Legal and Regulatory Considerations of Small Satellite Projects

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Engineering constraints and technological hurdles are not the only obstacles to the successful completion of a small satellite project. You must also understand the legal and regulatory responsibilities and requirements from the outset.

Consider a situation where your small satellite is integrated as a secondary payload and is already on the launch pad. Your country's foreign ministry suddenly contacts you and orders you to halt the launch, as the government is unwilling to accept any potential international governmental responsibility for your operations. It turns out that the government lacks national legislation regulating space activities, but has ratified a number of international treaties related to outer space. Additionally, its radio frequency administrator has not granted you a radio license or notified other nations of your intended use of certain frequencies, and radio interference is likely. Despite being ready to launch, your satellite project will likely be halted until you clarify and resolve these issues.

This chapter outlines the legal and regulatory issues impacting small satellite missions, and offers a process to handle them as they arise during the different phases of your project. Section 5.1 is an overview of the entire legal and regulatory landscape, introducing laws from a variety of sources—including international space law, national legislation, contracts between partners, insurance policies, and the international and national regimes for radio frequency coordination. These work together, forming a framework of laws and regulations that must be understood and anticipated when preparing and executing a small satellite project. The following sections further explain the international and national legal issues for space activities, including contractual arrangements between industrial partners, insurance concerns, and space debris mitigation. Later sections address the equally important issue of international and national radio frequency coordination.

5.1 Overview of the Legal and Regulatory Framework

States balance their right to explore and utilize space with the restrictions set out in internationally agreed-upon legislation. Advanced space hardware and technologies can be used for both military and civilian purposes, and international legislation at the highest levels between sovereign states regulates the use of such high-tech “dual-use” technology.

Legally binding international treaties declare that states are responsible for their space activities and for the international registration of their space objects, and must accept liability for damages they cause. International space law also requires that each state ensure that their national space activities be conducted in accordance with international law, even when these national activities are conducted by non-state actors such as corporations, institutions, universities, and amateurs. Consequently, national governments are keenly interested in regulating, authorizing, licensing, and supervising all space activities that implicate their country on the international level.

National regulations addressing rights and responsibilities supplement this international legal framework. Domestic laws may cover licensing and authorization of domestic space activities, require waivers of claims between parties (which prohibit them from suing each other in case of accidents), or require insurance for all entities involved in space activities. Laws regulating the import, export, and use of advanced technology may also apply.

National regulations differ between states. Some lack national legislation specific to space, while others have a full framework of national space legislation in place. Managers of small satellite projects must understand the relevant national legal framework in addition to knowing the requirements of international space law. Their activities must comply with both national and international requirements.

While national space legislation directly regulates the licensing and authorization of domestic space activities, or requires industrial partners to enter reciprocal waivers of claims, a supplemental legal investigation should look at the business and contractual relations between partners. The insurance industry offers policies that mitigate the financial implications and risks of a project. An insurance policy for potential risks may be required by law before your satellite is integrated into a launch payload, and even if not legally required, it might be a shrewd risk mitigation strategy. This chapter discusses the space insurance market and space insurance policies, though insurance might not be necessary for every type of small satellite project, especially those with short operational lifetimes and small budgets.

International agreements cover more than just the launch of the satellite. Rules and guidelines also exist for the orderly allocation and use of radio frequencies. The usable portion of the electromagnetic spectrum for radio communications between satellites and ground stations is limited, so this finite natural resource must be used conscientiously and cooperatively. The International Telecommunication Union (ITU) has long regulated the global community's use of radio frequencies. Working with the national administrator for radio frequencies and other users requires advanced planning. You will need to examine

the master chart of used frequencies, find which ones are allocated and appropriate for your project, determine which defined services best match your project, and then work with the relevant authorities to secure your license and call sign. The process requires advance notice to the ITU and to other users, calculating the probability of interference, and finally, entering your license for a frequency on the master chart of used frequencies.

The scope of this chapter does not extend to more general legal advice (e.g., intellectual property, employee relations and administrative law, land use, and property law) but these should be included in planning and executing any project involving people and resources. Because your project will consume significant amounts of time and resources, you should also consult with experts familiar with the legal aspects of your project, especially space lawyers acquainted with export controls, space insurance, launch services agreements, national authorization, and frequency allocation from national administrators.

This chapter covers all of the legal issues relevant to planning, launching, and operating a satellite and explains how these laws affect your small satellite project. It will also walk you through the steps you need to ensure compliance with the law and other regulatory requirements. The chapter progresses thematically, from the larger dimension of international state-to-state relationships, through a discussion of the domestic sphere of national oversight and regulation, and down to the company-specific. Sections 5.6 and 5.7 return to the international level to explain international frequency coordination by the ITU, and how administrators on the national level implement this international regime.

5.1.1 Small Satellite Project Legal Checklist

Table 5-1 provides a process and checklist for space-specific legal and regulatory issues to track when planning and executing a small satellite project, along with the relevant sources of law, and tells which section discusses it in further detail.

Topic	*Question*	*Section*	*Sources of Law*
International Space Law	Which state is the launching state for your satellite? • Is there more than one launching state?	5.2.1	Outer Space Treaty (OST) Art. VII; Liability Convention Art. I
	Which state is the state of registry?	5.2.2	Registration Convention
	Which international treaties on space are binding on your launching state and state of registry?	5.2	Status of Outer Space Agreements (OOSA)
	Which national agency will inform the United Nations of your launch for registration? • What information do they require?	5.3.2	Different for each state; OOSA registry form
	Will you be adhering to the space debris mitigation guidelines? • Can you predict end-of-life circumstances? • Will the satellite burn up completely upon re-entry, or be placed into a "graveyard orbit"?	5.7	IADC space debris mitigation guidelines; COPUOS space debris guidelines
	Are foreign nationals or companies involved? Their state's international responsibility may be implicated.	5.2.1	OST Art. VI
National Space Law	Which supervising states have national space legislation or other laws applicable to your project?	5.3	OOSA National Space Law Database
	What does that national legislation require? • Insurance policies? • Waivers of claims between contracting parties?	5.3	National legislation, including national space legislation
	Are any components of your satellite subject to export control concerns, including the US export control regime?	5.3.4	National arms control/export control regime
Business and Contractual Concerns	What requirements does your launch provider impose? • Insurance? • Waivers of claims?	5.4	Launch services agreements and waivers of claims

Topic	*Question*	*Section*	*Sources of Law*
	Even if not required by national law, or from business partners like the launch provider, is it wise to get insurance? Is it affordable?	5.4	Your project plan and budget
Frequency Allocation and Coordination	What data will you be sending to and receiving from your satellite, and what frequencies are best suited for these transmissions?	5.6	ITU Radio Regulations
	What type of frequency license will you need? • Do you conform to the definition of amateur services/amateur-satellite services?	5.6	ITU Radio Regulations and Definitions
	Which frequency band type is appropriate for your project?	5.6	ITU Radio Regulations and Definitions
	How can a license be acquired for the designated satellite operator for the radio frequencies?	5.7	Specific to national regulatory administrator
	Where applicable: how do you coordinate frequencies with your national radio society/amateur satellite organization / IARU Satellite Advisor?	5.7	Specific to national regulatory administrator

TABLE 5-1. Checklist of Legal and Regulatory Concerns. (OOSA = Office for Outer Space Affairs; IADC = Inter-Agency Space Debris Coordination Committee; COPUOS = Committee on the Peaceful Uses of Outer Space; ITU = International Telecommunication Union; IARU = International Amateur Radio Union.)

5.2 International Space Law

Space activities were pioneered during the Cold War by technologically advanced countries for geopolitical purposes such as building international prestige and demonstrating technological superiority. In an effort to prevent the weaponization of space and to preserve space for peaceful purposes, the international community drafted various international treaties regulating outer space. These treaties establish each sovereign nation state as the responsible entity under space law. Consequently, we must briefly explain the international legal framework applicable to states, and then show how a small satellite project fits into a framework of state authorization, supervision, responsibility, potential liability, and international registration.

The most important source of space law is the 1967 Outer Space Treaty, which contains the foundation for the rights and obligations of states in their space activities. This short, six-page treaty warrants reading by anyone interested in pursuing space activities, and its principal features include the right to freely explore outer space, including the Moon and other celestial bodies, in accordance with international law. Balanced with this right to explore are the prohibitions on national appropriation and claims of sovereignty, and the prohibitions on placing nuclear weapons and other weapons of mass destruction into orbit or on celestial bodies. The treaty also includes such responsibilities as rendering assistance to astronauts and protecting the space environment.

