resolution, spectral resolution, radiometric resolution, and swath width are considered in remote sensing (Johnston 2012). Temporal resolution represents the rate of temporal change between consecutive frames in a visual image or video, indicating the smoothness of the portrayal of the object. Spectral resolution refers to the ability to detect specific wavelengths within the electromagnetic spectrum based on the number and size of intervals the sensor can capture. Radiometric resolution, on the other hand, is the sensor's sensitivity, indicating the smallest detectable energy difference. Lastly, swath width refers to the width of the area captured by the sensor, which varies depending on the sensor's resolution.

The sensors used in satellite remote sensing are primarily classified into optical sensors, which are used to capture images through photographic observation, and radar sensors, such as SAR, which are used to conduct radar observations. Optical sensors are typically unobtrusive, passively receiving electromagnetic waves reflected or emitted from objects without causing any damage. In contrast, radar sensors, such as those utilizing lasers or radar, are active systems that emit energy, potentially impacting the object being observed (Lyall and Larsen 2024).

The data collected through satellite remote sensing must be processed into useful information, as this is the essential purpose of remote sensing (Johnston 2012). Satellite data undergo several stages of information processing, where identification and usability are paramount (Hayward 1990). Once the data are collected by the satellite, they are transmitted via wireless communication to ground stations, where they are interpreted for information extraction. However, this process can introduce human error, which necessitates the classification of the collected data to minimize interpretive inaccuracies (Bourely 1988).

For this reason, the UN Principles on Remote Sensing classify data obtained through remote sensing into three categories: primary data, processed data, and analyzed information. In practice, primary data are often referred to as raw or unenhanced data, while analyzed information may be described as derived products or value-added products (Tronchetti 2015).

2.2.2. Commercialization of Satellite Data

The essence of the satellite remote sensing business lies in the commercialization and sale of data acquired by observation satellites (Hayward 1990). However, even if the data detected by sensors attached to the satellite are transmitted directly, they hold little value

as information without processing and refinement. Only when the primary data have been processed and refined do they acquire value as a tradable commodity. The commercialization of data refers to the processed images or visual data resulting from such procedures (Arzt 1999).

In practice, the satellite remote sensing business often involves adjusting the angle of the observation satellite's sensor or designating specific targets for imaging at the request of customers, even during the initial data acquisition stage, such as image capturing. However, at this stage, the data transmitted are not yet in a form that can be perceived or identified by humans.

The data transmitted from the satellite must undergo a processing phase to be converted into identifiable images. During this phase, various distortions may be corrected, and in some cases, additional data such as ground reference points or altitude information are referenced to create images with higher added value (Tronchetti 2015). Following this, the converted images undergo further precision processing to meet the intended purpose of use. This includes various processes, such as adding contour lines to satellite images, applying color coding for vegetation, or enhancing the representation of topographical features. These processing tasks may be determined by the terms of the user's supply contract or produced as general products for an unspecified number of users (Arzt 1999).

2.2.3. Satellite Data Access Policies

Each country's satellite data policies vary in terms of access and pricing depending on the type of data (Ito 2011). With regard to data access, the United States emphasizes openness and autonomy, while EU countries impose relatively more restrictions on data access (Tronchetti 2015). Policies that promote openness and autonomy in data access allow users to freely access specific data or, at most, pay only the marginal cost of access, regardless of the intended use or whether they are the end consumer. Landsat data from the United States are freely available via FTP (File Transfer Protocol), and NASA distributes Quick SCAT data free of charge for scientific and educational purposes (Joyner and Miller 1985; West 1990). On the other hand, the European Space Agency (ESA) implements a regulatory policy that distinguishes between different categories of distributors and users regarding data access (Ferrazzani 2005; Harris 2008). For example, the Envisat data policy categorizes users into two groups: the first category is for data use for research and development purposes, while the second category pertains to data used for commercial purposes (von der Dunk 2002). In this context, data processing companies such as GeoEye and Digital Globe may distribute processed data or analyzed information for certain purposes, but only to commercial users. Therefore, under such data policies, there is a limitation on the potential for expanding the commercial viability of data. It should be noted, however, that even in the United States, regulatory policies such as shutter control exist, meaning that complete autonomy in data access is not guaranteed (Tronchetti 2015).

Regarding the commercialization of data, one key issue is the pricing structure. The pricing varies depending on whether data access is liberalized or restricted. Under a policy of liberalized data access, data obtained through remote sensing are generally priced based on a marginal cost pricing structure. This is the pricing model typically adopted by the U.S. remote sensing market. For instance, NASA applies a marginal cost pricing structure to all Landsat data, adjusting all marginal costs in accordance with user demand. However, under a restricted data access policy, pricing structures vary depending on the user category. For example, ESA has adopted a policy that provides data to users with public purposes, such as education, science, or environmental studies, either free of charge or at marginal cost. Conversely, commercial satellite data with high resolution, such as that from Orbview (https://www.orbview.world, accessed on 20 August 2024) from GeoEye, are distributed at full market price.

Thus, in the satellite remote sensing industry, pricing decisions during the commercialization stage of data have become a major point of contention. Although the data subject to commercialization typically include processed or analyzed information imbued

with added value, the determination of market structure depends largely on the data access policy (Schreier 2002). This also involves considering factors such as the capabilities related to the launch, operation, and maintenance of observation satellites, as well as the space policy of the respective country.

3. An Analysis of the Legal Relationships in the Commercial Use of Remote Sensing Data

3.1. License Agreements

The provision of satellite data acquired by observation satellites constitutes the "sale of images". However, since the transaction does not involve the direct exchange of tangible items such as photographs, the legal framework governing such transactions is typically structured as a license agreement for the use of electronic data. This framework allows the data provider to maintain ongoing control and management of the data even after the transaction has been completed (Tronchetti 2015).

In general, data transactions encompass the entire process by which the data producer exchanges and distributes data, along with related services, to consumers, thereby generating revenue and incurring costs for the company. This process involves multiple stages from the initial collection of satellite data to their final provision to the end user, during which numerous contracts between various parties are concluded and executed (KDLPS 2020). Given that the ultimate objective of providing satellite data is their use, the primary legal relationship in the satellite remote sensing business can be characterized as a "satellite data license agreement" (Golda and De Maestri 2022).

In a satellite data license agreement, the licensor provides the licensee with data within the scope of the license, and the licensee is required to pay a license fee, often referred to as a royalty, as compensation for the right to use the data. In satellite data transactions, the contract structure may vary, but a general distinction is made between royalties and license fees. Typically, a license fee is paid to access and use the data. However, intermediaries or distributors who aim to convert the data into value-added information for sale or dissemination must pay royalties directly to the satellite operator (Smith and Doldirina 2016). Licensees are obligated to comply with the conditions set forth by the licensor, which serve as the fundamental terms for granting the license.

3.2. The Parties in a License Agreement

Observation satellites consist of a satellite bus equipped with remote sensing devices, such as sensors. While the standard model involves both the satellite bus and the sensors being owned by the satellite operator, in certain cases, a business entity may own only the sensors attached to a satellite operated by another party. Consequently, the provider of satellite data —the entity granting usage rights—may or may not be the satellite operator. In instances where the satellite operator does not own the satellite, they are categorized as a sensor operator who has installed sensors on the satellite. Alternatively, they may be a business that acquires raw satellite data from the satellite operator and then processes, analyzes, and sells them. Based on these distinctions, the types of satellite data licensors can be classified as follows:

First, when the satellite operator, sensor operator, and data processing and sales entity are all the same party, the satellite operator not only manages the sensors but also processes, analyzes, and sells the primary satellite data. This scenario is illustrated in the following Figure 1.

Second, the satellite operator and the sensor operator are the same entity, but the satellite operator does not engage in the analysis or sale of satellite data. While the satellite operator handles both satellite operation and sensor operation, it outsources the processing, analysis, and sale of raw satellite data to a third party.

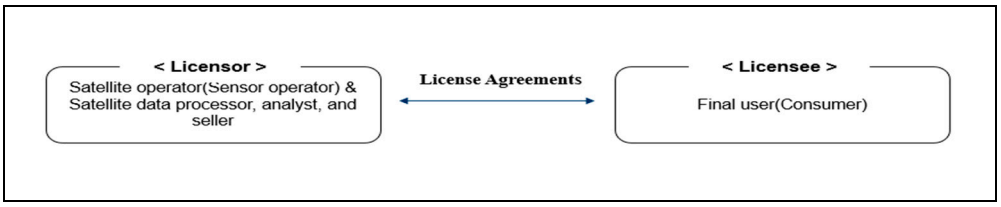

Figure 1. Type 1: relationship between parties in satellite data license agreements.

