Legal Considerations for Data Processing From Outer Space Through Remote Sensing

By Arsen Kourinian

Remote sensing has revolutionized the way humanity observes and interacts with the Earth. By collecting data from satellites and other platforms in outer space, remote sensing enables the monitoring of environmental changes, resource management, disaster response, and national security. The proliferation of remote sensing technologies has raised questions about state sovereignty and the right to the data collected from outer space about a sensed state. This article explores the evolution of remote sensing, including with advancements in artificial intelligence (AI), the international legal frameworks that govern its use, and licensing regulations in the United States for private operation of remote sensing technology in outer space and data sharing.

Evolution of Remote Sensing

Remote sensing refers to the acquisition of information from a distance, including through aircrafts and space-based platforms, such as satellites and spacecrafts.[1] The origins of remote sensing can be traced back to aerial photography in the early twentieth century,[2] but the launch of the first Earth observation satellites in the 1960s marked a new era.[3] The United States' Landsat program, initiated in 1972, was among the earliest efforts to systematically collect and distribute satellite imagery for civilian purposes.[4] The Landsat program played an important role in studying and managing human-survival resources, such as water, food, and forests.[5]

In the context of Earth observation, remote sensing typically involves the use of satellites equipped with sensors that capture data across various electromagnetic spectra, including visible light, infrared, or radio waves.[6] Satellites are either equipped with passive sensors, which capture sunlight from the Earth's surface, or active sensors, which send signals to Earth, such as radar or Light Detection and Ranging, and measure the radiation that is reflected back.[7] These remote sensing satellites generate more than 100 petabytes of data every day,[8] which makes it challenging for manual processing. Recent advancements in AI, however, have streamlined data processing by applying algorithms to sort through the information and retrieve data that is more relevant for a particular study or project.[9]

By automating the identification and classification of images and patterns, AI algorithms can detect anomalies in real time, such as ecosystem changes or wildfire hotspots, and even preprocess data onboard satellites to reduce transmission loads and provide timely insights.[10] This improvement in data processing has significantly impacted fields like meteorology, climate science, and environmental monitoring, where machine learning models help track phenomena such as climate change, deforestation, and natural disasters.[11]

Furthermore, AI enhances the precision and efficiency of satellite operations by prioritizing data collection and guiding satellites to focus on areas of interest.[12] For example, AI can analyze low-resolution imagery to detect changes and then direct satellites to capture high-resolution images of those regions.[13] Advanced deep learning models, such as Long Short-Term Memory networks, are particularly effective for analyzing time-series data like solar wind parameters, improving forecasts of space weather events.[14] Overall, AI-driven remote sensing represents a transformative leap, enabling faster, more accurate, and efficient use of satellite data.

As remote sensing technology continues to develop, including through AI, it is worth noting that there is, at the moment, no binding international treaty directly related to remote sensing.[15] Instead, as described below, states rely on international principles and domestic legal frameworks to address privacy, national sovereignty, and data sharing rights for information collected through remote sensing technology.

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The Outer Space Treaty of 1967

The foundational legal instrument governing activities in outer space is the Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies, commonly known as the Outer Space Treaty of 1967 (OST).[16] The OST, adopted by the United Nations and signed by over 100 countries, including the United States, United Kingdom, Russia, and China, establishes the basic principles for the peaceful use of outer space.

While the OST provides a helpful legal framework for outer space, the boundary between air space and outer space have not yet been settled.[17] One school of thought is the spatialist approach, which focuses on the altitude to determine the demarcation line.[18] However, the problem with this position is that there is no commonly understood altitude level for separating air and outer space, although some countries have passed legislation that assigns a de jure cut-off point (e.g., 100 kilometers above sea level).[19] Another school of thought is the functional approach, which is focused on the purpose of the instrumentality that the state is using, e.g., space versus aircraft, and not its location.[20] This approach also has weaknesses, as parties may disagree on how a particular activity is characterized.[21]

Despite this uncertainty regarding where space is, once a person or object is in outer space (in the words of U.S. Supreme Court Justice Stewart, "I know it when I see it"), the OST's articles apply. The OST states that outer space, including the Moon and other celestial bodies, is the province of all humankind, open for exploration and use by all states, and free for scientific investigation.[22] States cannot claim sovereignty over outer space, the Moon and other celestial bodies, and activities in these areas must be conducted in accordance with international law.[23] It also requires the peaceful use of outer space by prohibiting states from placing nuclear weapons or other weapons of mass destruction in orbit or on celestial bodies.[24] Notably, the OST holds states responsible for national activities in outer space, whether conducted by governmental or non-governmental entities, and requires states to provide authorization and continuing supervision over the activities conducted by non-governmental entities in outer space.[25] As described below, the United States has implemented licensing regulations to oversee the private operation of remote sensing technology.

