Satellite Earth Observation and Data Regulation

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Abstract

National space law in general aims to implement a State's obligations under the UN Space Treaties to authorise and supervise public and private sector space activities and to limit the liability risk exposure of a State. However, Earth observation data regulation is becoming of increasing importance as the Earth observation sector becomes more mature, although until recently only a few States have enacted legislation for private Earth observation activities. The purpose of this paper is to review the situations in five countries that have so far created Earth observation data regulations, namely Canada, France, Germany, Japan and the United States. The relevant laws and regulations for each country are reviewed and assessed, followed by the identification of common trends in Earth observation data regulation and legislation. The conclusions of the paper point to a growing need by nations to focus on Earth observation data regulation as the result of technology developments, national security considerations and increased international competition.

Key words: Earth observation, data, regulation, laws, national security, competition, commercial.

1. Introduction

The first meteorological satellite Tiros-1 and the first land remote sensing satellite ERTS-1 (subsequently re-named Landsat-1) were experimental missions. The emphasis with these early Earth observation missions was on ensuring that the technology worked, checking the quality and characteristics of the data and exploring the use of the data. Quickly it became clear that data from satellite Earth observation platforms has potential value for scientific research, operational applications and commercial programmes. The Tiros series of satellites and their successors in the Nimbus series had immediate value for meteorology as was their purpose, but the success of Landsat-1 as a technology demonstrator was shown in the widespread use of the images from the first and subsequent satellites [1].

These initial Earth observation missions (Tiros, Nimbus and Landsat) were all funded by the US government and therefore were the legitimate concern of public policy. In subsequent years there was a debate in the US about whether the Landsat satellites should be funded from the public purse or should be transferred to the private sector [2]. This debate has continued more or less unabated since then [3]. Most recently in 2018 the Landsat Advisory Group was asked to consider new prospects for cost sharing of Landsat data between the public and the private sectors to support the Sustainable Land Imaging model of Landsat continuity [4]. This topic is discussed below in section 2.

An important thread running throughout the period since the launch of Landsat-1 in 1972 has been the role of government in the Earth observation sector. Initially the US government was the funder, owner, operator and data distributor for Landsat. Over time the US government has become the funder and owner for some Earth observation satellites but also the regulator for private sector satellite Earth observation missions. This form of evolution has happened in other countries as well. We are now at the stage where data policies have been developed nationally and internationally to define the conditions of access to Earth observation data [5]. The next step after defining an Earth observation data policy is to create a legal basis for access to Earth observation data. This legal basis is typically in the form of a data regulation and it is the purpose of this paper to review the data regulations of five countries that have so far created Earth observation data regulations. The five countries reviewed in this paper are Canada, France, Germany, Japan and the United States. These five countries were chosen because they have been prominent in satellite Earth observation and because they have regulations that govern access to their Earth observation data.

National space law in general aims to implement a State's obligations under the UN Space Treaties [6, 7] to authorise and supervise public and private space activities and to limit the liability risk exposure of a State. National space law [8] in this field therefore primarily focusses on the launch and in-orbit operations of Earth observation systems, not in the first place on the data produced by the systems. Earth observation data regulation will become of increasing importance as the Earth observation sector becomes more mature [9]. Until recently, only a few States have enacted legislation for private Earth observation activities, sometimes as part of comprehensive national space legislation, sometimes self-standing. Under these frameworks, the competent licensing authority sets conditions under which the satellite mission will be operated and under which the data produced by the mission will be distributed. New regulatory challenges will emerge because of the advent of new private operators, new Earth observation satellite constellations such as Planet

[10], new technology capabilities in instruments and the growing availability of near-real-time data. The key drivers for adopting Earth observation data regulation include the following.

- The division of public and private sector Earth observation missions where data policies are characteristic of the public sector and regulation by government is characteristic of the private sector. The focus in this paper is on national data regulation and therefore on the rules for the private sector, although public sector rules are still important.
- International obligations on data sharing under the UN Remote Sensing Principles [11], the Group on Earth Observation (GEO), Copernicus and other policy instruments.
- National security and defence, foreign policy and international relations.
- Protection of database integrity.

In addition, the planned growth in the number of Earth observation satellite missions [12] and the increasing use of complex instruments at high spatial resolution and often with high revisit cycles increase the pressure to clarify the definition of the legal basis of the offer of Earth observation data. In particular there is a concern for whether Earth observation data are sensitive or not, that is whether there is a national security dimension to the data. The context is important here: the national legal structure will frame the approach to national Earth observation data regulation. In turn the national legal structure then guides whether there is primary or secondary legislation on Earth observation data access. The five country case studies in this paper include both Earth observation *satellite* regulation material and Earth observation *data* regulation material because in some cases the two types of regulation are indivisible in the sense that the regulation of a satellite mission incorporates the regulation of the data resulting from that mission. There is no single approach to this question adopted by the regulations in the five countries reviewed in this paper. Some countries focus on the satellite mission and some focus on the data.

2. National Earth observation data regulations

2.1 Canada

The applicable legal framework in Canada consists of the Remote Sensing Space Systems Act (RSSSA) [13] and the Remote Sensing Space Systems Regulations [14]. An applicant submits an application for a licence to operate a remote sensing system to the Minister of Foreign Affairs who then consults with the Departments of National Defence, Public Safety Canada, Industry Canada and the Canadian Space Agency. The Minister of Foreign Affairs of Canada introduced the Remote Sensing Space Systems Act on 23 November 2004. The Act received Royal Assent on 25 November 2005 and came into force on 5 April 2007. According to Section 5 of the Act, no person "shall operate a remote sensing space system in any manner, directly or indirectly, except under the authority of a licence" from the Minister of Foreign Affairs [13].