The Outer Space Treaty establishes that nation states are the principal entities of international space law, both *responsible* for their national activities and potentially *liable* for any damage those space activities cause. In this context, responsibility means that states have the obligation to ensure that their national space activities adhere to all the requirements of international law, and that they are answerable for any violations of international law. Additionally, states are potentially liable under space law—meaning that they would be obliged to give compensation for any compensable damage. States are potentially liable for any and all compensable damage, regardless of whether that activity was prohibited by law.

For example, if a rocket launches from one state and then crashes into the territory of another state, the resulting physical damage will likely be compensable.

The regime established by the Outer Space Treaty, and expanded by the 1972 Liability Convention, allows space activity but requires a system for compensation. It is understood that space activities are inherently dangerous, and damage may occur regardless of whether a law was strictly broken or not. Because the Outer Space Treaty makes states the principal entities in space law, and responsible even for their non-governmental national space activities, states are "on the hook" for any and all of their national space activities. For a small satellite project, you must realize that these international obligations exist even in cases where private entities such as research institutions or private companies conduct the activity.

5.2.1 The Launching State

An important early investigation for your project involves determining which states are internationally responsible for the small satellite launch. This is especially relevant if your project has an international aspect. More than one state may be implicated, and the international rights and obligations of those states might be different. Achieving compliance with international space law requires determining who is the "launching state". According to the law, there may be more than one launching state.

Article VII of the Outer Space Treaty requires that "Each State Party that launches or procures the launching of an object into outer space, including the Moon and other celestial bodies, and each State Party from whose territory or facility an object is launched, is internationally liable for damage…"[19] Consequently, there are four categories of launching states:

- the state that launches
- the state that *procures* the launch
- the state from whose *territory* an object is launched
- the state from whose *facility* an object is launched

The first category applies to national space activities by national governments and space agencies. The subsequent categories concern state involvement in launching. Investigations are easier if the same state is implicated in each of these categories. However, if more than one state is implicated, each one is internationally responsible and potentially internationally liable under international space law, and their governments may be interested in regulating, supervising, licensing, and otherwise overseeing your satellite project.

In a small satellite project, the satellite might be integrated as a secondary payload into the launch of a larger satellite. That primary payload might be a large commercial telecommunications satellite from a company headquartered in Europe, but launched from Kazakhstan, French Guyana, or another country. Meanwhile, your small satellite project might be situated in North America. Which is the launching state? The country the rocket physically launches from? The European headquarters of the primary purchaser of the launch? Multinational launches make determining the launching state more complex. More than one state may fit the definition. Additionally, it's unlikely that either of these first two countries would be willing to take on the potential liability associated with your satellite project, headquartered elsewhere, and less connected with their state's national activities.

You must investigate which states are implicated in the launch of your satellite. Small satellite projects need to obtain authorization from at least one state, and possibly several. The following questions need to be answered to determine which state or states may want to regulate your project:

- Which (if any) national governments or agencies are involved in the project?
- Which (if any) states are funding the project, purchasing the launch, or otherwise financially involved?
- From which state's territory will you be launching? Is it from a facility owned or operated by a separate state?
- Are any citizens from foreign countries working in your project (even as contractors or subcontractors)?

On a related note, Article VI of the Outer Space Treaty declares that while states are internationally responsible for national activities in outer space, these national activities may be the activities of a national space agency or related governmental institution, or the actions of an international organization that the state is a member of, or they may be the activities of private entities. National activities may even be the activities of a citizen working on a space project abroad. Consequently, in addition to determining the launching states, if you have foreign nationals engaged in your project, you need to find out if their home state is implicated merely by their participation.

Under space law, because their international responsibility and potential liability are implicated, states are motivated to actively regulate and supervise. When making decisions on your launch contract, you should also consider which state or states would be interested in regulating your project as part of their national activities. The good news is that because small satellites can be hosted as secondary payloads on larger launches, the other entities involved in your launch will be concerned with many of these same questions. When coordinating with launch partners, you should discuss the issue of which are the launching states. When you find and coordinate with your launch service provider, be assured that they also will be concerned with these complex issues.

Once the launching states question is answered, it is wise to investigate what international space treaties these states are party to (e.g., the 1967 Outer Space Treaty19, the 1972 Liability Convention2, and the 1975 Registration Convention3). Determining the launching states will show which ones have what international responsibilities under international space law. Chief among these is international registration.

5.2.2 International Registration

International space law encourages states to register their space objects on international registries as a way of notifying the global community of their space activities, and to track which space objects belong to whom. On the international level, the United Nations Office for Outer Space Affairs (OOSA) maintains a registry of space objects based on information voluntarily supplied to the UN by its member states.[23]

There are various sources of law for international registration. While the 1967 Outer Space Treaty only speaks of national registries,[19] an earlier United Nations General Assembly Resolution from 1961 recommends that states register their space objects with the UN as part of an international registry,[20]and the 1975 Registration Convention makes that international registration mandatory for states that are party to that convention.[3] Consequently, OOSA maintains two separate (though nearly identical) international registries: one for voluntary compliance with the 1961 Resolution (1721 B), and one under the 1975 Registration Convention. A state that is a party to the United Nations is encouraged to comply with the 1961 Resolution. If it is also party to the 1975 Registration Convention, then international registration with OOSA is mandatory.

For this aspect of international compliance, your satellite project must determine whether the relevant, responsible states are parties to the 1975 Registration Convention. By 2014, 60 states were parties to it, while four additional states have signed but are not yet parties (Burundi, Iran, Nicaragua, and Singapore), and two international organizations (ESA—the European Space Agency, and EUMETSAT—the European Organisation for the Exploitation of Meteorological Satellites) have declared their acceptance of its rights and obligations.[25] Consequently, international registration is likely to be mandatory.

Registration with the UN is usually done after launch, and according to a state's registration practices and their frequency of sending notifications to the UN. The information listed with the UN about a space object is usually its launch information and other basic data. Figure 5-1 shows the application form for UN information registering with data needed.

FIGURE 5-1. Registration Information Submission Form. Part A is required for new small satellites. The form is available in the 6 official UN languages.[23]

Part A: Information provided in conformity with the Registration Convention or General Assembly resolution 1721 B (XVI)		
New registration of space object	Yes ☐	Check box
Additional information for previously registered space object (see below for reference sources)	**Submitted under the Convention: ST/SG/SER.E/** _____ **Submitted under resolution 1721B: A/AC.105/INF.** _____	UN document number in which previous registration data was distributed to Member States
Launching State/States/international intergovernmental organization		
State of registry or international intergovernmental organization		Under the Registration Convention, only one State of registry can exist for a space object. Please see annex.
Other launching States (where applicable. Please see attached notes.)		
Designator		
Name		
COSPAR international designator (see below for reference sources)		
National designator/registration number as used by State of registry		
Date and territory or location of launch		
Date of launch (hours, minutes, seconds optional)	dd/mm/yyyy hrs min sec	Coordinated Universal Time (UTC)
Territory or location of launch (see below for reference sources)		
Basic orbital parameters		
Nodal period		minutes
Inclination		degrees
Apogee		kilometres
Perigee		kilometres
General function		
General function of space object (if more space is required, please include text in a separate MSWord document)		
Change of status		
Date of decay/reentry/deorbit (hours, minutes, seconds optional)	dd/mm/yyyy hrs min sec	Coordinated Universal Time (UTC)
Sources of information		
UN registration documents	http://www.unoosa.org/oosa/SORegister/docsstatidx.html	
COSPAR international designators	http://nssdc.gsfc.nasa.gov/spacewarn/	
Global launch locations	http://www.unoosa.org/oosa/SORegister/resources.html	
Online Index of Objects Launched into Outer Space	http://www.unoosa.org/oosa/osoindex.html	

Part B: Additional information for use in the United Nations Register of Objects Launched into Outer Space, as recommended in General Assembly resolution 62/101			
Change of status in operations			
Date when space object is no longer functional (hours, minutes, seconds optional)	dd/mm/yyyy	hrs min sec	Coordinated Universal Time (UTC)
Date when space object is moved to a disposal orbit (hours, minutes, seconds optional)	dd/mm/yyyy	hrs min sec	Coordinated Universal Time (UTC)
Physical conditions when space object is moved to a disposal orbit (see COPUOS Space Debris Mitigation Guidelines)			
Basic orbital parameters			
Geostationary position (where applicable, planned/actual)			degrees East
Additional Information			
Website:			