Since the satellite and sensor operator does not directly manage data sales, a third-party data vendor is granted the right to enter into a license agreement to sell the satellite data. The data vendor, after receiving the raw satellite data from the satellite and sensor operator, processes and analyzes them into commercially valuable information for sale. For instance, this model applies to the case where a private company, Infoterra, purchased the data sales rights for data acquired by Germany's TerraSAR-X satellite and sold them to end users. In such a transactional structure, the data vendor may perform part of the data processing and refinement. After receiving the raw satellite data, the vendor processes and analyzes them, converting them into commercially valuable information for sale to the end user. The specific structure is illustrated in the following Figure 2.

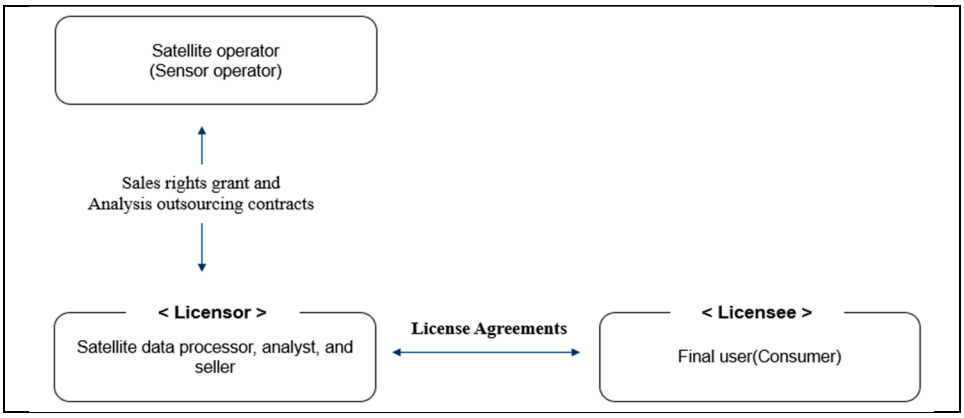

Figure 2. Type 2: relationship between parties in satellite data license agreements.

Third, the satellite operator and the sensor operator are different entities. The sensor operator enters into a sensor payload agreement with the satellite operator to install the sensors on the satellite. A "Sensor Installation and Usage Agreement" governs the relationship between the satellite operator and the sensor operator.

The sensor operator, responsible for the operation and management of the remote sensing equipment, processes and analyzes the raw satellite data obtained from the sensors, and subsequently sells them to the end user. The specific structure is illustrated in the following Figure 3.

In the United States, satellite data acquired by observation satellites launched by the government or NASA have been distributed free of charge, provided that the resolution falls below a certain threshold (Hoversten 2001). Europe follows a similar data policy. Satellite data are made available by governments or government agencies as a form of "public good", while private companies add value to these data and commercialize them. In Japan, satellite data acquired by government satellites, including those operated by JAXA, are likewise made publicly available and provided free of charge. To support this, the platform "Tellus" has been developed and is currently in operation.

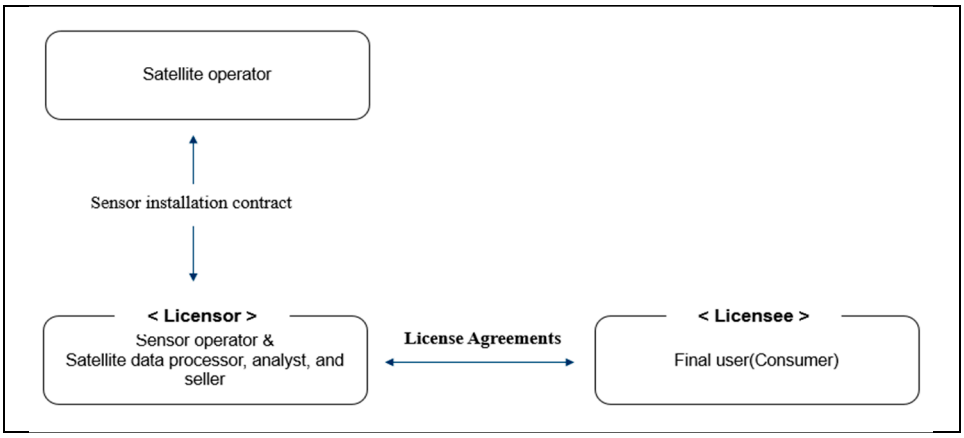

Figure 3. Type 3: relationship between parties in satellite data license agreements.

3.3. Rights and Obligations of the Licensor

The licensor of satellite data is obligated to provide the licensee with data within the scope defined in the contract. A key aspect of this obligation is delineating the scope of the licensed data. For example, it is essential to specify whether the licensed data consist of raw data, processed data, or analyzed data.

If the licensed data are raw data, risk allocation regarding the unavailability of data becomes a critical issue in the contract. Conversely, if the licensed data consist of processed data or final analyzed information, in addition to the risks related to raw data acquisition, it is crucial to allocate risks arising from errors during the processing and analysis stages. For instance, if raw data on green spaces are acquired via satellite and processed into a dataset that is combined with administrative land-use data to analyze the correlation between land use and green spaces, errors may occur during the processing of the raw data or from inaccuracies in the administrative data, resulting in defective analyzed data.

At each stage, from raw data to processed and analyzed data, multiple parties may be involved, such as the entity responsible for converting raw data into processed data or the provider of the administrative land-use data. Therefore, it is essential to clarify who bears the risk of errors in the data processing stages. Generally, the licensor has the authority to determine the specific scope of the licensed data (Golda and De Maestri 2022).

In addition to specifying the type of data to be provided, the quality of the data—such as their resolution or suitability for a particular purpose—must be defined as precisely as possible, and the licensor has the right to establish these parameters.

Since satellite data are intangible, they may not always be subject to legal ownership. As a result, even if the satellite data provided to the licensee under the license agreement are transferred or leaked to a third party without authorization, the licensor cannot demand the deletion or return of the data based on ownership rights. In this context, it is critical to consider whether the licensor holds contractual intellectual property rights (Masson-Zwaan and Hofmann 2019).

The first issue is whether copyright protection can be established for satellite data. To qualify as a copyrighted work, the data must be a "creative expression of ideas or emotions". In other words, the data must exhibit originality, and the extent of originality may vary significantly depending on the stage of data acquisition, processing, or analysis in satellite remote sensing (Doldirina 2015).

In the case of raw data, which are mechanically collected using sensors mounted on satellites, it is difficult to classify the data as a "creative expression of ideas or emotions". However, processed data and analyzed information may exhibit originality during the processing and analysis stages, and if this originality is recognized, it may fall within the scope of copyright protection (Oshima 2021).

Nonetheless, the processing or analysis of satellite data generally involves the mechanical visualization or quantification of image information, which makes it difficult to

argue that the process involves true "originality". Consequently, the extent to which satellite data can be protected under copyright law is likely to be limited (Lemaire 2024). Even if copyright is recognized, the copyright holder should be the licensor who processed, analyzed, and licensed the raw data, not the original acquirer of the raw data.

Second, when satellite data are processed and analyzed for sale to the licensee, the question arises as to whether the analysis techniques used to generate the final analyzed information can be protected by patents. Given the variety of methods for converting raw data into processed data or extracting analyzed information, even if the analysis techniques themselves are protected by patents, it would still be difficult to grant exclusive rights over the satellite data themselves (Oshima 2021).

3.4. Rights and Obligations of the Licensee

Upon the granting of a satellite data license, the licensee acquires the right to utilize the purchased data or information for specific actions or the exercise of certain rights. However, the specific terms governing the use of the satellite data are subject to the contractual provisions agreed upon between the licensor and the licensee.

Under a satellite data license agreement, the licensee is entitled to receive the satellite data in accordance with the conditions stipulated in the license while bearing the obligation to pay the licensor a license fee in exchange for the usage rights. Moreover, the licensee must adhere to the conditions set forth by the licensor, which serve as the foundational terms for the granting of the license.

A frequent issue in practice involves the violation of usage conditions established by the licensor, particularly with regard to the unauthorized reproduction or distribution of satellite data. A crucial question arises as to whether the licensee, after processing and analyzing the satellite data, may provide the modified data to third parties. This issue is especially pertinent in cases where the license pertains solely to raw data, as the licensee may process, analyze, and subsequently transmit the refined data to a third party for economic gain. Therefore, it is essential to clearly delineate the obligations of the licensee, which generally fall into two categories: (1) The licensor may allow the licensee to provide processed data or analyzed information to third parties, on the condition that the licensee pays an additional license fee proportionate to the economic benefit derived from such third-party transactions. In such instances, the scope of data permitted for third-party dissemination is typically specified, and a further obligation may be imposed to prohibit third parties from engaging in reverse engineering to reconstruct the raw data from the processed or analyzed information. (2) The licensee may be authorized to process and analyze the raw data but may be explicitly restricted or prohibited from providing the processed data or analyzed information to third parties.

