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Annex 13 to Working Party 4A Chairman's Report

WORKING DOCUMENT ON DEVELOPING AN ITU-R SMALL SATELLITE HANDBOOK

Based on contributions 4A/183 and 4A/239, Working Party (WP) 4A have prepared this draft revision to Annex 14 of the WP 4A Chairman's Report (Document 4A/155) for the Small Satellite Handbook, following offline consultation as directed by the first Plenary session of WP4A. Annex 14 of document 155 contained only the skeleton of the handbook and all content to the various sections has been added from contributions 4A/183 and 4A/239 to this meeting. This text is shown as clean text in the attached document. Text shown with revision marks indicates changes during the informal consultations during the WP 4A meeting.

The attached updated document is proposed to remain as a working document towards Small Satellite Handbook. More contributions to further progress the work on this handbook is encouraged for the future meetings of WP 4A.

Editorially, in further work, use of recognized ITU terminology as defined in the ITU-R literature (e.g., Radio Regulations, ITU-R V-series Recommendations and/or Rec. ITU-R S.673) should be ensured to be used throughout this handbook.

Considering that this handbook is still at an early stage of development, it may be premature to consider liaison statement to other working parties including reply liaison statement to WP 5A in response to their liaison statement 4A/42 and to WP 7B in response to their liaison statement 4A/69. Consequently, no liaison statements are being proposed at this early stage.

Attachment: 1

ATTACHMENT

Draft Small Satellite Handbook

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Foreword

With the increasing maturity of satellite communication technology and satellite manufacturing technology, the development of low-Earth orbit and short-duration small satellites, known as nano- and pico- satellites and other similar short-duration mission satellites, has risen dramatically and the industry has experienced an unprecedented boom in growth. The development of traditional satellites is long and costly. Quite often it is the prerogative of national level entities or some commercial companies with significant market power and resources to develop, launch and operate these satellites. However, in the field of small satellites, the technical and capital barriers to entry are lower, and satellite development can be rapidly completed by ordinary enterprises or smaller administrations due to their lower cost, simpler design, flexible launching and payload-carrying configurations.

In view of the diverse application modes of small satellites, their inherent cost and development advantages, and the fact that this field is attracting new entrants that may lack knowledge of, or experience with, the International Telecommunication Union (ITU) and the ITU Radio Regulations (Edition of 2020) and procedures, this handbook provide an overview of key issues and information to actual and potential participants in the small satellite segment of the industry.

1 Introduction

The launch of the first artificial Earth "small" satellite, Sputnik 1, triggered the space race in 1957. In the decades that followed, there was the development of increasingly larger satellites in order to provide reliable services from space over extended periods of time. Since then, with the increasing demand of radio-frequency spectrum and satellite-orbit usages and sustained growth of technological breakthroughs and innovation of space communication along with the booming capabilities in satellite manufacturing, a dramatic rise in the development of small satellites and systems has been witnessed, especially over the last ten years. The small satellite industry is experiencing an era of unprecedented change.

The term "small satellite", including minisatellite, microsatellite, CubeSat, nanosatellite (nanosat), picosatellite (picosat), femtosatellite (femtosat) and others, is becoming increasingly common and widespread, even though there is currently no legal or regulatory definition of this term.

In the field of small satellites, the technical and capital barriers to entry are often low, and small satellite development can be more affordable and rapid for various entities (start-ups, universities, research institutions, etc.) due to their lower cost, simpler design, flexible launching requirements and modular payload configurations. The development of small satellites is an evolution in the overall satellite industry, which provides opportunities for greater and easier access to, and use of, space services by all countries.

Governments and private enterprises are developing small satellite projects to promote not only the traditional satellite applications in data communications, Earth exploration, space research, monitoring of ground environment including climate change and global warming, space environment monitoring, satellite navigation and positioning, education, agriculture, forestry, disaster recovery, scientific experiments, testing innovative technologies, national defence, but also the development of multi-satellite fleets (constellation) for the satellite internet access, and further enabling integration with 5G, the Internet of Things (IoT), smart cities, business intelligence, and many other areas in completing various difficult tasks in space. The vast range of possible diverse applications stems from a number of small satellite characteristics that can be summarised as follows:

– Rapid build/launch cycle,
– Affordable projects with low capital investment and operating costs,

– Modular and standardized design (e.g. CubeSats standard),
– Lower latency due to lower orbits,
– Seamless coverage to all areas of the world when used in LEO constellations,
– Easy to expand, update, renew, augment and replenish the satellite fleet.