Part C: Information relating to the change of supervision of a space object, as recommended in General Assembly resolution 62/101			
Change of supervision of the space object			
Date of change in supervision (hours, minutes, seconds optional)	dd/mm/yyyy	hrs min sec	Coordinated Universal Time (UTC)
Identity of the new owner or operator			
Change of orbital position			
Previous orbital position			degrees East
New orbital position			degrees East
Change of function of the space object			

Part D: Additional voluntary information for use in the United Nations Register of Objects Launched into Outer Space	
Basic information	
Space object owner or operator	
Launch vehicle	
Celestial body space object is orbiting (if not Earth, please specify)	
Other information (information that the State of registry may wish to furnish to the United Nations)	
Sources of information	
General Assembly resolution 62/101	http://www.unoosa.org/oosa/SORegister/resources.html
COPUOS Space Debris Mitigation Guidelines	http://www.unoosa.org/oosa/SORegister/resources.html
Texts of the Registration Convention and relevant resolutions	http://www.unoosa.org/oosa/SORegister/resources.html

International space law defines a "space object" in Article I of the Liability Convention, but lacks definitions for satellite, payload, launch vehicle, space debris, or other related terms.[2] According to space law, all launched objects are space objects, including your satellite. Even it is a secondary payload, it must be registered separately from the launch vehicle and other payloads.

Re-registration is also done if the object is sold or control over it is transferred, and if it de-orbits. States also notify the UN of decay rates, or when space objects become non-functional. It is important to note that there can be only one state of international registry, even if there is more than one launching state. Registration with the United Nations is free, and forms can be sent electronically and as hard copies via the registering state's Permanent Mission to the United Nations. For compliance with this international legal requirement, your small satellite project manager should consult the UN Register of Space Objects application form on the OOSA website to become familiar with its disclosure of information requirements.[23]

5.2.3 Remote Sensing

If your proposed small satellite project intends to do remote sensing of Earth and its regions, you should be aware of the political issues of remotely sensing foreign states. Article I of the Outer Space Treaty stipulates that states have the right to access space, to freely use and explore space for peaceful purposes, and to conduct scientific investigations. However, international law also embodies the idea that states are sovereign over their territory. So they may have issues with foreigners taking pictures of their territory from space—whether for scientific purposes, or with the intention of profiting from these remotely sensed regions, or for espionage. Some states have argued that they should be able to exercise prior consent to the sensing of their territory, or at least to the dissemination of remote sensing data about their territory.

Taking into account views of both remote-sensing and sensed states, the international community sought to develop norms to regulate this difficult issue. In 1986, COPUOS formulated the Principles Relating to the Remote Sensing of the Earth from Outer Space. These are in the form of a UN General Assembly Resolution, and contain a number of standards that might affect a remote sensing satellite project. Principle IV recognizes state freedom to explore outer space, but balances it with the "full and permanent sovereignty of all states and peoples over their own wealth and natural resources" and requires that space activities shall not be conducted in a manner "detrimental to the legitimate rights and interests of the sensed states." The effect of this provision is rather vague, but reflects the tension between sensing and sensed states.

Principle XII, however, requires that remote sensing data (primary and processed data) be made available to the sensed states on a "non-discriminatory basis and on reasonable cost terms," along with analyzed information concerning its territory.[21] While these principles contain vague and unquantifiable terms like "reasonable cost," and they take the form of a non-binding resolution rather than binding treaty law, if your satellite project intends to conduct remote sensing activities, then these principles may impact your use of the data and who has a right to access it.

5.3 National Space Law

Along with the international legal framework, national legislation is just as important. An understanding of the national legal framework for space activities is crucial, as is coordinating with the relevant national agencies charged with authorizing and supervising their national space activities—which includes small satellite projects. Many states have national space legislation and a sophisticated licensing and authorization regime. OOSA

keeps an online database of states with national space legislation, which you should consult early in your small satellite project.[24]

By 2014, 22 countries had enacted national space legislation: Argentina, Australia, Austria, Belgium, Brazil, Canada, Chile, China, France, Germany, Japan, Kazakhstan, the Netherlands, Norway, Republic of Korea, the Russian Federation, South Africa, Spain, Sweden, Ukraine, the United Kingdom, and the United States of America.[24] If any of these states are connected with your project (even if nationals from those states are abroad and working on your project), it is absolutely crucial to consult and review their national laws to see if they apply, and then to see what requirements for oversight, licensing, and supervision they mandate.

Alternatively, some states that would be concerned with regulating your small satellite project might not have enacted any national space legislation. This does not mean that your project must be halted, but that you will have to spend more time conducting research ("due diligence") to find out what regulations and laws from concerned states might affect your project. Sources of applicable law might be in the telecommunications regulations, laws regarding hazardous activities (in states you might physically launch from), or analogous laws in the existing aviation regime. If your launch provider or other industrial partners are from foreign states, their national legislation might apply. Additionally, keep in mind that the stipulations of international law, as discussed above, are also valid and applicable on the states implicated by your activities.

5.3.1 National Supervision and Control

As discussed above, when launching your small satellite from a country with national space legislation, or if you use that state's territories or facilities abroad, you need to investigate the

requirements of that nation's space legislation. This also holds if your launch is part of a launch procured by such a country, but launching elsewhere. In addition, if any of your personnel are from countries with national space legislation, your project might legally fall under the definition of "national activities."

Because states are internationally responsible, they are motivated to oversee launching, and only license and authorize launches that they consider appropriate, conforming to their interests, and that meet their requirements. Private industry helps foster innovation and economic activity, and many governments understand that it is desirable to have private industry involved in domestic space activity. States balance their desire to minimize their risks from space activity, with the lost opportunity of not allowing any space activity at all. To strike this balance, they exercise oversight and authorization over private activities, which allow launches but also minimize the risks.

Be aware that some nations argue that if the orbit of your small satellite cannot be controlled, it is not "active" enough to be a national space "activity," and thus does not fall under their remit for regulation. Under this interpretation, your satellite is seen merely as a projectile in orbit, and the government might refuse to acknowledge your in-orbit activities as sufficiently active to implicate their supervisory role. Both the Netherlands and Belgium have previously used this literal interpretation of the law in relation to their domestic small satellites, although both nations have since corrected their understanding of "space activities" as requiring "active" control.[15] It is better to consider national activities as both launching a space object into outer space, and the use, operation, or control of a satellite, probe, platform, space station, or any other space object. Operation and control means any basic control of the object, including telemetry, tracking, or control commands, and of course using such objects for satellite telecommunications, remote sensing, or other applications.[18]

Further issues might arise regarding the labeling of a state as a launching state under the "procuring" definition of a launching state. As explained above, a state is considered a launching state when it "procures the launching" of a space object. Some have suggested that this procurement must be done by the national government, and thus procurement of a foreign launch by a private entity (merely incorporated or headquartered in a state) would not give rise to that state being labeled the launching state under the "procurement" definition.

Indeed, for both the Netherlands and Belgium, a private procurement of a launch is not considered sufficiently relevant to implicate state liability, and those countries are unwilling to assume any international responsibility and liability in these circumstances.[15] This trend away from state oversight and responsibility for small satellite projects with foreign launch partners complicates your investigation. Consequently, reviewing the relevant national space legislation for its impact on your small satellite project is crucial, and includes determining who are the relevant states and governmental agencies that should be contacted for guidance. It is better to notify the government early on in the project than have them halt your launch in the final hours.

5.3.2 Launch Requirements

The launch is perhaps the most precarious phase in your project. While unpredictable events can happen during launch, laws exist to divide the risks from loss and damage among all the parties, making risk manageable and helping to assign responsibilities when accidents happen. Some states indemnify (promise to repay) private actors if and when accidents and damage happen. This indemnification is a promise, by the government, to cover damage caused by private industry's space activities and suffered by third parties, such as the uninvolved domestic public. Before they offer this indemnification, governments may require stringent safety measures, insurance policies, and waivers between parties.