4. Comparative Regulatory Frameworks for Satellite Remote Sensing Business

4.1. UN Principles on Remote Sensing

Discussions regarding satellite remote sensing at the UN level began in 1969, following technological advancements that made Earth observation via artificial satellites possible (Christol 1987). COPUOS (Committee on the Peaceful Uses of Outer Space) proposed the need to review the legal issues surrounding remote sensing in space law and emphasized the necessity of international cooperation starting in 1970. This proposal was recognized by the UN General Assembly, which initiated full-scale international discussions on satellite remote sensing (von der Dunk 2020). At that time, developing countries raised concerns that the widespread use of satellite remote sensing might lead to violations of sovereignty, as advanced nations could collect and exploit domestic information, including natural resources (Kim 2020). For instance, Argentina and Brazil demanded that developed nations conducting remote sensing of data within their territories show respect for the sovereignty of the surveyed countries. They called upon the UN to establish a legal framework to manage such issues internationally. Consequently, discussions

within COPUOS regarding remote sensing were conducted in response to these demands (Ambrosetti 1984).

From 1975 onwards, the collection, processing, and use of remote sensing data became a focal point of more detailed discussions, and by the 1980s, technical drafting of the principles commenced. This process culminated in 1986 with the adoption of a final draft consisting of 15 principles (Magdelenat 1981; Christol 1987).

According to the final draft, satellite remote sensing was defined as being conducted to improve the management of natural resources, land use, and environmental protection. Regarding the collection of satellite data, one of the key issues—the requirement for prior consent from the sensed state—was deemed unnecessary. It was agreed that data dissemination could proceed freely, even without the consent of the sensed state (Feinaeugle 2007). However, in consideration of the interests of the sensed state, the principles stipulated that the sensed state should have non-discriminatory access to data collected within its territory at a reasonable cost (Masson-Zwaan and Hofmann 2019). This provision largely reflected the proposals made by the United States, which was leading satellite remote sensing efforts at the time, and the views of the U.S. government were strongly incorporated into the final principles (Mosteshar 2017).

4.2. United States

In the 1970s and 1980s, the United States led the industrialization of satellite remote sensing. The world's first civilian Earth observation satellite, Landsat 1, was launched by the United States in 1972 (Greenburg 1983). Although launched by NASA, there were no specific restrictions on the distribution and dissemination of data provided by Landsat. This allowed many countries to acquire Landsat data at a low cost (Weaver 1993).

As the number of private companies operating commercial satellites increased, satellite data acquired through remote sensing came to be recognized as intellectual property with informational value. With the commercialization of satellite data, a vast data trading market emerged. During this period, domestic legislation on satellite remote sensing was also developed, with the Land Remote-Sensing Commercialization Act of 1984 (hereinafter LRSCA) serving as a representative example. The LRSCA focused on practical issues such as licensing systems for observation satellites, satellite data policy, and regulations on data access and dissemination.

However, although the LRSCA was enacted to expand the commercialization of remote sensing, it did not lead directly to industry growth or significant revenue generation. This outcome can be attributed to several factors. First, the competitiveness of Landsat data in the international satellite data market was relatively limited. By the late 1980s, countries operating remote sensing satellites included the United States, France, the former Soviet Union, and Japan (Kramer 1989). Among these, France's SPOT data surpassed Landsat data significantly in terms of satellite sensor resolution and the pricing structure for data distribution. For instance, while Landsat's resolution was approximately 30 m, SPOT achieved a resolution of 10 m, offering superior spatial resolution. SPOT datas' market dominance was further supported by the active marketing and sales efforts of Spot Image, a private French company responsible for their distribution (DeSaussure 1989). By 1990, Spot Image's sales performance had exceeded that of EOSAT (Earth Observation Satellite Company), the company managing the Landsat system, allowing SPOT data to dominate the global satellite data market (Gupta 1995). Moreover, the public distribution policy for first-generation data under the LRSCA acted as a barrier to EOSAT's market expansion. In the early 1990s, during the Gulf War, the U.S. government and Congress highlighted the national security importance of the Landsat program, sparking discussions on expanding the availability of Earth observation data for public purposes (Gabrynowicz 2005).

After conducting several reviews of the industry's profitability, the U.S. government ultimately abandoned the commercialization policy of the Landsat program. Instead, it adopted a government-centric management system for satellite remote sensing, with the

principle of government ownership. In 1992, as part of this policy, the U.S. repealed the LRSCA and enacted the Land Remote Sensing Policy Act of 1992 (hereinafter *LRSPA*).

The LRSPA does not classify satellite data into the three categories of primary data, processed data, and analyzed information. Instead, it defines only unenhanced data. Under the LRSPA, "unenhanced data" refer to unprocessed data that have undergone only "preprocessing", defined as signals or image products from satellite remote sensing (51 U.S.C.A. §60101(12)). The definition of "data preprocessing" includes the initial processing of data collected through remote sensing, such as: (1) correcting distortions in the remote sensing system and sensors, (2) adjusting the location of data related to Earth's terrain, and (3) calibrating the spectral response of the data (51 U.S.C.A. §60101(3)). This definition excludes any manipulations, outputs, or results derived from combining the data with other datasets.

Unenhanced data are neither synonymous with primary or raw data, nor do they correspond to processed data as defined by the UN Principles on Remote Sensing (Baumann and Pellander 2024). They refer to data that have undergone preliminary adjustments, such as corrections for sensor distortions, location adjustments, and spectral response calibration, before transmission to ground stations. Thus, satellite data under the LRSPA can be categorized as: (1) primary or raw data, (2) unenhanced data, and (3) enhanced data. Although "enhanced data" are not explicitly defined, they are understood to include processed data and analyzed information (Hoversten 2001).

Under the LRSPA, the existing satellite remote sensing industry was restructured into a government-centered management system, and the Landsat program became a national policy initiative. The basic regulatory framework for remote sensing established under the LRSPA can be divided into two main categories: (1) the regulatory framework for operating remote sensing businesses, and (2) the regulatory framework for the dissemination and trade of satellite data. Specifically, the operation of satellite remote sensing businesses requires licensing or permits from administrative authorities, and the dissemination of satellite data is subject to distribution control measures, such as shutter control (Gabrynowicz 2005).

The licensing requirements for satellite remote sensing systems are governed by the LRSPA and the Licensing of Private Remote Sensing Systems, with the specific licensing procedures being administered by NOAA under the Department of Commerce (Pomfret 2024). National security and compliance with international obligations are prioritized as conditions for granting licenses, and the operation of systems must align with the Landsat program's management framework. Operators are subject to various reporting obligations and the duty to provide unenhanced data related to national security. Administrative agencies must regularly oversee and supervise the operation of the systems (Kim 2020).

U.S. data trading policy seeks to secure national interests through long-term oversight, governed by the LRSPA and various delegated administrative legislations (Pomfret 2024). Different dissemination procedures are applied depending on the type of data (Baumann and Pellander 2024). While the principle of non-discriminatory use applies to unenhanced data, it does not apply to enhanced data or analyzed information, which are left to the autonomy of the market. Additionally, data trading restrictions, such as the government's right of first access, are enforced only for reasons of national security or public interest. One of the most significant features of U.S. law concerning data trading restrictions is the shutter control mechanism (Prober 2003). As part of PDD-23, shutter control allows the U.S. government to completely halt the dissemination of satellite data for reasons including: (a) national security, (b) foreign policy, or (c) compliance with international obligations. When shutter control is implemented, the collection and dissemination of related satellite data are entirely restricted for a certain period. Unless special measures are taken to block unauthorized users from accessing the data, data trading cannot resume (Waldrop 2004).

4.3. Canada

In November 1995, Canada initiated its satellite observation operations with the launch of RADARSAT-1. The Canadian government engaged in regulatory coordination with the United States concerning the acquisition and dissemination of satellite data, and in June 1999, it introduced the Canadian Access Control Policy, establishing a licensing system for commercial remote sensing satellites (Gillon 2008). The primary objective of the Access Control Policy was to safeguard Canada's national security and foreign policy interests, permitting certain restrictions on data transactions. Subsequently, based on the agreement with the U.S. government and the previously announced Access Control Policy, the Canadian government pursued domestic legislation on remote sensing and enacted the Remote Sensing Space Systems Act (hereinafter RSSSA) in 2005 (Jakhu 2010).