The RSSSA establishes the legal framework under which all remote sensing space system operators (whether government, military or civil) must operate. The RSSSA requires operators to obtain remote sensing licences prior to operating their satellite systems and the Minister of Foreign Affairs may impose conditions. The Minister of Foreign Affairs has powers to request priority access to data collected by a remote sensing system, to order an interruption of service if necessary to protect national security, defence, foreign policy interests and/or upholding Canada's international obligations, to impose conditions or restrictions on the operation of remote sensing satellite

systems, as well as on the reception, storage and dissemination of data collected by such systems and to inspect, monitor and audit remote sensing system operators.

The Standard Licensing Conditions under the Remote Sensing Space Systems Act are: (1) that the licensee keeps control of the licensed system; (2) that the licensee does not permit any other person to carry on a controlled activity; (3) that raw data are made available in accordance with the UN Remote Sensing Principles; (4) that the licensee keeps control of raw data and remote sensing products from the system until they are disposed of; (5) that raw data are only made available to entities designated under the Act and the licence; and (6) that agreements with the customer ensure that raw data are used in a manner compatible with the licensing conditions. Additional conditions can also be prescribed in the licence.

As the term "operate" is not defined by the Act, in theory any activities which are directly or indirectly related to the operation of a remote sensing space system may fall under the scope of the Act. In contrast to other legislations reviewed in this paper, that is France, Germany and Japan, the scope of the national regulation in Canada is not limited to systems generating data with a certain resolution or information content.

The RSSSA was reviewed in 2017 as a formal part of the Act. Pursuant to section 45.1 of the Act, Global Affairs Canada tasked the Institute of Air and Space Law at McGill University's Faculty of Law with conducting an independent review of the Act for the period 2012 – 2017 in order to assess, in particular, the impact of the Act on technological development and on the implementation of international agreements and treaties [15]. The review found that the Act and the associated licensing conditions were helpful in facilitating compliance with Canada's international agreements and treaties and may have had a positive impact on the development of technology (for example in data handling), but it had a lack of clarity on scope and it leans more in favour of protecting national security interests at the expense of commercial interests and technological development. The review noted "that although the Act was appropriate and useful at the time of its enactment in 2005, the players, activities, technology and internationalization of remote sensing activities have since changed significantly and outgrown the confines of the Act".

In its 2019 space strategy Canada anticipated the creation of simpler, clearer and more modern regulatory systems for space-related activities to ensure they provide timely responses for industry, maintain strategic oversight for national security and enable commercial growth [16].

2.2 France

The applicable laws in France are (1) Title VII Space Operations Act [17, 18]; (2) Decree 2009-640 of June 2009 implementing the provisions of Title VII of the Space Operations Act; (3) Order of 4 September 2013 on prior declaration of an activity carried out by primary operators of space based data; and (4) Decree 2013-654 of July 2013 on monitoring the activity of primary operators of space-based data. The competent authority in France is the Secretary-General for Defence and National Security who can seek assistance, comment and advice from the country's Inter-ministerial Committee. The development of this framework was driven by the transition from government-owned to commercial remote sensing satellites as illustrated by the privatisation of SPOT Image.

Unlike the other jurisdictions reviewed in this paper, France does not foresee a licensing procedure for collecting and disseminating Earth observation data *per se*. Whilst the launch and operations of Earth observation satellites are subject to a fully-fledged licensing procedure under the French Space Operations Act, the use of a payload for the collection of Earth observation data and their subsequent dissemination are only subject to a prior declaration.

Under Art. 23 of the Space Operations Act any primary space-based data operator undertaking in France an activity having certain technical characteristics defined in a decree passed at the Council of State must make a declaration to the competent administrative authority, that is the Secretary-General for Defence and National Security. The declaration must be submitted at least two months before the activity begins. The assessment by the Secretary-General for Defence and National Security determines whether the activity harms the fundamental interests of France, particularly defence matters, foreign policy and international commitments. The declaration is not subject to a formal statement of approval.

The technical characteristics required in the declaration are related in particular to the spatial resolution, location accuracy, observation frequency band and quality of the Earth observation data which are received or for which a satellite system is programmed. These general characteristics are made specific by the implementing Decree 2009-640 of 9 June 2009, as amended by Decree 2013-653 of July 2013, which define the following key technical characteristics of space data that are subject to a prior declaration.

- Data from panchromatic optical sensors with a spatial resolution less than or equal to two metres.
- Data from multispectral optical sensors with a spatial resolution less than or equal to eight metres and with the number of spectral bands greater than or equal to ten.
- Data from stereoscopic optical sensors with a spatial resolution less than or equal to ten metres or with altimeter accuracy less than or equal to ten metres in relative value (15 metres in absolute value).
- Data from thermal infrared sensors with a spatial resolution less than or equal to five metres.
- Data from radar sensors with a spatial resolution less than three metres.
- Data with an intrinsic location accuracy less than ten metres.

That these types of data fall under the scope of the declaratory procedure under Title VII of the Space Operations Act does not mean that the acquisition and/or dissemination of the data is prohibited and/or might be restricted. It only implies that these data are subject to the declaratory procedure under Title VII of the Space Operations Act, under which restrictions might be imposed. In turn, the threshold definitions listed above imply that data produced from systems that do not meet these technical characteristics are not subject to the declaratory procedure under Title VII and cannot be subject to any restrictions derived from this procedure.

According to Art. 1 (7) of the Space Operations Act, the term “space-based data primary operator” means any natural or juridical person ensuring the programming of an Earth observation satellite system or the reception of Earth observation data from outer space. In other words, the entity that is subject to the declaratory procedure under Title VII is the entity that controls the programming of

the satellite payload through control of sensor activation and parameter adjustment or the entity that directly receives the data from the satellite at its installations on the ground surface. The primary operator under the terms of the Space Operations Act is not necessarily the same entity as the entity applying for the (prior) authorization to proceed with the launch and the (prior) authorization to command the satellite in outer space. Any entities other than the primary operator (namely those in the upstream and downstream sectors) are not subject to the declaratory procedure described above.