In the USA, regulatory and licensing authority of commercial space launching is vested in the Department of Transportation's Federal Aviation Administration (FAA). The FAA has established the Office of Commercial Space Transportation (FAA/AST), which implements national space legislation for commercial launches. For such launches, the FAA conducts a significant safety review, and requires both insurance and waivers of claims before issuing a launch license.

For insurance, the FAA/AST requires launch services providers to secure insurance for their commercial launches, to cover losses from third party claims or governmental damages, up to $500 million USD or the maximum probable loss of their launch (whichever is less). The US government will indemnify third-party losses above $500 million USD, up to $1.5 billion USD.[26] The launch service provider also has to enter into reciprocal waivers of claims between itself and all industrial parties (including contractors and subcontractors), and ensure that they and all contractors and subcontractors enter into reciprocal waivers of claims among themselves, as well as with the US government.[26] Waivers of claims are legally binding agreements between parties, in which each party agrees that it will not bring claims for damages suffered. Should your small satellite project have the opportunity to launch with a US-licensed launch service provider, you will likely be a party to such reciprocal waivers of claims.

Similar governmental supervision, requirements for insurance, and possible partial indemnifications are all possible with other governments conducting oversight on your project. Additionally, if your satellite project is a remote sensing project, governmental agencies such as NOAA (National Oceanic and Atmospheric Administration) in the U.S. may wish to exercise some level of supervision and regulation.

5.3.3 National Registration

In addition to the international laws establishing and requiring international registration (discussed above in Section 5.3.2), the 1967 Outer Space Treaty confers to a state the powers of jurisdiction and control over space objects that appear on their national registry of space objects.[19] Because a space object might implicate a state's responsibility and liability, states may want to place that space object on their domestic registry to secure these jurisdictional powers. In addition to requiring international registration, the 1975 Registration Convention encourages states to establish national registries. A state must inform the UN of its national registry.

For domestic compliance, your project should determine if your satellite needs to be placed on a national registry. As of spring 2014, the following 24 countries have their own national registries of space objects: Argentina, Australia, Belarus, Belgium, Brazil, Canada, China, Czech Republic, France, Germany, Greece, India, Japan, Kazakhstan, Mexico, the Netherlands, Norway, Pakistan, Republic of Korea, Russia, South Africa, Spain, Ukraine, and the United States of America.[22] If these countries are involved in your activity (as described above), your satellite may need to appear on their registry. Beginning from the above list of national registries, investigate the applicable national registration practices, including which governmental authority maintains the national registry, their registration process, and what information they require. In the USA, the US Department of State maintains the national registry of space objects.

5.3.4 Export Controls

Space technology and hardware are considered dual-use technology. Advanced hardware and sophisticated technologies are useful for peaceful purposes such as disaster management, Earth observation, telecommunications, and space exploration. However, they can also be useful in warfare, in delivering explosives to distant territories, spying on enemy fortifications, and disrupting lines of communications. Advanced space technology created for peaceful and commercial uses can also be traded and sold between nations, and even analyzed and reproduced by states with less than peaceful intentions, or for the benefit of foreign manufacturers (who did not have to pay research and development costs). Consequently, a state has both political and economic reasons for protecting its nation's technological edge. To prevent foreign militaries or industries from gaining knowledge of advanced systems and technologies, many states restrict the exporting of their domestic space technologies, hardware, and intellectual property.

Controls on exports arise both from multilateral treaties and from unilateral acts by states in the form of domestic legislation. Multilateral treaties on export controls include the 1994 Wassenaar Arrangement among over 40 states, and the 1987 Missile Technology Control Regime (MTCR) between Canada, France, Germany, Italy, Japan, the UK, and the USA. The MTCR was augmented in 2002 by the Hague International Code of Conduct against Ballistic Missile Cooperation (HCOC), and any state may subscribe to the HCOC.

In addition to the multilateral treaties, various states have their own domestic legislation regulating the export of proscribed advanced technologies and hardware. Unlike the multilateral treaties, these domestic laws have enforcement provisions beyond mere political ramifications. For the sake of brevity, we detail here only the most stringent and noteworthy national export control regime.

Export Control in the United States of America

In the US, two agencies concurrently regulate exporting. The Arms Export Control Act authorizes the US Department of State to administer the International Traffic in Arms Regulations (ITAR), which cover items on the United States Munitions List (USML).[27] The Directorate of Defense Trade Controls, a specialized office within the Department of State, performs this task. On the other hand, the US Export Administration Act authorizes the Department of Commerce to administer the Export Administration Regulations, which cover items on the Commerce Control List. The Bureau of Industry and Security, an office within the Department of Commerce, performs this task. For large space and satellite programs, virtually all space-related technologies fall under the ITAR. The ITAR requires a license to export defense-related articles, and operates under a "presumption of denial" for applications to export. It defines a defense article as either:

- A physical object (e.g., a satellite or subcomponents, a launch vehicle, telemetry equipment for ground station) or
- Technical information relating to such an object (e.g., blueprints, photographs, instructions, software directly relating to the item)

According to the ITAR, "exporting" has an open-ended definition. Exporting includes "the sending [or] taking of a defense article (e.g., an item subject to ITAR) outside of the United States or a performance of a defensive service (whether or not in the United States) or the disclosure or transference of technical data to a foreign person (whether or not in the United States)."

There are many conceivable situations where ITAR might apply to a satellite project, especially where foreign nationals or foreign companies are involved. Because of this, special attention and heightened scrutiny should be the minimum preventative precautions taken when dealing with foreign nationals in the context of US-related dual-use technology. Become familiar with the USML, which regulates satellite technology under Category XV—

Spacecraft Systems and Associated Equipment, which includes satellites, ground stations, fuel, and support equipment for telemetry, tracking, and control.[26]

From 1999 until 2014, all satellites and space-related technology were placed under the USML by an act of Congress. Starting in 2012, the US Congress began steps to remove the blanket allocation, allowing the president to remove commercial satellites and components from the USML, and to decide which satellite technologies are the most important to protect. Currently, both the US Department of State and the US Department of Commerce are reviewing which items are defense articles to be kept on the USML, and which can be placed on the Commerce Control list. These efforts are intended to make the US domestic satellite industry more competitive by lessening the stringent export control regulations.[7] However, exporting satellites and even launching US satellites or US-built components from foreign launch sites may remain problematic.4 Replacing blanket and broad restrictions with a more nuanced regime will require more attention for compliance with the law. If your satellite project is based in or has significant contacts with the US or its citizens or technology, you should consider obtaining a Commodity Jurisdiction determination from the US Department of State's Directorate of Defense Trade Controls (DDTC). If the DDTC determines that your items or activities are subject to ITAR, you must register with them and begin the ITAR licensing process.

Small satellite projects might circumvent many of the stringencies of ITAR and the US munitions list by ensuring that their items and activities stay under the less burdensome Department of Commerce's Commerce Control List, which is under the Export Administration Regulations. Rather than defense items, this list includes commercial and dual-use items, such as electronics, computers, and telecommunications items that are only peripherally related to space activities. The satellite maker community has already explored using components from the mobile phone and entertainment industry and other commercial-off-the-shelf (COTS) components, and your project might consider doing the same.

5.4 Contractual and Operational Concerns

In addition to the international and national legal requirements, your project will encounter business and project-specific legalities, which exist on a contractual level between your project and its partners, like launch service providers, contractors, and subcontractors.

5.4.1 Launch Service Providers and Launch Service Agreements

Securing the launch service agreement is a major step for the small satellite project, and these agreements require significant disclosure about your payload and mission plans. They may also require a waiver of claims in case of catastrophic launch mishaps, especially if your payload is the secondary payload on a large launch.

According to the launch provider's launch services agreement, coverage for a launch vehicle failure may extend to a small satellite as secondary payload. However, each contractual arrangement for launch is different. It may significantly lower costs if your small satellite project enters into a waiver of claims with the launch provider, in which they would not be held accountable if the satellite is damaged or even destroyed. These situations, where all parties assume their own risks, make it easier for them to know how much they are putting themselves at risk. The small satellite project only puts at risk the complete loss of their satellite, and not the potential for hundreds of millions of dollars in damage to innocent bystanders. Launching is fully addressed in *"Chapter 7—All About Launching,"* along with the various types of insurance policies. We discuss them here briefly to show their implications across the entire life of the project.