The RSSSA distinguishes between "data" and "information" by using the terms "raw data" and "remote sensing product". Raw data include: (1) "sensor data" collected by observation satellites, and (2) "any auxiliary data" that serve as foundational data for producing remote sensing products but have not yet been processed or converted into a final product (RSSSA §2 [Raw Data]). A remote sensing product is defined as an "image or data" derived from raw data through specific conversion methods (RSSSA §2 [Remote Sensing Product]). Unlike the UN Principles on Remote Sensing, the RSSSA does not categorize satellite data into "primary data", "processed data", and "analyzed information", nor does it adopt the distinctions of unenhanced and enhanced data, as found in the LRSPA (Baumann and Pellander 2024).

Operating a remote sensing system within Canada requires a license, and under the RSSSA, the licensing process is overseen by the Canadian Department of Foreign Affairs. As in the United States, strict controls are imposed when the operation of the system involves national security or international diplomatic obligations. The scope of licensing requirements is also broad, similar to U.S. law; even foreign operators require a license if they have substantial connections to Canada (Kim 2020).

The RSSSA mandates that the distribution of raw data is restricted to designated entities, such as specific governments, licensed entities, or system participants (Kerkonian 2021). In contrast to the LRSPA, which regulates all data, the RSSSA exclusively regulates raw data, leaving other forms of data subject to individual regulation. Regarding data trading restrictions, the RSSSA implements an "interruption of service" mechanism, analogous to shutter control in U.S. law. This provision allows for the suspension or limitation of all services, including system operations and data trading, if such activities are deemed contrary to Canada's national interests. Additionally, the RSSSA includes a provision for the government's right of first access to data in cases of national security, public safety, or emergency response, a measure that mirrors similar policies under U.S. law (Tronchetti 2015).

4.4. Germany

Until the 1990s, Germany primarily operated commercial communication satellites. However, in the 2000s, the country launched large-scale public–private partnership (öffentlich–private Partnerschaft) projects aimed at fostering industrial growth in satellite remote sensing. As a result, the TerraSAR-X program, an Earth observation satellite initiative, was established (Gerhard et al. 2008). TerraSAR-X, an observation satellite equipped with a synthetic aperture radar (SAR) sensor, was a high-performance satellite with a resolution of 1 m. It featured exceptional radiometric resolution technology, could access any point on Earth within a maximum of 2.5 days, and boasted world-class geometric accuracy at the time.

From the early stages of the TerraSAR-X program's development, issues regarding data distribution policies had already been raised. According to the operational agreement for TerraSAR-X, concluded between the German Aerospace Center (Deutsches Zentrum für Luft- und Raumfahrt e.V., Hardthausen am Kocher, Germany, DLR) and EADS (European Aeronautic Defence and Space Company, Paris, France) Astrium, ownership of the satellite was retained by DLR, while the management and operation of the satellite data

were assigned to EADS Astrium. Under this arrangement, EADS Astrium was granted the commercial rights to sell the data through its subsidiary, Infoterra Ltd. (Leicester, UK), a provider of geospatial products and services, while DLR was authorized to distribute the data for scientific purposes.

However, if the German government sought to utilize the data for purposes other than scientific research, it was required to purchase the data from Infoterra. Consequently, concerns were raised that the unrestricted dissemination of data collected by TerraSAR-X, with a resolution of 1 m, through Infoterra could pose risks to national security or compromise diplomatic interests (Gerhard et al. 2008).

In the early 2000s, existing German law did not provide mechanisms to restrict the distribution of satellite remote sensing data. Germany's export control laws were limited in scope, focusing on materials, technologies, and trade secrets, and there were no regulations specifically applicable to satellite data (Wins-Seemann 2008). Furthermore, Germany lacked a dedicated legislative framework governing space activities. As a result, issues such as national security threats posed by the dissemination of TerraSAR-X data or potential violations of the SRTM collaboration with the United States could not be resolved without new legislation. Therefore, before the launch of TerraSAR-X and the commencement of unrestricted data dissemination, it became imperative to establish a regulatory framework. To address this need, the German government initiated legislative efforts to create laws applicable to the operation of TerraSAR-X. The legislative process followed these key directions (Gerhard et al. 2008).

First, the primary objective of the legislation was to safeguard national security. If TerraSAR-X satellite data or derived information were to be used for military purposes, the government's inability to control such activities could pose severe national security risks. Moreover, the distribution of such data to third countries could not only generate international security risks but also lead to diplomatic conflicts.

Second, the regulatory measures aimed to maintain export control compliance with the United States. Germany's remote sensing satellite programs heavily relied on U.S.-manufactured components. In such cases, U.S. export control laws required the importing country to implement security measures ensuring the safe handling of satellite data. To sustain its satellite programs, Germany needed to establish a legislative framework that complied with U.S. export control requirements.

Third, beyond national security objectives, the legislation sought to enhance the industrial capacity of satellite remote sensing. Legal regulations were expected to provide predictability for private companies engaged in satellite data transactions and to support stable industrial growth. Thus, the legislative framework aimed to protect national security interests while fostering the development of related industries.

Fourth, the legal framework reflected domestic circumstances specific to Germany. At that time, only the United States and Canada had standalone laws governing satellite remote sensing. Although adopting a model similar to the U.S. Remote Sensing Space Act (RSSSA) was proposed, two primary reasons led to its rejection: (i) The satellite data markets in the U.S. and Canada were predominantly driven by government and public sector demand, whereas in Germany, commercial utilization by private entities constituted the majority of demand, with public sector demand being relatively limited. Introducing measures such as "shutter control", which could suspend data transactions under U.S. law, would disproportionately affect Germany's market structure. Consequently, it was deemed impractical to adopt the same regulatory measures as those in the U.S. and Canada. (ii) The U.S. Export Administration Regulations (EAR) operate under a strict export control regime, granting export permissions only when no national security concerns are identified. In contrast, Germany's Foreign Trade and Payments Act (Außenwirtschaftsgesetz, AWG), grounded in the constitutional principle of trade freedom, generally permits exports unless specific issues arise. Given these fundamental differences, it was not feasible for Germany to implement a regulatory framework analogous to that of the United States.

This legislative approach sought to balance national security imperatives with the demands of industrial growth while also addressing Germany's unique market structure and legal traditions. In 2000, the German government adopted a bilateral cooperation project with the U.S. government known as the Shuttle Radar Topography Mission (SRTM). However, the operation of the TerraSAR-X program posed a potential conflict with the terms of the SRTM. The satellite data from TerraSAR-X contained detailed topographical information about various countries' territories. While the German government maintained control over SRTM data for scientific purposes, it had no authority over the commercial data distributed by Infoterra (Kim 2020).

To address this issue, the German government initiated a legislative process to establish laws governing the operation of TerraSAR-X. In 2007, Germany enacted the Law for the Protection against Endangering the Security of the Federal Republic of Germany by the Dissemination of High-Quality Earth Remote Sensing Data (Gesetz zum Schutz vor Gefährdung der Sicherheit der Bundesrepublik Deutschland durch das Verbreiten von hochwertigen Erdfernerkundungsdaten, hereinafter SatDSiG) (Wins-Seemann 2008).

Under SatDSiG, "data" (Daten) refer to all products derived from sensor signals, regardless of the preservation, display, or processing methods applied to such signals by Earth orbit or transmission systems (SatDSiG §2). This includes not only primary or raw data collected by observation satellites but also any processed or refined data, as well as the final analyzed information with informational value derived from the original data.

In Germany, government authorization (Genehmigung) is required to operate remote sensing systems. The licensing requirements are governed by SatDSiG, which provides more detailed criteria for license issuance compared to the U.S.'s LRSPA or Canada's RSSSA. SatDSiG defines a different scope of jurisdiction, as foreign operators running systems outside of Germany are not subject to SatDSiG's licensing requirements.

SatDSiG is notable for its licensing regime for data trading and its sensitivity review process in data dissemination. Under SatDSiG, any provider of satellite data must obtain approval from the relevant administrative authority before distributing such data. For data containing special security information, SatDSiG establishes both a "sensitivity review system" and a "licensing system" to regulate data trading (SatDSiG §17). Under German law, the trade of data containing special security information follows two stages: first, sensitivity review, and second, license acquisition. In the first stage, the data provider is responsible for assessing the sensitivity of the information. If the provider determines the data to be highly sensitive, they must voluntarily suspend the transaction or refuse the sale of the data. If the data are deemed to have low sensitivity, the provider may proceed with the transaction without further measures. However, if highly sensitive data are intended for dissemination, government authorization must be obtained in the second stage, involving a detailed review by the competent administrative authority. After this review, even highly sensitive data may be distributed, provided the provider obtains the necessary governmental license (Kim 2020).