While the OST does not specifically address remote sensing, its broad provisions have informed the development of international principles and national regulations. It's emphasis on peaceful use, international cooperation, and the responsibility of states for activities conducted by their nationals underpins the legal framework for remote sensing.

United Nations Principles Relating to Remote Sensing of the Earth from Outer Space

Recognizing the need for more specific guidance on remote sensing, the United Nations adopted the Principles Relating to Remote Sensing of the Earth from Outer Space (the UN Principles).[26] The drafting of the UN Principles was a lengthy process that started in 1968, and was formally adopted in 1986.[27] Among the states, there were two polar viewpoints on remote sensing. Some states argued that remote sensing over their territories should not be permitted without consent because information regarding their natural resources was part of their state sovereignty and due to concerns over military security.[28] On the opposite end, some states argued that placing restrictions on remote sensing would be contrary to the OST, which permits the free use of outer space.[29] The UN Principles that were ultimately adopted attempt to strike a balance between these positions.

A key aspect of the UN Principles is the balance between the interests of sensing states (those operating remote sensing systems) and sensed states (those whose territory is being observed). The UN Principles encourage transparency, data sharing, and respect for the sovereignty of sensed states, while also supporting the free flow of information and the peaceful use of remote sensing technology.

Specifically, the UN Principles define remote sensing as, "the sensing of the Earth's surface from space by making use of the properties of electromagnetic waves emitted, reflected or diffracted by the sensed objects, for the purpose of improving natural resources management, land use and the protection of the environment."[30] The UN Principles group the information processed through remote sensing into three groups:[31]

1. *Primary data*, which "means those raw data that are acquired by remote sensors borne by a space object and that are transmitted or delivered to the ground from space by telemetry in the form of electromagnetic signals, by photographic film, magnetic tape or any other means;"

2. *Processed data*, which "means the products resulting from the processing of the primary data, needed to make such data usable;" and

3. *Analysed information*, which "means the information resulting from the interpretation of processed data, inputs of data and knowledge from other sources."

Under the UN Principles, sensed states have the right to access primary and processed data as soon as they are available on a non-discriminatory basis and for a reasonable cost.[32] The UN Principles also permit sensed states to have access to available analysed information concerning their territories, taking particular account of the needs and interests of developing countries.[33] Further, sensing states are required to provide processed and analysed data to sensed states as promptly as possible if they may be affected by natural disasters.[34] Moreover, states are encouraged to maximize the benefits available from remote sensing activities by establishing and operating data collection and storage stations and processing and interpretation facilities, through regional agreements and arrangements.[35]

The UN Principles affirm that remote sensing activities should be conducted for the benefit and in the interests of all countries, irrespective of their degree of economic or scientific development.[36] They emphasize the importance of international cooperation and making available to other states the opportunities for participating on equitable and mutually acceptable terms[37] in "remote sensing activities," which is defined as "the operation of remote sensing space systems, primary data collection and storage stations, and activities in processing, interpreting and disseminating the processed data."[38]

Regulations in the United States for Remote Sensing

In the United States, private remote sensing is governed by the Land Remote Sensing Policy Act of 1992 and its implementing regulations (the Act), which provide the legal framework for operating private remote sensing systems. This legislation was enacted in response to the growing commercialization of remote sensing and the need to balance national security, foreign policy, and commercial interests. The Act authorizes the licensing of private remote sensing space systems and sets forth the requirements for obtaining and maintaining a license.