In recent years, small satellites have been steadily launched, which gradually proved the feasibility of small satellite constellations. The small satellite industry has seen an incredible surge in the number of small satellites launched over the last few years. Small satellites with advanced technology, artificial intelligence (AI), and machine learning in the future are likely to bring new features to the field of satellite communications.

The use of small satellite technology is also becoming an increasingly powerful tool with multi-missions, functions, capabilities, which can be fundamental to support those that need seamless services on a worldwide basis. This trend in the adoption of small satellite technology, while “democratizing” space for all nations irrespective of their economic status, also play a role in helping these nations achieve the sustainable development goals (SDGs).

In view of the diverse usages of small satellites, this field may attract new entrants lacking knowledge of, or experience with, the ITU and the ITU Radio Regulations and related procedures. An ITU-R handbook addressing various elements including regulations, procedures, and key information of small satellites as well as other similar short-duration mission satellites in similar applicable situations, would be useful to administrations, satellite operators, manufacturers and service providers interested in operating or utilizing such small satellites.

It is noted that there already exists a training mechanism in ITU for various areas. Training programs on radio communication have been organized and conducted on a regular basis, including the biennial ITU World Radiocommunication Seminar and thematic regional workshops. However, these seminars and workshops rarely target specifically the application of the Radio Regulations in the research, launch and application of small satellites.

Studies had been carried out under ITU-R Working Party 7B in response to Question ITU-R 254/7 and Reports, such as ITU-R SA.2312, ITU-R SA.2348 and ITU-R SA.2426, have been generated focusing on the characteristics and spectrum requirements, as well as practice situation for notifying nano and pico-satellites. However, it has been expressed that a more detailed guidance on the regulatory environment and procedures for new operators and service providers in this field is needed.

In view of the above, this stand-alone Handbook, separate from the more general Satellite Handbook or MSS Handbook, has been generated by the ITU-R to effectively promote development of small satellites and better serve the needs of Member States and the whole satellite industry.

1.1 Purpose of this Handbook

Based on the above reflections and observations, the purposes of this Small Satellite Handbook are as follows:

– to extend international cooperation among all ITU Member States, entities and organizations for the development and rational use of small satellites;
– to promote the adoption of small satellite technologies on a worldwide basis while striving to meet in a rational, equitable, effective, efficient, economic, and timely way of use of radio-frequency spectrum and satellite-orbit resources;
– to provide a detailed guidance on the regulatory environment and procedures, specifically the application of the Radio Regulations, for administrations, small satellite operators and service providers in the study/research, design, launch and application of small satellites;

– to promote and to offer technical assistance to developing countries, enterprises and individuals in the field of small satellite utilization;

– to help administration/new entrants with information on the relevant space services with allocated radio-frequency spectrum, types of small satellites, characteristics of space and Earth segments, types of missions, space object registration, launch considerations, as well as space debris mitigation;

– to raise international awareness on current practices and applications with key drivers, restraints, challenges, and opportunities;

– to ensure interference-free operations of small satellite systems by implementing the Radio Regulations and regional agreements, as well as updating the system in an efficient and timely manner through the processes of world and regional information sharing and cooperation.

– to provide a reference tool for satellite operators and service providers interested in operating or utilizing such satellites, as well as national regulators to manage the small satellite applications.

1.2 Historical perspectives on small satellite

Sputnik 1 was the first artificial Earth "SMALL" satellite launched on 4th October 1957 with external radio antennas to broadcast radio pulses. It was a 58 cm diameter, 83 kg polished metal sphere with a 1 W transmitter on 20.005 and 40.002 MHz. Analysis of the radio signals was used to gather information about the electron density of the ionosphere.