4.5. France

In 2008, France formally began establishing its space legislation system with the enactment of the Law on Space Operations. However, governmental policies regarding the operation of satellites and remote sensing had already been in place since the 1970s. By the 1980s, France had developed a competitive structure in the satellite data market, rivaling the United States' Landsat data.

In 1986, France launched its first observation satellite, the Satellite Pour l'Observation de la Terre (SPOT), whose data achieved significant commercial success compared to Landsat data. Unlike the Landsat system, SPOT data focused on fostering industrial growth for purely business purposes, allowing it to better meet market demands. However, in the 2000s, concerns arose regarding the security of information related to SPOT data transactions. Since France did not have comprehensive domestic legislation regulating space activities, remote sensing activities conducted for military or public purposes were governed

by general laws, with no specific restrictions. While satellites used for military activities were subject to government export controls under French law, the export of satellite data remained outside the scope of governmental control.

In response, the French government recognized the need for legislation to ensure transparency and legality in remote sensing activities. Consequently, in 2008, France enacted the Law on Space Operations (LOI n° 2008-518 du 3 juin 2008 relative aux opérations spatiales, hereinafter referred to as "LOS") to regulate all space activities. The LOS was designed to govern a wide range of space activities, including rocket launches, satellite and other space object management, and re-entry operations. Provisions related to remote sensing activities are set forth in Title VII, Primary Exploitation of Space-Originated Data (Exploitant primaire de données d'origine spatiale) (Achilleas 2008). Specifically, Title VII addresses three key aspects: prior notification for space data usage, restrictions on data dissemination, and penalties for violations. Decree n° 2009-640, enacted to implement Title VII, specifies the criteria and scope of regulated satellite data, although its regulatory content is significantly less extensive than that of the U.S.'s LRSPA or Canada's RSSSA (Kim 2020).

Under the LOS, the space data subject to prior notification include all data obtained by observing the Earth from space, encompassing both raw and processed data (Achilleas 2008). However, this is limited to commercial data, and military data or data handled by the French Ministry of Defense are exempt from the notification requirement.

Data classified as "space data" include data extracted from panchromatic optical sensors (de capteurs optiques panchromatiques), multispectral optical sensors (de capteurs optiques multi-spectraux), stereoscopic optical sensors (de capteurs optiques stéréoscopiques), thermal infrared sensors (de capteurs infrarouges), and radar sensors (de capteurs radar), with resolution and precision characteristics governed by the standards set forth in the Decree (Achilleas 2008).

Unlike the United States, Canada, and Germany, France does not explicitly provide for a licensing system for the operation of remote sensing systems; instead, it has established a notification system. This notification system reflects a more lenient regulatory approach compared to the licensing regimes in the U.S. and Canada. Under French space law, the entity responsible for submitting the notification is the primary operator accountable for acquiring and managing space data. This applies only to natural or legal persons domiciled within France. Foreign operators conducting satellite remote sensing activities within France are also subject to the notification requirement, but unlike the U.S. or Canada, foreign operators located outside of France are not subject to this regulation. The space data handled by primary operators are limited to commercially driven data, while data intended for military purposes or handled by the French Ministry of Defense are exempt from the notification requirement. In terms of data trading procedures, French space law provides for discretionary administrative measures to restrict data transactions based on national defense, foreign policy, international agreements, and other significant national interests (LOS §24).

4.6. Japan

Japan established its space legislation system with the enactment of the Basic Space Law in 2008, thereby institutionalizing its space development policies. According to Japan's Basic Space Plan, satellite systems related to remote sensing are classified into three categories: (1) "Land and Ocean Observation Satellite Systems", which capture images of the Earth's surface on land and at sea using optical sensors or radar in the visible spectrum; (2) "Earth Environment Observation and Meteorological Satellite Systems", which primarily acquire atmospheric data such as greenhouse gas concentrations, precipitation levels, or cloud conditions; and (3) "Security Satellite Systems", which capture images of specific areas for reasons of national security or military intelligence (Cabinet Office 2016).

Japan's satellite remote sensing industry experienced significant expansion in the late 2000s. However, concerns arose regarding the lack of legal infrastructure for managing

satellite remote sensing operations and satellite data transactions, highlighting the need for a more structured legal framework (Kozuka and Aoki 2017). The terrorist attacks of 11 September 2001, heightened awareness of the potential threats posed by satellite information to national security in Japan, and the growing legislative regulations on remote sensing among major spacefaring nations in the mid-2000s further fueled calls for legislative reform within Japan (Uga 2019).

Against this backdrop, the Third Basic Space Plan in 2015 proposed the need for new legislation on satellite remote sensing as an institutional measure to secure Japan's security interests and those of its allies while promoting the business activities of private companies utilizing remote sensing satellites. In 2016, with the enactment of the Space Activities Act and the Act on Ensuring the Proper Handling of Satellite Remote Sensing Records (衛星リモートセンシング記録の適正な取扱いの確保に関する法律), Japan established an independent space law framework for satellite remote sensing (Shintani 2017). The Act on Satellite Remote Sensing Records is composed of seven chapters and a total of 38 articles. The core framework of the law is found in Chapter 2, which addresses the "Licensing of Satellite Remote Sensing Devices", and Chapter 3, which regulates the "Handling of Satellite Remote Sensing Records" (Sato 2017). Chapter 4 establishes a certification system for the handling of satellite data, outlining the scope, requirements, and obligations of certified data handlers, while Chapter 5 details provisions for supervision and penalties related to remote sensing activities.

The Act on Satellite Remote Sensing applies only to systems operated within Japan, excluding Japanese nationals, permanent residents, and corporations operating outside Japan. Even if a Japanese corporation operates a remote sensing system abroad, it is not subject to the licensing requirements of the Act (Shintani 2017).

The Act defines satellite data as "Satellite Remote Sensing Records" (衛星リモートセンシング記録) and includes a provision specifying their definition. "Satellite Remote Sensing Records" refers to satellite data collected by remote sensing satellites, with the scope of the term limited to specific criteria (Oshima 2021). Specifically, the term applies to (a) electronic records of detection information transmitted from satellite remote sensing devices to Earth and electronic records that have undergone "processing"; (b) the range and extent of changes made through processing, the elapsed time since the electronic records were recorded, and the object identification accuracy; and (c) records that, if utilized, may pose a threat to international security or Japan's national security.

Regarding data transactions, the Act adopts a "certification system", which is a form of approval from government authorities that ensures the proper handling of satellite data (Satellite Remote Sensing Act §21). This system differs from the dissemination procedures in the U.S. or Canada and the licensing regime in Germany. The certification system under the Remote Sensing Act applies only to raw or standard data (processed data) and does not extend to analyzed information (Uga 2019). The Act and its implementing regulations establish conditions and scope for different types of data, based on technical information regarding sensors, observation conditions, and the operational period of the sensors (Sato 2017).

As a measure for restricting data transactions, the Act provides for an "Order of Data Provision Prohibition" (Satellite Remote Sensing Act §18), which temporarily suspends data transactions in cases where national security, international peace, or security threats are identified. This provision is similar to the U.S. shutter control mechanism. Another unique feature of the Act is its stipulation of security management measures for data transactions. The Act distinguishes between raw data and standard data, categorizing security measures into organizational, personnel, physical, technical, and practical measures (Kozuka and Aoki 2017).

5. Discussions on Civil Liability in the Satellite Remote Sensing Business

5.1. Liability of the Licensor

5.1.1. Liability to the Licensee

Transactions involving the use of data obtained through satellite remote sensing are fundamentally based on commercial relationships and are conducted through licensing agreements for the use of data (Smith and Doldirina 2016). Although the structure of liability may become complex due to the involvement of multiple parties, it can generally be divided into the licensor's liability and the licensee's liability, both of which are rooted in the licensing agreement (Ito 2008; Salin 1992b). The licensor bears liability for damages to both the licensee and third parties, such as the subjects of the imaging. First and foremost, the licensor is obligated under the licensing agreement to provide the licensee with the data within the scope of the licensed subject matter, and failure to do so will result in liability for breach of contract.