Under the Act, the Secretary of Commerce, through the National Oceanic and Atmospheric Administration's (NOAA) Commercial Remote Sensing Regulatory Affairs division, is responsible for licensing private remote sensing operators[39] (with consultation with the Secretary of Defense for matters affecting national security and international obligations.)[40]

If a licensee is permitted to operate a private remote sensing space system, it must comply with certain transparency, data sharing and national security obligations, which are consistent with the UN Principles. These include:[41]

1. Preserving the national security of the United States and observing international obligations;

2. Making available to the government of any country, including the United States, unenhanced data collected by the system concerning the territory under the jurisdiction of such government;

3. Making unenhanced data available without preference or bias;

4. Disposing satellites in space once it terminates operations under the license;

5. Providing the Secretary of Commerce with complete orbit and data collection characteristics of the system, and inform the department of any deviation; and

6. Notifying the Secretary of Commerce of any significant or substantial agreement the licensee intends to enter with a foreign nation, entity, or consortium involving foreign nations or entities.

With respect to the above-described data sharing obligations, "unenhanced data" is defined as "land remote sensing signals or imagery products that are unprocessed or subject only to data preprocessing."[42] Data preprocessing includes: (1) rectification of system and sensor distortions in land remote sensing data as it is received directly from the satellite in preparation for delivery to a user; (2) registration of such data with respect to features of the Earth; and (3) calibration of spectral response with respect to such data.[43] However, "conclusions, manipulations, or calculations derived from such data, or a combination of such data with other data" fall outside the scope of unenhanced data.[44]

To apply for a license, NOAA strongly encourages applicants to initially complete a contact form to schedule consultation meetings, which are informal and not considered part of the application record.[45] Thereafter, the applicant needs to submit an application containing accurate information about the operator and the system in response to questions contained in Appendix A and pursuant to the instructions in Appendix B of the Act.[46] After the application is submitted, the Secretary of Commerce will determine within seven days whether it is complete and provide notice to the applicant.[47] If the application is incomplete, the applicant will be notified regarding what additional information or clarification is necessary.[48]

Within seven days of notifying the applicant that the application is complete, the Secretary of Commerce must also determine whether the private remote sensing space system should be characterized as Tier 1, 2 or 3.[49] A system is categorized as Tier 1 if it is capable of collecting unenhanced data substantially the same as unenhanced data already available from entities or individuals not licensed under the Act.[50] A Tier 2 categorization is provided if the system is capable of collecting unenhanced data substantially the same as unenhanced data from entities or individuals that are already licensed under the Act.[51] And a Tier 3 categorization is provided if the system is capable of collecting unenhanced data that is not substantially the same as unenhanced data already available.[52] The Act requires additional conditions depending on the system's tier ranking.[53]

The Secretary of Commerce will assess whether the applicant can comply with the Act, and either grant or deny the application within 60 days.[54] If the application is denied, the applicant may appeal the decision within 21 days.[55]

Once the license is granted, the licensee is required to annually certify to the Secretary of Commerce that each material fact in the license remains accurate.[56] If the material facts are no longer accurate, the licensee must provide all accurate material facts, explain the reason for any discrepancies, and seek guidance on how to correct errors.[57] The license remains valid until the Secretary of Commerce determines that one of the following has occurred:[58]

1. The licensee has successfully disposed of, or has taken all actions necessary to successfully dispose of, all on-orbit components of the system, and is in compliance with all other requirements of the Act and the license;

2. The licensee never had system components on orbit and has requested to end the license term;

3. The license is terminated for noncompliance; or

4. The licensee has executed one of the following transfers, subsequent to the Secretary of Commerce's approval of such transfer: (a) ownership of the system, or the operations thereof, to an agency or instrumentality of the U.S. Government; or (b) operations to a person who is not a U.S. person and who will not operate the system from the United States.

Conclusion

Remote sensing stands at the intersection of technology, law, and policy, offering powerful tools for observing and understanding the Earth. The OST and UN Principles provide the foundational international framework for the peaceful and cooperative use of remote sensing technologies. In the United States, the Act establishes a comprehensive system for licensing and oversight of private remote sensing operators.

The process of obtaining a license in the United States is designed to ensure that remote sensing activities are conducted in a manner consistent with national and international interests. As the capabilities of remote sensing systems continue to grow, the

integration of AI is transforming the field, enabling the analysis of massive datasets and unlocking new applications.