Under Article 24 of the Space Operations Act, together with Article 5 of the Decree 2009-640 of 9 June 2009 and Article 3 of the Decree 2013-654 of July 2013, the Secretary-General for Defence and National Security may at any time prescribe restrictive measures to the use of an instrument for high-resolution observation, the reception of data, the production of images and to the dissemination of data in order to protect the fundamental interests of France.

2.3. Germany

Germany has so far not adopted any overall space legislation, but it does have specific laws concerning satellite Earth observation data. The applicable laws in Germany are the Satellite Data Security Act (SatDSiG) of 2007 [19] and the Satellite Data Security Ordinance (SatDSiV) of 2008 [20]. The SatDSiG is the law and the SatDSiV contains the technical characteristics that are used to review Earth observation data as being either sensitive or non-sensitive. The lead department in Germany for the SatDSiG and the SatDSiV is the Ministry for Economic Affairs and Energy, while the operational administration for the two regulations is performed by the Office for Economic Affairs and Export Control. The German Foreign Office, the Ministry of Defence and the Ministry of the Interior are closely involved for security policy issues while the Office for Information Security is involved in some checks during the licensing procedure

The focus of the SatDSiG and SatDSiV is on the operation of non-military “high grade” Earth remote sensing systems from within the German territory and on the first level of dissemination of data generated by such systems from within the German territory. Accordingly, the SatDSiG pertains to the operator and/or primary data distributor, but not to re-sellers, value-adding companies or service providers further downstream. The SatDSiG also does not pertain to the dissemination of data generated by foreign systems that are not operated from within German territory. Both the operation of systems falling under the scope of the Act and the dissemination of data generated thereby are subject to licensing requirements. In the following, the analyses focus on the conditions regarding data dissemination [21].

The definition of “high grade” is concerned with the ability of the sensors to generate data with very high information content because of their high spatial resolution, high spectral resolution, large number of wavebands (i.e. hyperspectral), their frequency domains, their polarization characteristics and their phase history (for radar data). This concern with a law on high grade data grew out of the German initiatives for high spatial resolution radar systems, implemented as a public-private partnership between the German Aerospace Centre (DLR) and Airbus. Germany launched its TerraSAR-X satellite [22] in June 2007 followed by the almost identical TanDEM-X satellite in June 2010. Both satellites were equipped with a synthetic aperture radar (SAR) and the two satellites fly in close formation to collect SAR data of the Earth’s surface. Typically, the SAR images have a spatial resolution of 3 m in the ScanSAR mode, but in the Staring Spotlight mode the spatial resolution (pixel

size) can be 0.25 m x 0.8 m. By combining the data from the two satellites using the techniques of SAR interferometry [23], a global digital elevation model (DEM) can be produced with a vertical resolution of 2 m and a horizontal grid of 12 m x 12m. The next generation of German Earth observation satellites will be the Environmental Monitoring and Analysis Program (EnMAP). The EnMAP satellite [24] is a hyperspectral mission with 88 wavebands in the visible and near infrared parts of the electromagnetic spectrum and 154 wavebands in the shortwave infrared part of the electromagnetic spectrum. The spatial resolution will be 30 m.

Both the radar and the hyperspectral missions are "high grade" which has stimulated concern for whether the data produced could be sensitive and potentially misused. Under the SatDSiG, there is a detailed procedure to check whether a request for the dissemination of data is sensitive. These checks are to be undertaken by the data provider. The procedure is an algorithmic one that has a defined set of rules to check whether the Earth observation data are sensitive or not. The sensitivity check is performed with the metadata associated with the data and not an inspection of the data sets themselves. That is to say that the images are not checked for content but the sensitivity check concerns the overall characteristics of the data set. The SatDSiG Act pertains to primary data distributors but generally not to Earth observation service providers, value-adding firms or data re-sellers.

The sensitivity check is summarised in simple form in figure 1. The main characteristics of the sensitivity check are as follows.

FIGURE 1 ABOUT HERE

1. Whether the request comes from the German military.
2. Information content of the individual data product as specified by the operation mode of the sensor and the processing level. At different stages of the evaluation the spatial resolution limit is first 2.5 m and then later 1.2 m depending on other criteria. This part of the evaluation also includes whether the data are hyper-spectral and whether radar phase information is supplied.
3. The target area surveyed by the data is assessed as to whether the area belongs to a list of sensitive target areas.
4. The time period between data generation and supply to the customer. The time period criterion is five days.
5. Ground segments to which the data are to be transmitted as defined by a list of sensitive ground segments. Ground segments must be authenticated in Germany and adequately secured.
6. Individual customer, that is the source of the data request.

The sensitivity checks are performed automatically against these criteria. If the result of the check is "non-sensitive" then the data supplier is free to supply the data. If the result of the check is "sensitive" then a permit by the Office for Economic Affairs and Export Control (BAFA) is required. BAFA has the right to prohibit dissemination of the data or permit dissemination with certain conditions attached or permit dissemination with no conditions attached.

The target area negative list provided in Annex 3 to the SatDSiV was amended in 2014 [20]. Further changes on the SatDSiV can be anticipated. The SatDiSG was amended in April 2020, however only

with limited changes on the provisions dealing with foreign investment in entities licensed under the Act. The German government plans to adopt an overall national space legislation during the current legislative cycle. A draft is currently (year 2020) in inter-ministerial consultation and a summary document has been announced for public release, followed by an initial consultation round with industry stakeholders. While no details are available at the time of writing, it can be expected that the legislative process for the overall national space legislation will also lead to a review and likely amendments to the SatDiSG and the SatDSiV.

2.4 Japan

The applicable laws in Japan are the Space Basic Act (2008) [25, 26], the Act on Ensuring Appropriate Handling of Satellite Remote Sensing Data (2016) [27], the Regulation for Enforcement of the Act on Ensuring Appropriate Handling of Satellite Remote Sensing Data (2017) [28] and the Order for Enforcement of the Act on Ensuring Appropriate Handling of Satellite Remote Sensing Data (2017) [29]. Together with these legislative instruments, the Japanese authorities have also published Guidelines on Measures under the Act on Ensuring Appropriate Handling of Satellite Remote Sensing Data ("Guidelines") [30] and Application Manuals for the Act on Ensuring Appropriate Handling of Satellite Remote Sensing Data ("Application Manuals") [31]. In these legal instruments the term *satellite remote sensing* is synonymous with *Earth observation*. The competent authority in Japan is the Prime Minister, in practice the Cabinet Office.