5.4.2 Space Insurance

Insurance works in conjunction with waivers of claims as the best way of allocating risks to all the involved parties. As discussed in *Section 5.3.2*, a small satellite project may be required by national legislation to take out an insurance policy before the national regulatory

authority issues a launch license. Your launch services provider may also require insurance. However, even if not required, insurance may simply be a wise business decision on behalf of your project. Alternatively, it may be unaffordable or unnecessary for a purely amateur or scientific project. As with export controls, space insurance is a necessary consideration for larger satellites, and small satellite projects should be aware of this potential issue.

Depending on the size and cost of your project, it may be wise to approach an insurance broker who has experience in the space industry and who will be able to advise you on the need, advisability, and financial implications of securing insurance. However, if the project finds the cost of insurance too high, it may be unable to secure it. In this case, your project may choose to bear the entire risk of satellite failure or loss.

For larger commercial space projects like commercial satellite operators and earth observation companies, the insurance industry has long provided adequate space insurance, and these policies cover a number of possible events. They may cover a failed launch, or in-orbit failure, total or partial loss of the satellite, or merely loss or diminution of services (such as satellite telecommunications services) if a satellite is placed in the wrong orbit or with faulty, less-than-optimal equipment. Insurance may cover claims by third parties (those you are not in contractual relationships with, such as the uninvolved public) or by parties and firms that you are in contractual relations with, such as industrial business partners.

Insurance firms offering policies for the space industry are few in number. They include Germany's Munich Re, Switzerland's Swiss Re, Lloyds of London, XL Aerospace and the ACE Group, La Reunion Spatiale, SCOR, SpaceCo Group AGF, and Tokio Marine of Japan.13Launch providers for large satellites take out insurance policies to cover their launches—both for the launch vehicle and for potential damage caused. These insurance policies are generally required by their governments. Damage insurance is for damage to third party bystanders, and even for damage to government launch facilities. Launch providers minimize risk by planning their trajectories over unpopulated areas, and by incorporating flight termination systems.

In the USA, before the FAA authorizes a launch, commercial launch companies are required to have insurance or demonstrate financial capacity to cover up to $500 million USD or maximum probable loss, whichever is less (as discussed in Section 5.3.2). Provisions depend on the country, however. In Austria, the minimum level of space insurance required is €60 million, but the Ministry of Transport may grant a waiver or lower the insurance amount, as there is an exemption for space activities that are in the "public interest," which might be the case for amateur small satellite projects.1 In France, and indeed across Europe, laws crafted with large telecommunications constellations in mind require insurance policies of many millions of Euros. As with frequency coordination, insurance regimes created for large players may have to adapt to the burgeoning small satellite industry.

5.4.3 Policy Terms and Clauses

From the insurance company's perspective, a project has three phases: 1) manufacturing and pre-launch activities, 2) launch into space, and 3) in-orbit life. When satellite manufacturers and operators are separate parties, manufacturers usually take out policies during manufacturing and pre-launch, and operators take out policies during launch and in-orbit phases, each similar to property insurance policies.[11] *Figure 5-2* shows an expensive remote sensing satellite damaged during manufacture, illustrating the necessity of insurance to apportion risk to those best suited to bear it. Manufacturers may also have policies similar to product liability insurance for in-orbit operations, in case a satellite fails to perform as warranted to the operator. For the small satellite project, the manufacturer will probably be the same as the operator (e.g., a university), so less insurance is required, and policies would be similar to first-party property insurance for their satellite.

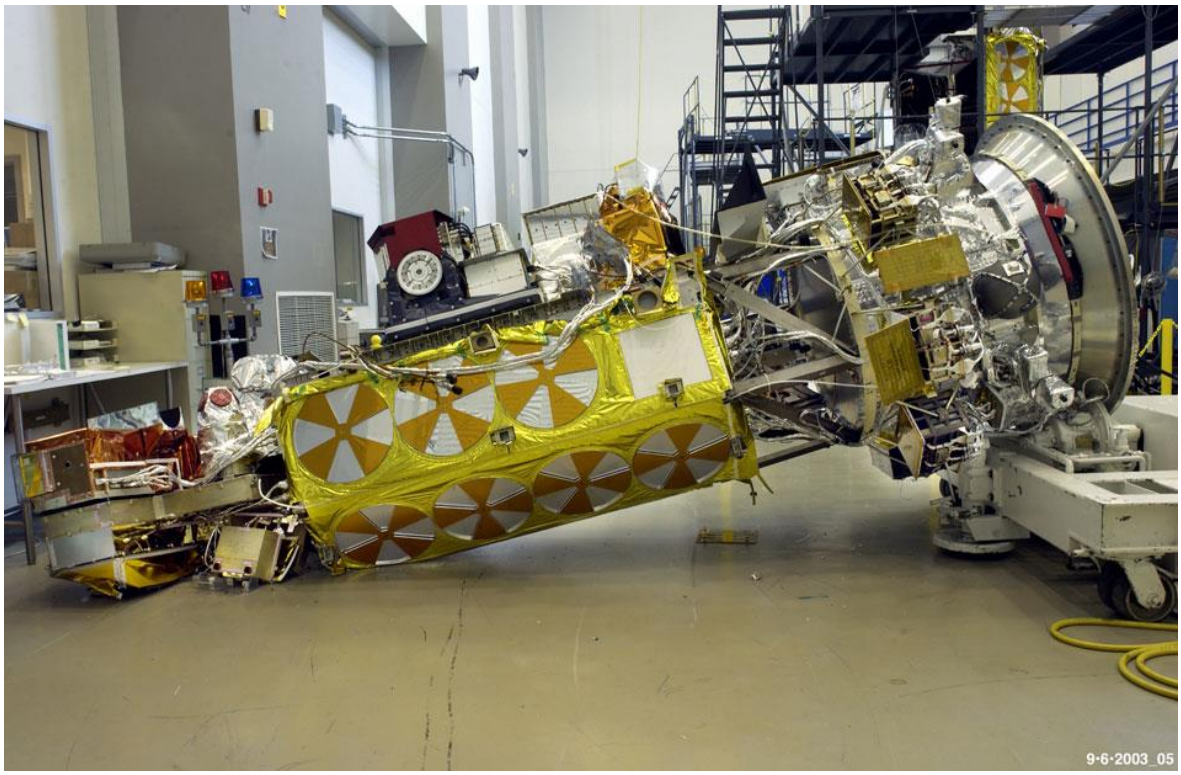

FIGURE 5-2. NOAA Satellite Damaged During Manufacture. The NOAA-N Prime satellite build for NASA, was damaged during testing in 2003 but subsequently repaired and launched. During manufacture, manufacturers can take out insurance for damage or loss. (Courtesy of NASA)

Legally speaking, the risk of loss has a time component, which concerns a period during which the legal and financial burden is borne by a certain party. The risk of loss changes during the life of a satellite, from its manufacture, to launch, and through operations and beyond. For a typical launch insurance policy, coverage begins at the moment of intentional ignition of the launch vehicle's engine. The risk of loss ends at the end of the stated policy period, which may be some time after operations have ended, upon the partial or total loss of the satellite, or when payments for partial loss are equal to the total value of the satellite, whichever happens first. During this entire policy period, the risk of loss is borne not by the insured (the owner or operator) but by the insurance company.

Insurance companies are required to pay for loss when the insured has satisfied all of the conditions stated in the insurance policy, such as when conditions meet the definition of partial loss, or total loss (depending on the policy). A number of related clauses affect that determination. First, a standard insurance clause requires that the insured cannot recover for

misrepresentations or concealments to the insurance company of any material or important facts about the satellite or of the policy. This requires careful observance of disclosure and information duties to the insurance company, and updating them of changes in the satellite—during pre-launch, launch, and in-orbit phases. Insurance policies are usually issued before launch and before the risk of loss "attaches" to the insurer, but the insurance company will want to be aware of any material changes during planning and building of the satellite, and during payload integration onto the launch vehicle. Should your satellite project take out insurance, be aware of the time periods mentioned in the contract, and of the language requiring disclosure of information to the insurance company.

5.4.4 In-orbit Issues

Once your satellite is in orbit, different legal and policy issues may arise. Most small satellites in orbit lack propulsion and cannot be maneuvered into different orbits or otherwise controlled beyond mere "station-keeping." As collisions and other "conjunction events" cannot be avoided (even when anticipated) by most small satellites, the risk from collisions exists, and is increasing as space becomes more congested. Small satellites lacking the ability to change their orbits are essentially ballistic, but their size and non-maneuverability does not mean that they are exempt from potential liability for damage to other actors in space.