Notes

1. See NASA EARTHDATA, Remote Sensing, https://www.earthdata.nasa.gov/learn/earth-observation-data-basics/remote-sensing.
2. See Francis Lyall, et al., Space Law: A Treatise, at 337 (3rd ed. 2025).
3. See NASA, Learning About Earth From Space, https://www.nasa.gov/specials/60counting/earth.html.
4. See id.
5. See id.
6. See Dr. Svetla Ben-Itzhak, The Use of Artificial Intelligence in Outer Space Capabilities, SAIS Review of International Affairs, vol. 44 no. 2, 2024, at 10, available at, https://muse.jhu.edu/article/950954#:~:text=This%20AI%2Ddriven%20approach%20to,generated%20by%20modern%20satellite%20systems.
7. See id.
8. See id.
9. See Emily Newton, Four Ways Artificial Intelligence is Changing Remote Sensing, BBM Times (Mar. 10, 2023), https://www.bbntimes.com/science/4-ways-ai-is-changing-remote-sensing.
10. See Dr. Svetla Ben-Itzhak, The Use of Artificial Intelligence in Outer Space Capabilities, SAIS Review of International Affairs, vol. 44 no. 2, 2024, at 11, available at, https://muse.jhu.edu/article/950954#:~:text=This%20AI%2Ddriven%20approach%20to,generated%20by%20modern%20satellite%20systems.
11. See id. at 13.
12. See id. at 14.
13. See id.
14. See id. at 13.
15. See Francis Lyall, et al., Space Law: A Treatise, at 341 (3rd ed. 2025).
16. See United Nations, Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies (Jan. 27, 1967), available at, https://www.unoosa.org/oosa/en/ourwork/spacelaw/treaties/outerspacetreaty.html.
17. See Francis Lyall, et al., Space Law: A Treatise, at 148-149 (3rd ed. 2025).
18. See id.
19. See id. at 153-154.
20. See id. at 154-155.
21. See id. at 155.
22. See United Nations, Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies, at Article 1 (Jan. 27, 1967), available at, https://www.unoosa.org/oosa/en/ourwork/spacelaw/treaties/outerspacetreaty.html.
23. See id., Articles II & III.
24. See id., Article IV.
25. See id., Article VI.
26. See United Nations, Principles Relating to Remote Sensing of the Earth from Outer Space (Dec. 3, 1986), available at, https://www.unoosa.org/oosa/en/ourwork/spacelaw/principles/remote-sensing-principles.html#:~:text=Remote%20sensing%20activities%20shall%20be,needs%20of%20the%20developing%20countries.
27. See Francis Lyall, et al., Space Law: A Treatise, at 341 (3rd ed. 2025).
28. See id.
29. See id.
30. See United Nations, Principles Relating to Remote Sensing of the Earth from Outer Space, at Principle I(a) (Dec. 3, 1986), available at, https://www.unoosa.org/oosa/en/ourwork/spacelaw/principles/remote-sensing-principles.html#:~:text=Remote%20sensing%20activities%20shall%20be,needs%20of%20the%20developing%20countries.
31. See id. at Principle I(b)-(d).
32. See id. at Principle XII.
33. See id.
34. See id. at Principle XI.
35. See id. at Principle VI.
36. See id. at Principle II.
37. See id. at Principle V.
38. See id. at Principle I(e).
39. See 51 U.S.C.A. § 60121(a); 15 C.F.R. § 960.1; NOAA, Office of Space Commerce, Licensing, https://space.commerce.gov/regulations/commercial-remote-sensing-regulatory-affairs/licensing/.
40. See 51 U.S.C.A. § 60147.
41. See id. at § 60122(b).
42. See id. at § 60101(12).
43. See id. at § 60101(3)(A).
44. See id. at § 60101(3)(B).
45. See NOAA, Office of Space Commerce, Licensing, https://space.commerce.gov/regulations/commercial-remote-sensing-regulatory-affairs/licensing/.
46. See 15 C.F.R. § 960.5(b).

47. See id. at § 960.5(c).
48. See id.
49. See id. at § 960.6(a).
50. See id. at § 960.6(a)(1).
51. See id. at § 960.6(a)(2).
52. See id. at § 960.6(a)(3).
53. See id. at §§ 960.8-960.10.
54. See id. at § 960.7.
55. See id. at §§ 960.18-960.19.
56. See id. at § 960.14(a).
57. See id. at § 960.14(b).
58. See id. at § 960.15.