On 16 November 2016 Japan adopted the the Act on Ensuring Appropriate Handling of Satellite Remote Sensing Data, the Satellite Remote Sensing Data Act [27]. The Act aims to ensure the appropriate handling of Satellite Remote Sensing Data in Japan, lists the responsibilities of the national government, establishes a licensing system for the use of satellite remote sensing data and provides a certification of a person handling satellite remote sensing data. For both licensing and certification, the scope is limited to activities undertaken on or from the Japanese territory. The Satellite Remote Sensing Data Act also specifies the obligations of a satellite remote sensing data holder, the supervision of the Act by the Prime Minister and other necessary matters concerning the handling of satellite remote sensing data.

The thresholds for the scope of the *licensing* regime on the use of remote sensing instruments refer to sensors "capable of discerning the movement of vehicles, ships, aircraft and other moving facilities" [30]. The criteria use the term "Distinguishing Accuracy of Target". In general terminology in Earth observation this means the spatial resolution, although we note that the spatial resolution of an instrument is not a constant and varies with the state of the atmosphere and the contrast in the target area [32]. In this sense the term "Distinguishing Accuracy of Target" is more accurate.

- An optical sensor with a Distinguishing Accuracy of Target not exceeding 2 metres.
- A SAR sensor with Distinguishing Accuracy of Target not exceeding 3 metres.
- A hyperspectral sensor with Distinguishing Accuracy of Target not exceeding 10 metres and with the number of wavelength bands exceeding 49.
- A thermal infrared sensor with Distinguishing Accuracy of Target not exceeding 5 metres.

The licensing requirements for the use of satellite remote sensing instruments include measures to prevent persons other than the applicant from the use of the satellite remote sensing instrument; measures for the prevention of divulgence, loss or damage of satellite remote sensing data; and a

requirement to ensure that the use of the satellite remote sensing instrument does not cause adverse effects on ensuring peace in the international community.

The thresholds for the scope of the certification procedure for data handling refer to data where the use of information "is likely to cause adverse effect on ensuring the peace and security of the international community and the national security of Japan" [30]. For raw data the criteria are the same as those listed above for the licensing of instruments but with the addition of a time period of five years after data recording. For data which has been processed by radiometric or geometric correction the spatial resolution limits for optical data is 25 centimetres and for SAR data 24 centimetres [30].

The Enforcement Regulation and its associated Enforcement Order (both of 2017) specify the procedures to apply for a licence for the use of data and the certification of individuals to use the data.

As regards the dissemination of data falling under the scope of the Japanese data regulations, the Satellite Remote Sensing Data Act provides that a person possessing satellite remote sensing data shall not disseminate the data, except when

- Data are disseminated to persons holding a certificate for the handling of satellite remote sensing data in accordance with the procedures set forth in the Act.
- Data are disseminated to a person holding a licence to use the instruments through which the data are produced in accordance with the procedures set forth in the Act.
- Data are disseminated to a specified data handling organization (which is exempted from the certification requirement) in accordance with the procedures set forth in the Act.

The Enforcement Order gives a list of the Japanese government entities capable of performing an appropriate use of satellite remote sensing data without a licence or without a certificate. This list numbers over 32 organisations including a strong legal representation such as the Public Prosecutor's Office, the Supreme Court and the Ministry of Justice, a brief reference to application users in the Ministry of Agriculture, Forestry and Fisheries and the government organisations in Canada, France, Germany and the USA (incidentally the other four countries covered in this paper).

Finally, under the Regulations the Prime Minister may issue an order to a person possessing satellite remote sensing data, which is under the scope of the Act, prohibiting the provision of these data, designating the scope and the time period of the prohibition. Such an order may be issued only in the case that the Prime Minister believes on sufficient grounds that the use of the data is likely to cause an adverse effect on ensuring the peace of the international community.

2.5 United States

2.5.1 Public sector

The United States has a very mature foundation for its policy and legal approaches to Earth observation data regulation. The development of data policy has been carried out in close association with the development of legal instruments that define the ways in which Earth observation data from public sources are available. A key characteristic is that Earth observation has followed and implemented general government policies and laws that govern all federally-produced

data in the United States . The main public sector acts and policies relevant to Earth observation data regulation are listed below.

- Paperwork Reduction Act of 1980, updated in 1995 [33].
- Office of Management and Budget (OMB) Circular A-130 1985 (updated in 1994, 1996, 2000 and 2016) [34] implements the Paperwork Reduction Act in relation to US Federal data. OMB Circular A-130 states that that there are no restrictions and no copyright protection on data produced by the US Federal government and its agencies. OMB Circular A-130 has been the cornerstone of Earth observation data policy in the US for data from public sector missions since its introduction in 1985.
- US Data Quality Act 2001 [35] directs the Office of Management and Budget to issue government-wide guidelines that maximise the quality, objectivity, utility and integrity of data and information disseminated by Federal agencies.
- US Open Government Directive 2009 and US Open Data Policy 2013 [36]. This takes open data as a presumption for US public sector data. Government agencies must manage data and information as an asset throughout its life cycle to promote openness and interoperability.
- Space Policy Directive-2 2018 [37] which has as its objective the streamlining of regulations on the commercial use of space.

The list above shows the relevant general laws and regulations. In addition, there is the US Global Change Research Act of 1990 [38] which has policy statements on data management directly relevant to Earth observation because of the importance of Earth observation data in detecting and analysing global change. The statement covers full and open sharing of data, archiving policy, standards for data and the price of data.