The issue arises when the data or the paid information provided to the licensee contain errors due to flaws in the processing or analysis of the satellite data, causing harm to the licensee (Tronchetti 2015). In such cases, it is crucial that the initial raw data were error free. In other words, the problem arises from a mistake in the processing and analysis of the raw data, leading to inaccuracies in the final analytical information. If the licensee suffers damages due to reliance on such erroneous information, the licensor would be liable for damages under tort law. While providing incorrect information itself is not generally considered unlawful, the majority of global jurisprudence and academic doctrines reject this notion based on the principle of "caveat emptor"—that is, "the buyer bears the risk of verifying the truth of the information forming the basis of the transaction" (*Stuart v. Wilkins* 1778; *Parkinson v. Lee* 1802; *Gardiner v. Gray* 1815; *Jones v. Bright* 1829). Incorrect information provision may not be unlawful per se, but if it entails a breach of duty, it may give rise to illegality. For instance, providing intentionally false information that induces the other party to act based on that misinformation would constitute a breach of duty and may be deemed unlawful. However, in cases of negligent misrepresentation, such conduct would only be considered unlawful if it is evaluated as a breach of duty.

As the licensor is contractually obligated to provide correct information to the licensee within the licensed scope, it follows that the licensor also has a duty not to provide false information, thus establishing a breach of duty. Moreover, with respect to the licensor's exemption from liability based on contractual force majeure clauses, the principle of risk allocation must be explicitly stipulated. For example, if the satellite body or sensors malfunction, preventing the transmission of raw data after they have been collected, the key issue becomes who bears the risk. Although this is subject to contractual negotiation between the parties, force majeure is generally recognized in such cases. The operation of satellites in outer space involves far more unpredictable risks than the operation of equipment on Earth, and even if the satellite body or sensors are damaged, it is often difficult to determine the cause, let alone assign responsibility.

Clearly defining the scope of force majeure in the contract is one way to reduce the potential for disputes, but identifying whether the licensor's inability to perform was indeed caused by a force majeure event is itself a challenging issue. Ultimately, in the negotiation phase, a contractual provision should be included to classify events as force majeure only when the cause remains unidentified after a certain investigation period, or to impose the burden of proof on the licensor to establish that the non-performance was due to force majeure. The former option favors the licensor by increasing the likelihood of exemption from liability, whereas the latter makes it more difficult for the licensor to claim exemption (Oshima 2021).

5.1.2. Liability to Third Parties

The licensor's liability to third parties arises in cases where incorrect information causes harm to third parties or where the licensor's analysis infringes upon third-party rights, such as privacy or the right to one's image.

First, if the licensor processes the satellite data incorrectly or provides inaccurate analytical information to the licensee, and the licensee's use of that information causes harm to a third party, the question arises as to whether the licensor is liable for damages to the third party. If the licensing agreement is one "with protective effects for third parties" (Vertrag mit Schutzwirkung für Dritte), the licensor would be liable for damages. A "contract with protective effects for third parties" is a legal concept under German law that recognizes a third party, who is not a contractual party but has a direct interest in the protection obligations arising from the contract, as having a claim for damages in the event of a breach of duty. For example, if a property owner contracts with a roofer to repair a roof, and the roofer's negligence during the repair causes harm to the property owner's spouse or children, the injured third party may claim damages under the contract. Such contracts are known as "contracts with protective effects for third parties". This doctrine was developed in German jurisprudence to legally protect non-contractual parties closely associated with the contracting parties who suffer harm due to the negligent acts of an employee. Germany later codified this principle in Article 311(3) of the German Civil Code (Bürgerliches Gesetzbuch, BGB).

Therefore, if third-party protective effects are not recognized—i.e., if the third party does not fall within the scope of protection afforded by the licensing agreement—it would be difficult to hold the licensor liable for damages to a third party, even if the third party suffered harm from inaccurate information. In certain jurisdictions, however, doctrines like punitive damages could impose strict liability on the licensor, but such doctrines would be limited in their practical application.

Next, there is the issue of the licensor's liability for violating third-party privacy or image rights through the provision of satellite data. With advancements in remote sensing technology, particularly in sensor resolution, the accuracy of images obtained through such technologies has significantly improved. As sensor resolution continues to improve, personal rights could be implicated if the subject of observation is a physical entity embodying personal rights. For example, if satellite data are capable of identifying a specific individual and recording their behavior, they could infringe upon privacy or image rights (Lemaire 2024).

Although the specific content of "personal data protection laws" varies by country, the substantive principles are similar: when obtaining personal data, the purpose of their use must be disclosed in advance, or the data subject must be notified, and third-party transfers of personal data generally require the subject's consent. Therefore, if a licensor in country A sells satellite data to a licensee in country B, issues may arise concerning the cross-border transfer of personal data, potentially violating the data protection laws of country A.

However, it is practically difficult in the satellite remote sensing business to disclose the purpose of data use to every individual observed or to obtain consent in advance for the dissemination of their data. Thus, in the interest of protecting the rights of the observed individuals, the licensor may consider removing personal data or ensuring that identifiable information is not combined with other data when providing the processed data or analytical information to the licensee. If the licensor fails to take such protective measures, they may be liable for damages based on privacy or image rights violations, or violations of the right of publicity, to the observed third party (Keogh 2023).

5.2. Liability of the Licensee

The licensee is obligated to pay the licensing fee to the licensor for the provision and use of satellite data, and failure to do so will result in liability for breach of contract.

If the licensee, despite having agreed with the licensor on an information management system designed to prevent unauthorized reproduction or distribution of the provided data, violates this agreement by reproducing or distributing the data to third parties for commercial purposes, intellectual property issues under the licensing agreement may arise (Oosterlinck 1984; Salin 1992a; Mejia-Kaiser 1995; Reddix-Smalls 2014).

As previously mentioned, it is difficult to recognize creativity in raw data when the licensor only provides the licensee with primary data. This is because primary data typically consist merely of binary data transmitted from satellites and are mechanically acquired through the satellite's sensors (Chuvieco 2020). However, if the primary data undergo processing, treatment, or analysis to be transformed into processed data or analytical information, a degree of creativity may be introduced. Nevertheless, even in such cases, the licensor's copyright protection is significantly limited. While additional informational value may have been added, the transformation generally consists only of visualizing or quantifying the binary data into image or numerical form.

Nonetheless, if the licensee reprocesses, modifies without authorization, or reproduces the processed data or analytical information for commercial purposes in violation of the licensing terms, the licensor may pursue claims for damages based on copyright infringement within the scope of the licensing agreement.

Additionally, if the licensing agreement includes obligations related to confidentiality, prohibition on providing data to third parties, or restrictions on reverse engineering of the data, the licensee will be liable for damages in the event of a breach of such obligations.

6. Conclusions

The commercial use of satellite observation data constitutes a significant domain within the space industry. However, it establishes a set of relationships and legal responsibilities distinct from those in traditional commercial space launch activities, and the satellite data themselves are highly specialized, making them difficult to standardize. This is due to the fact that businesses leveraging satellite data are divided into distinct sectors, such as satellite communication based on communication satellite data, satellite remote sensing business utilizing observation satellite data, and satellite navigation business employing navigation satellite data.

The satellite remote sensing business has already seen legislative progress on a global scale, with countries such as the United States, Canada, Germany, France, and Japan enacting relevant laws. However, the issue lies in the fact that the legal frameworks of these countries fail to provide clear regulations regarding the civil liability of parties involved in satellite remote sensing. The licensing structure governing the provision and use of satellite remote sensing data raises questions of responsibility between licensors and licensees, particularly concerning any damages resulting from incorrect satellite information. This includes third-party liability in cases where satellite information either causes harm or infringes upon privacy or portrait rights through the use of licensed data or analytical reports.

Given the commercial use of satellite remote sensing, the foundational role of satellite data in various industries, differing data policies, security concerns, and diverse business contract structures, it is imperative that tailored legislation is enacted. There are several reasons for this necessity.

First, from a national security perspective, high-resolution satellite data must be regulated institutionally. The spatial and temporal resolution of current satellite data have drastically improved compared to the past, and the platforms for accessing and utilizing these data have become more accessible and cost-effective. As a result, the benefits to data users are expected to increase significantly. On the other hand, data misuse by hostile states or terrorist organizations has also become far easier. For this reason, countries like the United States, Canada, Germany, France, and Japan have enacted laws restricting the dissemination of satellite data by private companies. Korea should, therefore, follow these international trends and establish domestic regulatory mechanisms to control the distribution of satellite data.