International law makes no distinction between maneuverable and non-maneuverable space objects, and assigns a fault-based liability test between launching states of space objects which cause damage in outer space, and a strict liability test for damages on the Earth or in airspace. Strict liability does not require a showing of fault, but merely that the damage occurred. As such, the international responsibility and liability of your authorizing state is now implicated by the presences of your small satellite in outer space. If your satellite cannot be recovered or serviced, be aware of its potential for damage until safe re-entry into the atmosphere.

5.5 End-of-Life and Space Debris Mitigation

Space debris is a growing problem that is the responsibility of all who use space. Everything from a used rocket body upper stage to an errant screw or paint fleck can prove disastrous to a space mission. Due to their high velocities, even paint flecks can cause massive damage to space objects. On the international level, the creation of space debris is not legally prohibited, but in the spirit of cooperative and sustainable use of outer space it should be avoided. Several sources of laws and policies relate to the preservation of the outer space environment. On an international level, Article IX of the Outer Space Treaty requires that states pursuing activities in outer space shall avoid the harmful contamination of outer space, and shall adopt appropriate measures to prevent such contamination.19 While lacking precision, this requirement seems to prohibit the creation of space debris, or to at least take operational measures (that the state deems "appropriate") to prevent contamination.

In response to a growing awareness of the problem of space debris, the Inter-Agency Debris Coordination Committee (IADC) formulated a set of technical and precise guidelines to address the problem.[8] The IADC is a group of 14 space agencies and governmental bodies from around the world that pool knowledge and coordinate activities between agencies with an aim of identifying space debris mitigation options. The IADC's 2002 space mitigation guidelines (revised in 2007) recommend techniques and practices during the planning, design, launch, and operation phases of a mission.

The IADC guidelines provide agreed-upon technical definitions of terms and of protected regions and orbits, and define mitigation-related terms like passivation, de-orbit, re-orbit, and break-up. They recommend specific mitigation measures like limiting debris release during normal operations and minimizing the potential for in-orbit break-ups during operational phases, and resulting from stored energy, intentional destruction, or in-orbit collisions. For objects passing through low-Earth orbit (LEO) or ending their operational life there, the IADC guidelines recommend de-orbiting through direct re-entry, or re-orbiting with a

reduced lifetime. The IADC has found that 25 years is a reasonable and appropriate lifetime limit for post-operational spacecraft, and that in the event of reentry, resulting debris should be confined to uninhabited regions like broad ocean areas.[8]

In addition to the IADC Guidelines, in 2010 the United Nations Committee on the Peaceful Uses of Outer Space (COPUOS) promulgated official UN Space Debris Mitigation Guidelines.[17] These are more political and less technical and precise than those of the IADC. They apply to mission planning, design, manufacture, and operational phases (launch, mission, and disposal) of newly designed spacecraft and orbital stages. They stipulate that spacecraft should be designed not to release debris during normal operations, or at least that debris release should be minimized (Guideline 1). Spacecraft and launch vehicles should be designed to avoid failure modes that result in accidental spacecraft break-ups (Guideline 2). In developing mission designs and mission profiles, the possibility of accidental collisions should be estimated and limited, using both orbital data and in-orbit avoidance maneuvers (Guideline 3). Intentional destruction of spacecraft in orbit and launch stages should be avoided, along with other activities generating long-lived debris (Guideline 4).

As the passivation of spacecraft at the end of life is essential to prevent post-mission fragmentation and debris creation, on-board sources of energy should be depleted or made safe when no longer necessary for mission operations or post-mission disposal (Guideline 5). Spacecraft and launch vehicle stages in LEO should be removed from that orbit in a controlled fashion, either through re-entry or placement into higher orbits (Guideline 6). Lastly, geosynchronous Earth orbits (GEO) are similarly addressed, with spacecraft ending their operational lives outside of GEO in a so-called "graveyard" orbit (Guideline 7).[17] While these UN guidelines are not legally binding, their existence is at least evidence that states are aware of the problem of space debris and have been able to articulate a set of "best practices" for space debris mitigation. With significant state practice that conforms to these guidelines, their stature will grow.

Many national agencies have issued their own debris mitigation instructions and policies. With a few important and regrettable exceptions, it is safe to say that most actors in space are

both aware of the problem of space debris and conscientious in their actions to limit the creation and growth of space debris. You should be aware that creating space debris is not a sustainable use of outer space and bear this in mind with relation to your project. Just as frequency coordination requires collective participation and cooperation, halting the creation of more space debris requires that everyone active in space take steps to prevent the worsening of an already bad situation.

Most small satellite projects involve small spacecraft placed in low orbits, usually below 500 km. Consequently, these spacecraft's orbits decay within a few years, and certainly within the IADC's recommended 25-year maximum. Additionally, they are small enough that their re-entry completely destroys the spacecraft, with little chance of material making it to Earth to cause damage. In conjunction with national frequency coordination, states may require an assessment of the probability of debris and collision. NASA has made available its Debris Assessment Software, which project managers may find useful.[14]

5.6 International Frequency Allocation and Coordination

As well as determining the launching state and correct registration of your small satellite, frequency coordination is essential. Avoiding harmful interference is absolutely crucial to a small satellite project's success. The usable sections of the electromagnetic spectrum are limited, so a system to avoid interference and disruption of operations has long been necessary for all users of radio frequencies.

Radio frequencies, and even the use of Earth's geostationary orbit, are managed on an international level by the International Telecommunication Union (ITU), a specialized agency of the United Nations headquartered in Geneva, Switzerland. Tasked with ensuring the rational, equitable, efficient, and economical use of the radio frequency spectrum, the ITU has concerned itself with aiding the exploration and use of space through international coordination and frequency allocation since the beginning of the modern space age. The ITU

maintains the Master International Frequency Register (MIFR) of all frequencies notified to the ITU, which should be consulted before selecting a frequency for your small satellite project.

The ITU and regulatory authorities on radio frequency and spectrum management advise that space projects begin their frequency coordination process early, as determining which frequency a project will use ensures stable designs for transmitters, antennas, and receivers. This knowledge will save time and money across the life of the project. Project managers and engineers should consider what experiments and operations they will be running, what type of data transmissions this requires, and how data will be sent to the ground or uplinked to their satellites. Once they know this, they can consider what types of radiocommunication frequencies and services are suited to their needs. Because of the potential for conflicts or coordination problems, this process involves a large number of parties, and can be both lengthy and laborious.

5.6.1 The International Telecommunication Union (ITU) System

The applicable sources of law are the ITU Constitution, the ITU Convention, and the ITU Radio Regulations, which serve as the administrative regulations for satellite radio communication services. All three are intergovernmental treaties ratified by governments and are binding international law, ensuring that states domestically apply their provisions and adopt any appropriate national legislation to implement them. By 2013, 193 states had joined the ITU as member states, and 190 states are party to the ITU Constitution and Convention.[25] For the allocation of frequencies, the ITU divides the world into three administrative regions. Region one includes Europe, Africa, the former USSR, and Mongolia. Region two is the Americas and Greenland, and region three is the rest of Asia, Australasia, and the Pacific (See *Figure 5-3*). In recognition of the growing interest in small satellite projects, the ITU has begun looking at its regulatory regime and the long time scales needed for frequency coordination, and whether this long timeframe will not harm the small satellite community. However, as of 2014, this is the existing regime, and small satellite projects must understand how to proceed within this regulatory framework.