While not a law, the US National Strategy for Earth Observations 2013 [39] adheres to the principle that access to data that are managed or paid for using Federal government funds should be open to the public as soon as possible after collection, in a non-discriminatory manner, and generally free of charge, although agencies may charge the cost of fulfilling a user request (COFUR) [40]. It is worth noting that in the US context Earth observations covers both satellite observations and *in situ* observations.

A particular case of Earth observation in US law is the Landsat series of missions. The Land Remote Sensing Commercialisation Act of 1984 [41], which was designed to commercialise Landsat, was repealed by the Land Remote Sensing Policy Act of 1992 [42]. The 1992 Act noted that the high cost of Landsat data had impeded the use of the data for scientific purposes and for other public sector applications, and declared that full commercialisation of the Landsat programme was not feasible in the (then) foreseeable future and thus should not serve as a near-term goal of US policy on land remote sensing.

The question of data pricing has been challenged several times since the 1970s in the course of the Landsat programme. In 2008, the US made a policy change to provide all Landsat data in archive free of charge over the internet. This resulted in a large increase in the number of orders for Landsat

data. In 2012 the Landsat Advisory Group (LAG) was asked to review Landsat data pricing policy. The LAG recommended that the data should remain free of charge over the internet and identified nine reasons for their decision including that a change to charging for data would contradict the relevant US laws as listed above in this paper. In 2018 the Landsat Advisory Group [43] was asked once again to consider new prospects for cost sharing of Landsat data to support the Sustainable Land Imaging model of the US Geological Survey. The conclusions were broadly the same as the 2012 review in that any charging for Landsat data would:

- Require substantial changes to existing US Federal government laws
- Generate little net revenue
- Result in negative economic impacts for the US commercial Earth observation sector
- Would not be worth the economic, legal, societal or political costs both in the US and internationally

2.5.2 Private sector

The applicable laws in the United States for private sector Earth observation missions are the Land Remote Sensing Policy Act of 1992 [42] and the regulations 15 CFR Part 960 – Licensing of Private Land Remote-Sensing Space Systems [44]. The competent authority is the National Oceanic and Atmospheric Administration (NOAA), a part of the US Department of Commerce, which liaises with the Department of Defense on national security, the Federal Aviation Administration as far as the instrument payload is concerned and other government departments as required. According to Section 202 of the Land Remote Sensing Policy Act of 1992, "[n]o person who is subject to the jurisdiction or control of the United States may, directly or through any subsidiary or affiliate, operate any private remote sensing space system without a license".

A key topic in the history of satellite Earth observation in the United States has been the spatial resolution limit that private sector operators have been allowed to use. The spatial resolution limit has been a political decision in the US, not a technical decision, and it has essentially been the driving force for the worldwide limits on spatial resolution because other countries have followed the US lead. In the US there has always been the balance between enabling the private sector to exploit technology to generate very high resolution images from space on the one hand and on the other hand to protect the national security interests of the US by not allowing the very highest spatial resolution that intelligence space systems can provide. Smith summarises the tensions as follows [45].

> A major rationale for regulation is that public availability of certain data could imperil US national security interests. The tug of war between the [Department of Commerce] interest in ensuring US industry can compete on a level playing field with foreign sources of such data and the national security community's concern about revealing information they do not want shared has complicated the commercial remote sensing satellite business for decades. Especially vexing to companies is that [the Department of Defense] can hold up a license application indefinitely, or reject it without explaining why or what the company could change to win approval.

An important event in the history of very high resolution Earth observation systems was the decision by President Clinton on 10 March 1994 [46] to allow commercial satellites to have a best spatial resolution of 1 m in order to increase US industrial competitiveness [47]. Since then the spatial

resolution limit has been lowered by the US government and in 2014 NOAA issued an updated licence that allowed DigitalGlobe (now owned by Maxar) to sell Earth observation images to all its customers at up to 0.25 m panchromatic and 1.0 m multispectral spatial resolution.

In 2018 President Trump published Space Policy Directive-2 [37] intended in part to streamline the regulations on the commercial use of space. Concerning the licensing of Earth observation systems (and the data they capture) section 3 of Space Policy Directive-2 mandates a review of the current regulations by the Secretary of Commerce, coordination with other US authorities on the matter and a legislative proposal by the Secretary of Commerce. NOAA subsequently issued a Notice of Public Rule-Making (NPRM) on Earth observation licensing regulations on 14 May 2019 [48]. The 2019 NPRM proposed a generic licence for most private sector satellite remote sensing activities and to apply a more robust process for activities of potential national security concern. The 2019 NPRM proposed a review process and a set of licence conditions based on potential risk, separating "high-risk" Earth observation systems from "low-risk" systems. NOAA received 27 public comments on the 2019 NPRM and concluded that the NPRM proposal would be "overly restrictive and a disincentive to operating in the United States" [49].

One year later in 2020 NOAA published a revised NPRM that has a new approach to licensing private sector satellite remote sensing systems [49]. The new approach envisages three tiers of licences where the central question is whether the characteristics of the proposed Earth observation system are similar to or better than the characteristics of non-US Earth observation systems. The rationale is that the US Department of Commerce can only regulate US systems and cannot regulate non-US systems; therefore any licence for a US system that has characteristics similar to a non-US system should not be restrictive because customers for Earth observation data with those characteristics can purchase the data from non-US sources which would not be helpful to US industry. Extracts from the three tiers of licences are quoted below from [49] because they give the rationale as well as the approach to regulation.

> **Tier 1**. If an applicant proposes a system that is capable only of producing unenhanced data substantially the same as unenhanced data available from sources not regulated by [the US Department of] Commerce, such as foreign sources, the system will be ''Tier 1,'' and [will] receive the bare minimum of conditions. This is because Commerce cannot prevent the harm that such systems might cause to national security, regardless of how strictly they are regulated, because substantially the same unenhanced data are available from sources outside Commerce's control.
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> **Tier 2**. If an applicant proposes a system that is capable of producing unenhanced data that are substantially the same as unenhanced data available from US sources only, the system will be ''Tier 2.'' As there is no foreign competition for that unenhanced data, a US licence restriction could be effective.
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> **Tier 3**. If an applicant proposes a system that is capable of producing unenhanced data that are substantially the same as no available unenhanced data - that is, if the applicant has no competitors, foreign or domestic – the system will be ''Tier 3,'' and more stringent controls logically may be applied.