An additional benefit of individual legislation is the potential for the commercial expansion of the satellite remote sensing industry. Clear operational standards and data dissemination procedures, which private companies must adhere to, can be established through the enactment of specific legislation. Furthermore, the legislation will enhance

the predictability of business operations related to satellite remote sensing. At present, satellite data are widely used across numerous sectors, including agriculture, disaster management, natural resource exploration, and social infrastructure. With the potential future development and operation of small observation satellites in mind, the satellite remote sensing industry should be considered a key driver of new industrial fields. By legislating for satellite remote sensing, broad opportunities can be offered to the private sector while also promoting industrial development as part of national policy. Ultimately, the satellite remote sensing industry should serve as a driving force for future space development.

6.1. Theoretical Implications

The issue of civil liability concerning the commercial use of satellite observation data requires an examination of both legal and technical elements. Several legal principles must be considered.

First, the legal status of satellite data must be distinguished. Satellite data, whether from observation satellites or navigation satellites, possess both public and commercial characteristics. Since data collected from satellites are often used for public benefit, a clear distinction must be made between public and commercial data. The legal status of satellite data when used for commercial purposes can significantly impact the rights and obligations of the parties involved.

Second, the nature of civil liability arising from satellite remote sensing business should be considered in terms of both fault-based liability and strict liability. In licensing agreements between satellite data providers and users, clear provisions must be made regarding risk allocation, liability criteria, and compensation. Liability for damages arising from inaccuracies in satellite data or service errors would typically fall under the fault-based liability of the data provider. In cases of negligence in data management, fault-based liability would apply. When pursuing fault-based tort liability, the focus would be on whether there was a breach of the duty of care during the provision and use of satellite data, making the establishment of clear duty of care standards essential.

In contrast, when satellite data are used in sensitive sectors, strict liability may apply, regardless of the provider's fault. For example, in areas closely related to public safety, such as aviation or meteorology, or in national defense and security, strict liability is likely to be imposed.

6.2. Practical Implications

Satellite observation data used in the satellite remote sensing business are highly precise technical data. However, technical limitations in the acquisition, processing, and handling of satellite data may result in errors, which could lead to incomplete information.

In satellite remote sensing business models, data accuracy and quality may be subject to pre-disclosure obligations or indemnification clauses within licensing contracts. Such preemptive measures aim to ensure predictability in liability for damages, and the scope of damages from the use of satellite data can be outlined as follows:

First, economic damages resulting from errors in satellite data. The responsibility for economic loss should be individually assessed among the data provider, intermediary users, and end consumers. This includes not only direct economic losses caused by inaccurate satellite data but also indirect losses, such as damage to trust or a decline in market value.

Second, the scope of compensation in civil liability cases is generally limited to foreseeable damages. However, some damages resulting from the commercial use of satellite data may arise in unforeseen or force majeure circumstances. For instance, signal interference from solar storms could lead to inaccuracies in navigation satellite data, or errors could arise in satellite data during extreme events. It is necessary to debate whether such unforeseeable damages should be included within the scope of liability or exempted as force majeure. The extent of liability will depend on whether satellite data are categorized under fault-based or strict liability principles.

Third, scenarios involving limitations on liability must be considered. These could be addressed under specific legislative policies, and it is common for the provider of satellite data to have liability caps based on the potential risks and scale of damages. During legislative reforms or the enactment of specific laws, the validity of liability caps for damages resulting from incorrect information must be debated, alongside the implications for industry, consumer protection, and the safeguarding of public interests.

Fourth, the issue of privacy and data protection inevitably arises in the satellite remote sensing business. This is an essential matter in the commercial use of satellite data, closely tied to how satellite data are defined and classified. In the process of large-scale satellite data collection, processing, and handling, information that can trace individual privacy may be included. In such cases, violations of personal information protection laws may occur, and any future legislation should take into account potential conflicts with these laws. It will be necessary to establish legal standards for the collection, processing, and protection of personal data.

Fifth, the question of international liability for damages related to satellite data must be addressed. When satellite data collected by one country are transferred to another, the application of the latter's laws and regulations becomes a critical issue (Pomfret 2024). For instance, if satellite data collected by a particular country contain information impacting the national security or economic interests of another country, the latter may assert data sovereignty and impose restrictions on the commercial use of such data. Moreover, cases involving state liability may arise in addition to private claims for damages. Indeed, several national laws on satellite remote sensing address such scenarios through provisions known as "shutter control", which authorize the suspension of data transactions in cases where national security is at risk. It will be essential to establish concrete standards for exempting civil liability in the case of unavoidable suspensions of transactions for reasons related to national security or other force majeure events.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Data are contained within the article.

Conflicts of Interest: The author declares no conflicts of interest.

References

Achilleas, Phillipe. 2008. French remote sensing law. *Journal of Space Law* 34: 1–10.

Ambrosetti, Eleonora. 1984. Remote sensing from outer space: Its significance and problems from a third world perspective. *New York University Journal of International Law and Politics* 17: 1–33.

Arzt, Clemens. 1999. Use of satellite imagery in legal proceedings. *Air and Space Law* 24: 195–203. [CrossRef] [PubMed]

Baumann, Ingo, and Erik Pellander. 2024. Regulation of commercial Earth observation systems and data. In *Routledge Handbook of Commercial Space Law*. Edited by Lesley Jane Smith, Ingo Baumann and Susan-Gale Wintermuth. Oxfordshire: Routledge, pp. 297–314.

Bourely, Michel. 1988. Legal problems posed by the commercialization of data collected by the European remote sensing satellite ERS-1. *Journal of Space Law* 16: 129–46.

Cabinet Office. 2016. Basic Space Plan. *Cabinet Decision*, April 1, p. 14.

Christol, Carl Q. 1987. Remote Sensing Principles: Emerging or Existing Law. *Proceedings on Law of Outer Space* 30: 268.

Chuvieco, Emilio. 2020. *Fundamentals of Satellite Remote Sensing: An Environmental Approach*, 3rd ed. Boca Raton: CRC Press.

de Saint-Lager, Olivier Juillet. 1983. Remote Sensing Systems: The International Dimension. *Proceedings on Law of Outer Space* 26: 259.

DeSaussure, Hamilton. 1989. Remote sensing satellite regulation by national and international law. *Rutgers Computer & Technology Law Journal* 15: 351–82.

Diederiks-Verschoor, I. H. Ph. 1984. Current Issues in Remote Sensing. *Michigan Yearbook of International Legal Studies* 5: 305–16.

Doldirina, Catherine. 2015. Intellectual property rights in the context of space activities. In *Handbook of Space Law*. Edited by Frans von der Dunk and Fabio Tronchetti. Cheltenham: Edward Elgar Publishing, pp. 949–94.

Emery, William, and Adriano Camps. 2017. *Introduction to Satellite Remote Sensing: Atmosphere, Ocean, Land and Cryosphere Applications*. Amsterdam: Elsevier, p. 1.