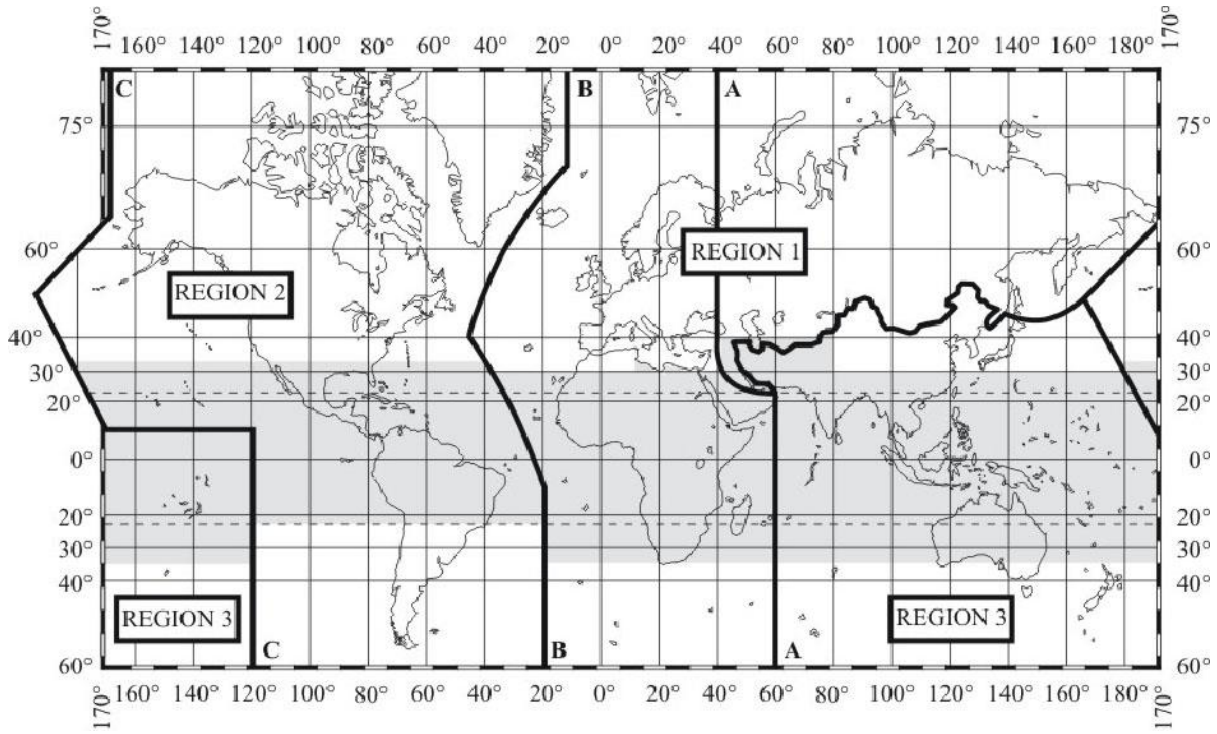

Figure 5-3. International Telecommunication Union (ITU) Regions. In its management of the usable spectrum, the ITU devidies the world into three large administrative regions. The lines A,B, and C divide the regions while the upper part of line A also divides between Europe and Euroasia inside Region 1. (Courtesy of ITU).

allocates these bands to over forty defined services. The spectrum is divided into bands with either exclusive allocations or shared allocations. Exclusive allocations are for applications with broad international usage, while shared portions of the spectrum can be allocated to one or more services (either on a regional or worldwide basis). Services in these shared bands can be either primary or secondary services.

Space activities comprise nine categories of satellite services under the ITU Radio Regulations: Fixed Satellite Services, Mobile Satellite Services, Broadcasting Satellite Services, Earth Exploration Services, Space Research Services, Space Operations Services, Radiodetermination Satellite Services, Inter-Satellite Services, and Amateur-Satellite Services.[10]

Users should note that the ITU system uses the terms allocation, allotment, and assignment in specific ways. The ITU allocates frequency to certain services, while it allots frequencies to specific geographic regions and areas, and assigns frequencies to certain users. Consequently,

certain portions of the spectrum are allocated to particular services, while a license holder can receive a frequency assignment.[10]

Primary and Secondary Services

Many portions of the spectrum coordinated by the ITU are devoted to specific services. There are primary services and secondary services of the use of the frequency bands. A primary service means that users of this portion of the spectrum enjoy rights superior to secondary services. The Radio Regulations mandate that secondary services shall:

- Not cause harmful interference to stations of primary services to which frequencies are already assigned or to which frequencies may be assigned at a later date *(Radio Regulations 5.29)*
- Cannot claim protection from harmful interference from stations of a primary service to which frequencies are already assigned or may be assigned at a later date *(Radio Regulations 5.30)*
- Can claim protection, however, from harmful interference from stations of the same or other secondary services to which frequencies may be assigned at a later date *(Radio Regulations 5.31)*[10]

Coordinating Procedure

The ITU has mandatory and voluntary regulatory procedures for frequency allocation, including coordination, planning, notification, and recording in the MIFR. To begin your investigation of appropriate frequencies and services, you should start with Article 5 of the Radio Regulations to see how the spectrum is divided up in the ITU Frequency Allocations (Article 5) table. There you can see which frequency bands are commonly allocated to small satellite systems, noting that 144–146 MHz is the only global primary amateur-satellite service frequency band, but that frequencies from 14 MHz all the way up to 10,500 MHz are used on a secondary status, and there are primary amateur-satellite service frequency bands up to 250 GHz used by amateur satellites.[12] The other amateur-satellite service bands are mostly with a secondary services status, and the ITU Radio Regulation footnote 5.282 is applicable:

> *In the bands 435 – 438 MHz, 1,260 – 1,270 MHz, 2,400 – 2,450 MHz, 3,400 – 3,410 MHz (in Regions 2 and 3 only) and 5,650 – 5,670 MHz, the amateur-satellite service may operate subject to not causing harmful interference to other services operating in accordance with the Table (see No. 5.43). Administrations authorizing such use shall ensure that any harmful interference caused by emissions from a station in the amateur-satellite service is immediately eliminated in accordance with the provisions of No. 25.11. The use of the bands 1,260 – 1,270 MHz and 5,650 – 5,670 MHz by the amateur-satellite service is limited to the Earth-to-space direction*. (Radio Regulations 5.282)[10]

Each country has its own notifying administration (usually the national telecommunication regulatory authority) that sends correspondence and submissions to the ITU. For example, in the USA, the Federal Communications Commission (FCC) is the frequency regulatory administrator. In the UK, it's the Office of Communications (Ofcom), while in Brazil, ANATEL (*Agência Nacional de Telecomunicações* / National Telecommunications Agency) serves as the national frequency regulatory administrator. Your project will not be working with the ITU directly, but through your national frequency regulatory administrator, so your small satellite project should determine which governmental entity this is.

You should first download the various Advance Publications of Information (API), coordination, and notification software tools from the ITU website. The software pack includes Space Capture Software (SpaceCap) for electronic form capture, Space Filing Validation Software (SpaceVal) for validating electronic forms, Space Data Query Software (SpaceQry) for querying and accessing the ITU's space radiocommunication station database, and Space Publication Software (SpacePub) for printing satellite and earth station data. This software is available from the ITU for free, and will allow you to easily determine your national frequency regulatory administrator.[16]

The process involves the satellite operator applying to the national administrator, and the national frequency regulatory administrator then determining what type of license is appropriate. The national administrator must consider other users, including foreign users within your region, as coordination is a multilateral and international process between frequency regulatory administrators. In considering each license, they take into account other national administrations whose assignments are likely to be affected, and coordinate with them and reach agreement. Administrators must also be able to calculate the potential for

interference by your proposed license. The steps are outlined in Article 9 of the ITU Radio Regulations and can be consulted for more detail, a simplified version for small satellites can be seen in *Figure 5-4*. The national frequency regulatory administrator must go through certain administrative steps before the satellite notification can be entered into the ITU's MIFR.

As a coordination procedure, they must give advance publication of information (API), then coordination in accordance with Article 9, and then the final entry into the MIFR (called "Notification").[10] Your project should determine early on which defined services best match your project.

ITU Defined Services

For a small satellite project, one of the four types of satellite services is most applicable. They are defined in the ITU Radio Regulations.

Commercial Services

A commercial license from your national administrator will likely not be appropriate for your small satellite project, as these licenses involve very costly application procedures, expensive yearly dues, and a long, multi-year application process. Commercial licenses are most appropriate for international corporations like commercial satellite telecommunications enterprises using entire constellations of satellites.

Amateur-Satellite Services

The ITU Radio Regulations define an amateur service as:

> *"A radio communication service for the purpose of self-training, intercommunication and technical investigations carried out by amateurs, that is, by duly authorized persons interested in radio technique solely with a personal aim and without pecuniary interest."(Radio Regulations 1.56)*

In conjunction with this, an amateur-satellite service is:

> *"A radio communication service using space stations on earth satellites for the same purposes as those of the amateur service." (Radio Regulations 1.57)*

If the project's mission plans are consistent with these definitions, then frequency coordination as an amateur-satellite service may be considerably easier. Amateur satellite projects are typically for educational or scientific purposes, but many small satellite projects may also be testing and demonstrating new technology. If this testing and demonstration has a pecuniary aspect, the project may not be an amateur-satellite service undertaking (strictly speaking, using the ITU definition). While many users of the project might be part of a not-for-profit undertaking, if the project is selling or allocating use of your satellite or data, then users have a financial interest in your project and amateur status might be impossible. Amateur-satellite users enjoy primary service or secondary services in some frequency bands, as described above.