A key characteristic of the 2020 NPRM is that the three tiers have no defined technical limits. All tiers depend on what non-US competitors are offering. Under the 2020 NPRM rules, the requirement to specify limitations on operational performance in each licence disappeared. The wording of the 2020 NPRM rules indicates that general resolution limits that private sector operators are allowed to use will not anymore be a standard license condition.

One element of the history of US Earth observation data regulation is shutter control. The regulation on the licensing of private remote sensing systems [44] has for some years allowed for shutter control. Under Regulation 15 CFR 960.1(c) the US government may restrict operations of commercial Earth observation systems in order to limit collection and/or dissemination of certain data and products to the US government or to US government-approved recipients. This restriction originated in 1997 with the Kyl–Bingaman Amendment [46, 47] which was put into force by the National Defense Authorization Act of 1997. The restriction prohibits US authorities from granting a licence for collecting or disseminating high resolution satellite imagery (originally only of Israel) at a higher resolution than available from other commercial sources. The practical effect at the time was a 2 m spatial resolution limit for images of Israel, but this has now been overtaken by US licence changes and non-US competition in satellite Earth observation technology. The 2020 NPRM issued by NOAA makes specific reference to the Kyl-Bingaman Amendment because of the non-US competition element. So far, the US government has never formally put shutter control into effect. However, after 9 September 2001, so-called cheque-book shutter control was implemented for high resolution images of Afghanistan from the Ikonos satellite. Instead of placing restrictions on the collection and distribution of these images, the US government bought exclusive rights to all Ikonos images of Afghanistan, making it impossible in practice for any other user to gain access to the images.

3. International law commitments

Non-governmental entities operating Earth observation systems and disseminating data generated thereby are not directly subject to obligations established under international law. However, the space activities of non-governmental entities are attributable to a State in terms of Article VI of the Outer Space Treaty [6] which provides that “States Parties to the Treaty shall bear international responsibility for national activities in outer space … whether such activities are carried on by governmental agencies or by non-governmental entities and for assuring that national activities are carried out in conformity with the provisions set forth in the present Treaty …”. To flow down obligations under international space law, Article VI requires “authorization and continuing supervision by the appropriate State.” A State typically ensures adherence to its obligation to authorize and continuously supervise the space activities of its non-governmental entities by establishing a licensing regime under national space legislation, setting licensing conditions under which non-governmental entities are required to act in conformity with a State’s obligations under international space law and to compensate the State in case it is held liable under Art. VII of the Outer Space Treaty. In this regard, typical features of national space legislation are:

- certain information and notification requirements ensuring that a State is in a position to adhere to its obligation under Article VIII of the Outer Space Treaty to register space objects and to its obligation to have due regard to the corresponding interests of other States under Article IX of the Outer Space Treaty;

- operational requirements on space debris mitigation ensuring conformity with Article IX of the Outer Space Treaty and international standards and guidelines on the matter;
- recourse clauses together with mandatory insurance requirements.

As for Earth observation missions, data sharing obligations under customary international law codified in the UN Remote Sensing Principles or as part of initiatives such as GEOS, UN-Spider or the Disaster Charter may further come into play.

Four out of the five jurisdictions reviewed in this paper, i.e. Canada, Germany, Japan and the United States, have ensured authorization and continuous supervision of national space activities carried on by non-governmental entities by establishing a licensing framework. In France, the use of a payload for the collection of Earth observation data and their subsequent dissemination is not subject to a formal licensing procedure, but only to prior notification. Conformity with the requirement to authorize and continuously supervise French Earth observation missions is rather ensured through a (prior) authorization to proceed with the launch and the (prior) authorization to command the satellite in orbit.

A closer look at the licensing regimes for Earth observation in Canada, Germany, Japan and the United States shows that these frameworks are mainly driven by national security concerns in relation to the collection and dissemination of Earth observation data. They only partially address matters in relation to flowing down international space law to private operators. This is largely restricted to the UN Remote Sensing Principles [11] by establishing certain governmental access rights and/or data sharing obligations. As for the implementation of other obligations, there are few references to any obligations under international space law except for the general requirements :

- to ensure international peace and security (Japan);
- to act in conformity with international obligations (US);
- on the disposal of the system (US).

However, three out of the four countries reviewed in this paper have licensing regimes for the launch and in-orbit operations of Earth observation satellites which do more comprehensively address international space law. In France, a licensing procedure for the launch and in-orbit operations is established under the 2008 Space Operations Act. In Japan, obligations under the UN Space Treaties are applied to non-governmental entities through the licensing procedures under the 2016 Space Activities Act. In the US, the licensing procedures under the Federal Aviation Administration and the Federal Communications Commission legal framework may become relevant for the launch and in-orbit operations of Earth observation satellites, in addition to the NOAA/NESDIS licensing procedure. Only Germany has currently no general national space legislation on private space activities.

4. Trends in Earth observation regulation and legislation

As section 2 of this paper illustrates there is an inter-weaving of national regulations that concern satellite Earth observation missions and the data that are created by them. This is not a surprise as the instrument collecting the data would not operate without a platform in space and would not create the data that are subject to any regulation. The regulations described above reflect this duality to a greater or lesser extent. For example, even though Germany has a specific Satellite Data

Security Act (SatDSiG) the Act is tied closely with the radar and hyperspectral technology of the German Earth observation missions.

Even though the approaches by the five countries surveyed are different there are trends in Earth observation data regulation that can be identified and these are summarised below.