Feinaeugle, Clemens A. 2007. The UN Principles on Remote Sensing and the GATS: Conflicts or peaceful co-existence. *Proceedings on Law of Outer Space* 50: 369–89.
Ferrazzani, Marco. 2005. The policies in remote sensing and the practices of the European Space Agency. *Proceedings on Law of Outer Space* 48: 506–25.
Gabrynowicz, Joanne Irene. 2005. The perils of Landsat from grassroots to globalization: A comprehensive review of US remote sensing law with a few thoughts for the future. *Chicago Journal of International Law* 6: 45–68.
Gardiner v. Gray (1815) 171 E. R. 46.
Gerhard, Michael, Max Kroymann, and Bernhard Schmidt-Tedd. 2008. Ein gesetz für die raumfahrt: Das neue satellitendatensicherheitsgesetz (The new german act on safeguarding security aspects in the distribution of satellite remote sensing data). *ZLW—Zeitschrift für Luft-und Weltraumrecht (German Journal of Air and Space Law)* 57: 40–54.
Gillon, Thomas. 2008. Regulating remote sensing space systems in Canada: New legislation for a new era. *Journal of Space Law* 34: 19–32.
Golda, Carlo, and Maria Elena De Maestri. 2022. Regulation of remote sensing activities. In *Outer Space Law: Legal Policy and Practice*, 2nd ed. Edited by Yanal Abul Failat and Anél Ferreira-Snyman. Surrey: Globe Law and Business Ltd., pp. 239–70.
Greenburg, David A. 1983. Third party access to data obtained via remote sensing: International legal theory versus economic and political reality. *Case Western Reserve Journal of International Law* 15: 361–96.
Gupta, Vipin. 1995. New Satellite Images for Sale. *International Security* 20: 94–125. [CrossRef]
Harris, Ray. 2008. Current status and recent developments in UK and European remote sensing law and policy. *Journal of Space Law* 34: 33–44.
Hayward, Cynthia M. 1990. Remote sensing: Terrestrial laws for celestial activities. *Boston University International Law Journal* 8: 157–86.
Hobe, Stephan. 2019. *Space Law*. Baden-Baden: Nomos Publishing, p. 149.
Hopkins, Gary L. 1977. Legal implications of remote sensing of earth resources by satellite. *Military Law Review* 78: 57–106.
Hoversten, Michael R. 2001. U.S. national security and government regulation of commercial remote sensing from outer space. *Air Force Law Review* 50: 253–80.
Ito, Atsuyo. 2008. Improvement to the legal regime for the effective use of satellite remote sensing data for disaster management and protection of the environment. *Journal of Space Law* 34: 45–66.
Ito, Atsuyo. 2011. *Legal Aspects of Satellite Remote Sensing*. Leiden: Martinus Nijhoff Publishers, p. 4.
Jakhu, Ram S. 2010. Regulation of space activities in Canada. In *National Regulation of Space Activities*. Edited by Ram S. Jakhu. Berlin: Springer, pp. 98–99.
Johnston, Shaida. 2012. Technical introduction to satellite EO. In *Evidence from Earth Observation Satellites: Emerging Legal Issues*, 2nd ed. Edited by Ray Purdy and Denise Leung. Leiden: Martinus Nijhoff Publishers, pp. 16–54.
Jones v. Bright (1829) 130 E.R. 1167.
Joyner, Christopher C., and Daegan R. Miller. 1985. Selling satellites: The commercialization of LANDSAT. *Harvard International Law Journal* 26: 63–102.
Keogh, Laura. 2023. EU data protection considerations for the space sector. In *Space Law in a Networked World*. Edited by P. J. Blount and Mahulena Hofmann. Leiden: Brill Publishers, pp. 230–55.
Kerkonian, Aram Daniel. 2021. *Space Regulation in Canada: Past, Present and Potential: The Case for a Comprehensive Canadian Space Law*. Berlin: Springer, pp. 138–41.
Kim, Young-Ju. 2020. A comparative review of the satellite remote sensing. *The Korean Journal of Air & Space Law and Policy* 35: 203–319.
Korea Data Law and Policy Society. 2020. *Legal Advisory on the Analysis of the Legal and Institutional Environment for Integrated Data Transactions*; Jincheon-gun: Korea Information Society Development Institute, p. 40.
Kozuka, Soichiro, and Setsuko Aoki. 2017. Background and practical considerations of the two space laws. *New Business Law* 1090: 29–34.
Kramer, Gary M. 1989. The first amendment viewed from space: National security versus freedom of the press. *Annals of Air and Space Law* 14: 339–68.
Lemaire, Thierry. 2024. The legal framework of remote sensing by satellites: The challenge of the new space. In *Space Law: Legal Framework for Space Activities*. Edited by Thomas Leclerc. Hoboken: Wiley, pp. 227–53.
Licor, Aylia. 2007. Satellite remote sensing: Commercialization of remote sensing—Is the use of satellite derived information for military purposes in violation of the peaceful purposes provision of the Outer Space Treaty. *ILSA Journal of International & Comparative Law* 14: 207–24.
Lyall, Francis, and Paul B. Larsen. 2024. *Space Law: A Treatise*, 3rd ed. Oxfordshire: Routledge, pp. 337–48.
Magdelenat, Jean-Louis. 1981. The major issues in the agreed principles on remote sensing. *Journal of Space Law* 9: 111–20.
Markowitz, Kenneth J. 2001. Legal Challenges and Market Rewards to the Use and Acceptance of Remote Sensing and Digital Information as Evidence. *Duke Environmental Law & Policy Forum* 12: 219–64.
Masson-Zwaan, Tanja, and Mahulena Hofmann. 2019. *Introduction to Space Law*, 4th ed. Hague: Kluwer Law International, pp. 171–83.
Mejia-Kaiser, Martha. 1995. Proprietary rights in remote sensing images. *Proceedings on Law of Outer Space* 38: 30.
Mosteshar, Sa'id. 2017. Regulation of remote sensing. In *Routledge Handbook of Space Law*. Edited by Ram S. Jakhu and Paul Stephen Dempsey. Oxfordshire: Routledge, pp. 144–59.

Oosterlinck, René. 1984. Legal Protection of Remote Sensing Data. *Proceedings on Law of Outer Space* 27: 112.
Oshima, Hinata. 2021. Satellite remote sensing business and satellite remote sensing law. In *Legal Affairs of Space Business*. Edited by Ryo Okubo and Hinata Oshima. Tokyo: Kobundo, pp. 76–92.
Parkinson v. Lee (1802) 102 E. R. 389.
Pettorelli, Nathalie. 2019. *Satellite Remote Sensing and the Management of Natural Resources*. Oxford: Oxford University Press, p. 4.
Pomfret, Kevin. 2024. Legal considerations for NewSpace companies when selling data (and associated products and services) to the US Government. In *Routledge Handbook of Commercial Space Law*. Edited by Lesley Jane Smith, Ingo Baumann and Susan-Gale Wintermuth. Oxfordshire: Routledge, pp. 281–96.
Prober, Raphael. 2003. Shutter control: Confronting tomorrow's technology with yesterday's regulations. *Journal of Law and Politics* 19: 203–52.
Reddix-Smalls, Brenda. 2014. Satellite remote sensing and database management: Who owns the digitized information relating to indigenous people and their artifacts. *North Carolina Central Law Review* 37: 1–30.
Salin, Patrick A. 1992a. Analysis of several bilateral remote-sensing contracts between satellite operators and ground stations. *International Business Law Journal* 1992: 219–34.
Salin, Patrick A. 1992b. Proprietary aspects of commercial remote-sensing imagery. *Northwestern Journal of International Law and Business* 13: 349–73.
Sato, Kohei. 2017. Overview of the act on ensuring the proper handling of satellite remote sensing records (Satellite Remote Sensing Act). *Jurist* 1506: 34–38.
Schreier, Gunter. 2002. Data policy implications on archive design. In *Earth Observation Data Policy and Europe*. Edited by Ray Harris. Oxfordshire: Routledge, p. 175.
Shintani, Mihoko. 2017. Overview of satellite remote sensing law and the future of satellite data utilization. *New Business Law* 1109: 4–10.
Smith, Lesley J., and Catherine Doldirina. 2016. Remote sensing: A case for moving space data towards the public good. *Space Policy* 37: 162–70. [CrossRef]
Staelin, David H., and John Kerekes. 1996. Remote sensing capabilities. In *Heaven and Earth: Civilian Uses of Near-Earth Space*, 2nd ed. Edited by Dorinda G. Dallmeyer and Kosta Tsipis. Hague: Kluwer Law International, pp. 169–96.
Stuart v. Wilkins (1778) 99 E. R. 15.
Tronchetti, Fabio. 2015. Legal Aspects of Satellite Remote Sensing. In *Handbook of Space Law*. Edited by Frans von der Dunk and Fabio Tronchetti. Cheltenham: Edward Elgar Publishing, pp. 501–53.
Uga, Katsuya. 2019. *Article-by-Article Commentary on the Two Space Laws*. Tokyo: Kobundo, pp. 222–30, 312–23.
von der Dunk, Frans G. 2002. Non-discriminatory data dissemination in practice. In *Earth Observation Data Policy and Europe*. Edited by Ray Harris. Oxfordshire: Routledge, pp. 44–70.
von der Dunk, Frans G. 2020. *Advanced Introduction to Space Law*. Cheltenham: Edward Elgar Publishing, pp. 59–63.
Waldrop, Elizabeth Seebode. 2004. Integration of military and civilian space assets: Legal and national security implications. *Air Force Law Review* 55: 157–232.
Weaver, Jefferson H. 1993. Lessons in multilateral negotiations: Creating a remote sensing regime. *Temple International and Comparative Law Journal* 7: 29–60.
West, Richard J. 1990. Copyright protection for data obtained by remote sensing: How the data enhancement industry will ensure access for developing countries. *Journal of International Law and Business* 11: 403–32.
Wins-Seemann, Elmar. 2008. Das satellitendatensicherheitsgesetz aus industrieller sicht—Angemessener Rahmen für die kommerzielle nutzung von weltraumgestützten fernerkundungssystemen (The satellite data security act from an industrial perspective: An appropriate framework for the commercial use of space-based remote sensing systems). *ZLW—Zeitschrift für Luft-und Weltraumrecht (German Journal of Air and Space Law)* 57: 55–66.
Zannoni, Diego. 2019. *Disaster Management and International Space Law*. Leiden: Brill, p. 148.