Also note that transmission to and from the amateur satellite must be open and clear, meaning that technical descriptions of codes, emissions, and formats must be widely and publically available, and these technical descriptions must be adequate for any other licensed amateur radio operator to access your system. If your project conforms to the amateur-satellite service definition, consult Article 25 of the ITU Radio Regulations.[10]

Experimental Stations

If your planned small satellite project does not conform to the ITU definitions of an amateur satellite service, then the licensing done by the national administrator for radio frequency coordination will follow different lines. Your satellite project might conform to an experimental station, which the Radio Regulations define as

> *"A station utilizing radio waves in experiments with a view to the development of science or technique. This definition does not include amateur stations." (Radio Regulations 1.98)*

For the experimental station it's necessary to declare a specific radio communication service, and not the amateur-satellite service, allocated for the frequency band used by this experimental station. It should be noted that, unlike amateur-satellite services, which have restrictions on who qualifies as amateur, non-amateur-satellite services have no similar restrictions. Consequently, schools and corporations may be licensed. Likewise, there are no restrictions on financial interests and participant payments. However, a "cost recovery" fee

applies to this service filing with the ITU (with Advance Publication costing 570 Swiss francs (about $650 USD), and Notifications at 7,030 Swiss francs (about $8,030 USD)).

Additionally, specialized emissions and ciphered transmissions may be permitted, in distinction to the open access policy for amateur-satellite services, but the usage of the amateur-satellite bands is very restricted (subject of coordination agreement with the IARU). If your project has outside investors (which constitutes a "pecuniary interest") it may be practical to pursue this experimental license. Experimental stations have only secondary status and cannot communicate with amateur-satellite stations. Experimental services also cannot use the 144–146 MHz band, which is reserved for amateur services and amateur-satellite services. Doing so without International Amateur Radio Union (IARU) assistance and coordination would likely result in interference. See Article 27 of the Radio Regulations to investigate further.[10]

Industrial, Scientific, and Medical (ISM) Stations

The ISM bands are not normally applicable for telecommunication purposes, and usage of these bands for any satellite communication comes under No. 4.4 of the ITU Radio Regulations. ISM licenses offer no protection against harmful interference, so they are secondary services. The Radio Regulations define ISM applications of radio frequency energy as:

> *"Operation of equipment or appliances designed to generate and use locally radio frequency energy for industrial, scientific, medical, domestic or similar purposes, excluding applications in the field of telecommunications." (Radio Regulations 1.15)*

5.7 National Frequency Allocation and Coordination

Frequency allocation and coordination for your small satellite project come from your national administrator, which uses the above ITU definitions and concepts in implementing international rules. If the project and its members are operating from more than one country,

all countries have to be listed in the service area of the satellite project when sending a filing to the ITU (such as a ground station in Austria, but with data relayed from amateur partners in Canada). One single-country satellite project license must be decided beforehand, so that only one national regulatory administrator communicates with the ITU Radiocommunication Bureau. Additionally, all operators of all amateur-satellite earth stations (in each country) must have a proper amateur service license.

If the project is defined as amateur-satellite service by the ITU Radio Regulations, project managers should begin liaising with any local or national amateur radio societies, amateur satellite organizations, and with the satellite advisor of the International Amateur Radio Union (IARU). The IARU is an international union for the cooperation and coordination of radio frequencies allocated to amateurs, including those using amateur-satellite applications. The IARU has a Satellite Frequency Coordination division. The IARU Satellite Advisor can help in planning space telemetry, space telecommands, and operating frequencies. The IARU website has a list of national amateur radio societies. Amateur-satellite operators will receive a frequency coordination letter from the IARU, which they send to their national frequency regulatory administrator.[9]

For projects licensed under the US regime, you apply to the Federal Communications Commission. If the project falls under the amateur-satellite service license, you should submit their pre-launch notification not less than 30 days after the date of launch vehicle determination, but no later than 90 days before integrating the small satellite into the launch vehicle.[9]

In relation to successful pre-launch frequency coordination, it is possible that the national administrator for frequency coordination will require your project to show, before a frequency license is granted, that your project has performed an orbital debris assessment test, which includes your satellite's altitudes, what the probability is for collisions with other objects, and how and when your satellite will either de-orbit or be sent to a safe "graveyard" orbit (along with predicting what exactly will come down, and where). The parameters of your project will allow you to compute these risks using various software products, such as Debris Assessment Software (DAS) from NASA.[14]

The ITU Radio Regulations Article 25 and also the IARU operational guidelines require that you be able to turn off the space station's (the satellite's) transmitter immediately in case of interference. The requirement applies to both ground stations and to your satellite. The IARU guidelines also require that the turn-off signal be located on a separate telecommand receiver.

> *"Administrations authorizing space stations in the amateur-satellite service shall ensure that sufficient earth command stations are established before launch to ensure that any harmful interference caused by emissions from a station in the amateur-satellite service can be terminated immediately (see No. 22.1)." (Radio Regulations 25.11)*

Many national frequency regulatory administrators require you to file a notice to them following the launch, indicating the status of transmissions - declaring a date of "bringing into use the service." In the USA, the FCC requires the notice of commencement of transmissions no later than seven days after the expected commencement of transmission. Additionally, at the end of transmission, notification of such termination is required no later than three months after your project's transmissions have ended.[6] Similar requirements are very likely with other national administrators.

5.7.1 Licensed Operators

In order to operate your amateur satellite under your national regime, you must have an amateur radio operator license granted by your national administrator. To receive a license, the applicant must take an examination on radio and electronic theory, radio law, and operating practices. The USA has three classes of amateur-radio operator license (Technician, General License, and Amateur Extra) and other countries may also have divided license schemes.

In dealing with the national administration for amateur-radio operating licensing, the project manager should determine who is the project's amateur-satellite control operator—the person with the ability to both remove the satellite from the launch manifest, and to disable operations in space once the spacecraft is launched (for example, in case of interference). For projects under the experimental services, this is also the party that controls decisions about

mission design, objectives, construction, and additional functions. Along with frequency assignment and coordination, you should get a radio license well in advance of launch.

5.8Conclusion

This chapter on legal and regulatory issues has sought to give readers a high-level overview of the various sources of administrative, legal, and regulatory requirements that they must understand for successfully planning and executing a small satellite project. Rather than list every national frequency regulatory administrator and every national law regulating space activities, it has offered a broad outline of the different types of law. Progressing from the international legal framework for state responsibility and liability, implemented by national governments regulating national space activities, the relevant laws also include private contractual arrangements such as cross-waivers and insurance policies.

Existing alongside this framework are the international and national systems of spectrum and frequency regulations, with the ITU managing the spectrum by allocating frequencies to particular services, and allotting frequencies to particular regions and countries.

While the ITU is an international system, each member state takes the final step of assigning frequencies for domestic users. Lastly, end-of-life and space debris issues have been discussed in their own section.

Readers are encouraged to proactively engage with the topics discussed in this chapter throughout the life of their small satellite project, beginning at the early stages of planning, until the end of the project. As your project plans begin to develop, consult the checklist in Section 5.1.1 and make sure you are aware of and are addressing these legal and regulatory issues before they arise.

The space community is small, and many actors (including regulators) are enthusiastic about space and want to see your project succeed, so understanding the relevant rules and regulatory actors will help you along your way. As mentioned in the introduction, it may be beneficial for your project to consult with legal specialists with expertise in such areas as

space insurance and frequency allocation and coordination. Additionally, many in the small satellite community and amateur radio community can be consulted.

The following references should also be consulted as your small satellite project progresses from understanding the legal issues it will face to understanding how to comply with the legal and regulatory framework. The regulatory landscape is different for each project—depending on what it wants to do, where it is located, and who its partners are. The logistics of legal compliance require understanding the law and then proactively addressing its requirements, not just to satisfy governments and their regulators, but to ensure that your project is technically implementable, sustainable, safe, and ultimately successful.

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