1. **Few countries**. Article VI of the Outer Space Treaty is the central provision that provides a clear requirement for States to address how satellite Earth observation data are regulated and how the private sector's Earth observation activities are monitored and controlled. So far only a few countries have established specific legislation regarding Earth observation and Earth observation data. In line with the general developments concerning national space law [48], it can be expected that more countries will adopt legislation in the near future: over 40 countries now have Earth observation systems and the trends towards commercialisation and privatisation have gained momentum in recent years.
2. **Commonalities**. Table 1 shows the regulatory spatial resolution and information content limits adopted by the five countries reviewed in this paper. These limits are defined in legislation and beyond which there are checks for sensitive data. It is clear that national legislation in one country affects that in another. There are no internationally agreed limits but there are international pressures connected to competitiveness.

TABLE 1 ABOUT HERE

3. **Technology developments**. The thresholds defined concerning spatial resolution have been lowered over time, with the United States setting the scene which other countries typically follow. Radar, lidar, hyperspectral sensors and space video systems are encouraging a greater concern for Earth observation legislation to allow clarity over data access. The complexity of the physical Earth observation instruments may lead to greater complexity of the legal regulatory instruments. The higher revisit time of some new systems, for example the Planet constellation, may even provide an artificial intelligence method of gaining very high spatial resolution from medium to high resolution data by the very frequent sampling of ground locations: this would mean that it would not be instrument characteristics that were the focus of legislation but the resultant derived data products. These developments, coupled with the increasing number of commercial stakeholders covering a broad range of system design, operations and business approaches, complicate the general approach and practical handling of regulations and licensing processes. The US 2020 NPRM rules are the first national regulations aiming to cope with these new challenges by focussing on international comparisons: other States may well follow suit.
4. **Commercial pressure**. While the Earth observation data regulations reviewed in this paper are national in character, international commercial considerations are a continuing dimension. Because typically Earth observation missions are global in character, and under the UN Remote Sensing Principles all States can observe all other States from space, then the opportunities to collect and sell Earth observation data are not limited to specific nations. This means that, particularly in the US, there has been pressure from the private sector to develop laws and regulations that do not hinder international competition, especially for very high resolution data.

   With the accelerated investment in commercial space activities, a marked increase in the number of commercial actors, much lower costs of satellite manufacturing and launching and a rise in commercial applications, legislators and regulatory agencies are strongly pushed towards

a more liberal, supportive regime and practice. The domain reserved for military and intelligence systems is narrowing to the most cutting-edge sensor technologies and the relevant actors will increasingly rely on the data and services delivered by the commercial sector.

5. **Legislative review**. All countries with Earth observation legislation review their legislation and regulatory practice from time to time. Canada is a case in point where a formal, independent review is built into the Remote Sensing Space Systems Act. In Germany, technical thresholds as well as sensitivity check criteria are regularly reviewed. Such reviews normally consider technology advancement, the developments in global markets, lessons learned and national security, defense and foreign policy developments.

5. Conclusions

The legal approaches taken by the five countries reviewed in this paper are highly variable, both in their procedural approach and in the emphasis given within governments. Table 2 presents the lead government department responsible for developing the Earth observation data regulations in each of the five countries plus the names of the supporting government departments. The variability can be in part explained by the differences in national approaches to legislation. As De Man [48] comments in the introduction to his paper on space law:

> "We are currently witnessing firsthand the evolution of the international space law framework from an ambitious set of general principles agreed to at the intergovernmental level at global forums, to a patchwork of national laws and policies navigating around an almost equally diverse set of informal, non-binding instruments of international origin."

This is a useful statement of a process which is happening at present. States have agreed general statements such as the UN Outer Space Treaty and the UN Remote Sensing Principles but when it comes to specifics the implementations are variable. International competition to launch more capable sensors produces a certain levelling of Earth observation sensor capability by different nations and a levelling of the issues addressed in the subsequent regulations. But nations have their own internal pressures on legislation and regulation that results in specific approaches to what are common problems. As more nations create their own Earth observation regulations then there is likely to be both internal tensions and tensions with international agreements.

TABLE 2 ABOUT HERE

It is difficult to discern common themes from table 2, with the exception that the subject of defence and national security is present somewhere in all countries, including in Japan where the Prime Minister has a central responsibility for national security in any event. Germany refers to "high grade" data to accommodate high spatial resolution, high spectral resolution and the exploitation of a large part of the electromagnetic spectrum. All these developments have implications for defence and national security because of the new information that can be collected from space. Associated with defence and national security is a major concern in the legislation for international relations, foreign affairs and the peaceful co-existence of nations. All of this points to a common concern for the security of the State that may be challenged by new Earth observation data. One way that defence and national security issues are considered within data regulations is by implementing a

sensitivity check. Germany is the clearest case with its SatDSiG law. The implementation of the law is by an algorithm that assesses the metadata and not the data sets themselves and this aids the implementation of the law.

As more countries gain their own Earth observation capability, commercialisation is a common theme. As this review of national Earth observation data regulations shows, there will always be a balance between commercial exploitation of Earth observation data and the national security and intelligence applications of the data. The leadership of the United States over the years is instructive: what may have been classified sensor capability and resultant data in (say) 1990 is now commonplace in the commercial domain and the data is available for all users in all countries. The 2020 US NPRM [44] sums it up well:

> "The pace of foreign competition has intensified, and [the Department of] Commerce anticipates that these trends will continue. Now, any U.S. company with a license restriction is at a disadvantage if a foreign competitor is not subject to the same restriction, all else being equal. The end result is that US operators may not meet, let alone surpass, the capabilities of such foreign competitors."

Recent technology and market developments in Earth observation challenge national regulation of Earth observation systems and data generated by them. As this review of national Earth observation data regulations has shown, past and current regulatory approaches tried to establish a complex but rather stable balance between policies fostering commercial space activities and national security, defence and foreign policy interests and concerns. Over the decades, only a few countries allowed private Earth observation systems to emerge and national regulation was tailor-made to the national private operator and its specific system capabilities. Relaxing regulatory boundaries was a slow process and focussed on the relaxation of sensor and data quality thresholds. As countries seek to maintain and strengthen the competitiveness of their national industry, to stimulate new companies and to create jobs, individual countries may use regulatory frameworks to gain advantages. This will result in more individual and less aligned approaches. As high-quality commercial data with new characteristics enters the international market, other relevant countries will be pushed to adapt their own regulations. As the focus on competitiveness grows, so will divergence of national policies and regulations in the interpretation of and compliance with existing international agreements. As high-quality commercial data with new characteristics enters the international market, other relevant countries will be pushed to adapt their own regulations.

It has been sixty years since the launch of the first weather satellite. In that time the technology of Earth observation has developed rapidly. We are now seeing the development of laws and regulations that govern the data produced by Earth observation satellites.

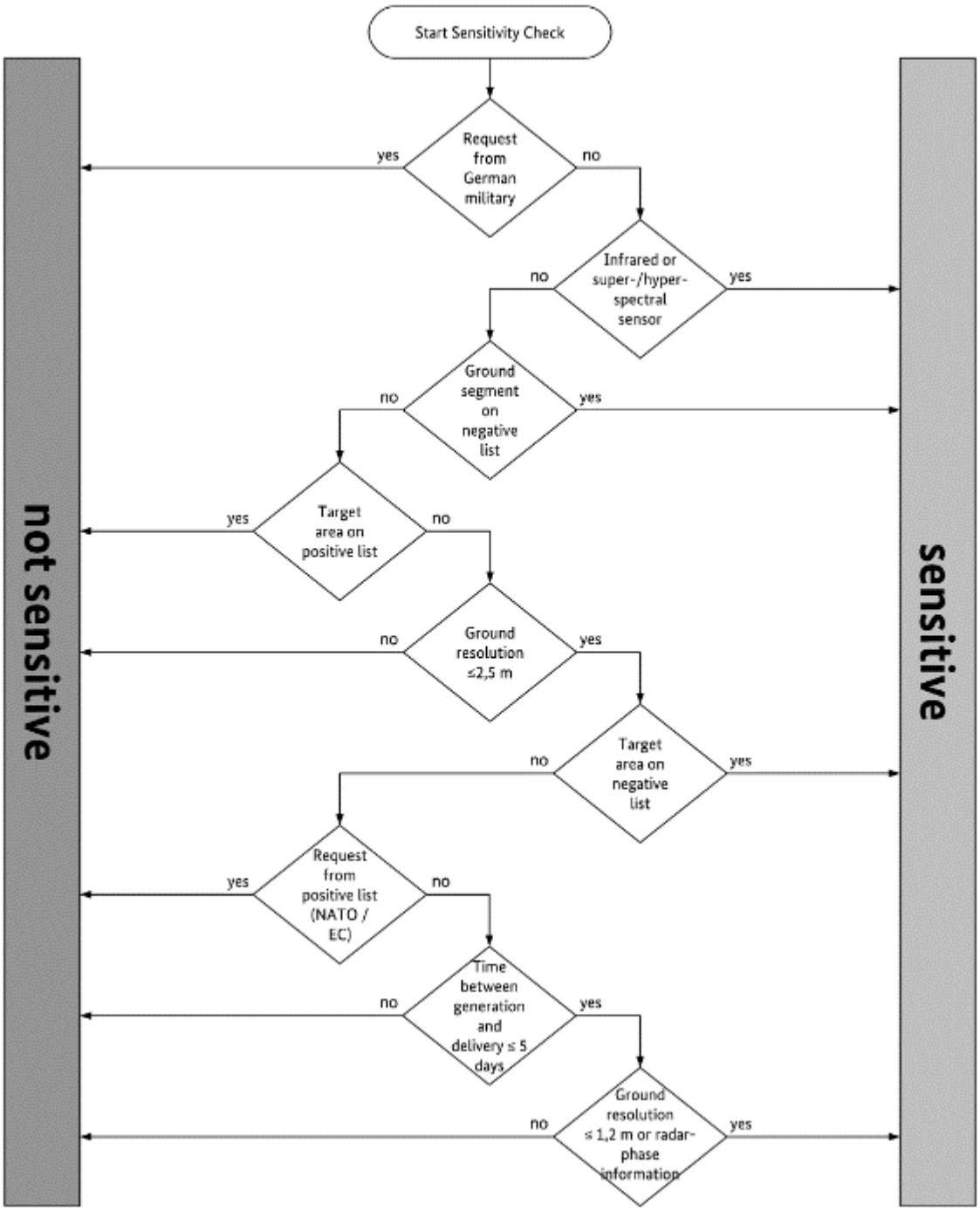

Figure 1. The sensitivity check of the German Satellite Data Security Act SatDSiG. Adapted from [19] and [20].

	Canada	France	Germany	Japan	USA
General spatial resolution limit					0.25 m
All types of sensors			<= 2.5 m		
Panchromatic optical sensors		<= 2 m			
Multispectral optical sensors		<= 8m or >= 10 spectral bands			
Stereoscopic optical sensors		<= 10 m			
Hyperspectral sensors			<= 10 m	<= 10 m	
Infrared sensors		<= 5 m	<= 5 m	<= 5 m	
Microwave sensors			<= 3 m		
Radar sensors		< 3 m		<= 3 m	
Data with intrinsic location accuracy		< 10 m			

Table 1. Spatial resolution and information content limits declared in national Earth observation regulations.

Country	Lead government department	Supporting departments and agencies
Canada	Foreign Affairs	Defense Industry Public Safety Space agency
France	Defence and National Security	Inter-ministerial committee
Germany	Economic Affairs and Energy	Defence Foreign Affairs Information Security Interior
Japan	Prime Minister (Cabinet Office)	
USA	Commerce	Defense Federal Aviation Administration

Table 2. Lead and supporting government departments involved in Earth observation data regulation

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