In the late 1980s, a new satellite paradigm, modern small satellites, arose and opened up a new class of space applications. The major design problems and constraints influencing the design of a small low-cost satellite bus are identified using the subsystem approach. Key design areas include the improvement of battery technology and the development of a deployable solar array, attitude control assemblies, onboard data processing/storage and ground station data acquisition. Although the eventual satellite would also have to be somewhat larger, more powerful and, above all, more sophisticated than the previous small satellites, this is considered to be a natural progression of research in this area, and form part of a more detailed future study.

Over the past few years, satellite industry has developed an integrated suite of satellite subsystems and small satellite buses. The subsystems include communications, attitude sensing and control, power conversion and distribution, and onboard data handling. They are inherently modular and readily adaptable to different satellite configurations, a concept known as semi-standardization. This concept has been adopted by two generic low-cost buses: MicroSIL for satellites in the mass range 40-80 kg; and MiniSIL for satellites in the range 100-500 kg. Their architecture is based on the semi-standard subsystems, but easily modified to utilize sub-systems from other manufacturers. They can support all stabilization methods including spinning, three-axis control and gravity gradient and are adaptable to a wide variety of missions including Earth resources, scientific, communications and technology demonstration.

Recently a great many small satellite systems are based on a constellation of tens (in some cases hundreds) of small satellites launched or to be launched over the next few years. Consequently, large numbers of spacecraft need to be produced in a very short time. The traditional concept for space production is no longer adequate to meet the requirements of these new systems and so a new approach to Assembly, Integration and Testing (AIT) is needed that satisfies the intensive production rate demands but without introducing complete process automation. The space industry is moving towards a future with large constellations of small satellites capable of providing all types of services in large geographical areas or across the globe.

1.3 Types of small satellites

Presently, a legal or regulatory definition of a small satellite does not exist. However, satellites may be grouped into different categories based on their mass, mission duration, functional density and others.

As indicated in Report ITU-R SA.2312-0, a convenient way to classify satellites is by their mass. Satellites that weigh less than ~ 500 kg are often referred to as small satellites, which can be further classified as shown in Table 1:

TABLE 1

Typical characteristics of small satellites

Denomination	Mass (kg)	Max. bus power (W)	Typical cost (USD)	Max. dimensions (m)	Development time (years)	Orbit	Mission duration (years)
Minisatellite	100-500	1 000	30-200 M	3-10	3-10	GEO MEO LEO HEO	5-10
Microsatellite	10-100	150	10-150 M	1-5	2-5	LEO (HEO)	2-6
Nanosatellite	1-10	20	100 k-10 M	0.1-1	1-3		1-3
Picosatellite	0.1- 1	5	50 k-2 M	0.05-0.1			
Femtosatellite	< 0.1	1	< 50 k	0.01-0.1	1		< 1

It is also mentioned that in the report, size and/or mass are not really the issue from a frequency management viewpoint, while factors such as mission duration, orbital uncertainty, low satellite equivalent isotropic radiated power (e.i.r.p.) and speed of development are rather more important factors.

From the mission duration aspect, non-geostationary (non-GSO) satellite system could be divided by long and short duration missions. Long duration missions are usually large constellations and commercial projects generally with significant capital investments, but short duration missions are generally consisted of one satellite or small number of satellites in the constellation, and normally for non-commercial usage or in early start-up phase.

From the functional density (function per unit weight) aspect, small satellite could be divided by simple and modern small satellite. The early 1980's ushered in the beginning of the era of the modern small satellite.

(Texts concerning other types of small satellites, including CubeSat, will be developed.)

1.4 Tutorial on small satellite systems engineering aspects

Systems engineering is concerned with the overall performance of a system for multiple objectives (e.g. mass, cost, and power). The system engineering process is a methodical approach to balancing the needs and capabilities of the various subsystems in order to improve the performance of the system. The size, volume, and mass constraints often uncounted in small satellite development programs, combined with increasing pressure from customers to pack more capability into a given size, make system engineering methods particularly important for small satellites.

Spacecraft systems engineering is an established and well-understood discipline. The characteristics of a small satellite can differ from those of traditional large satellites in a number of ways:

– Small satellite often have fixed solar arrays instead of sun-tracking solar arrays
– Small satellite often do not have deployable
– Small mass leads to recurred thermal inertia
– Small size leads to reduced power generation and storage capabilities
– Volume can be tightly constrained
– Surface area can be at a premium
– Small satellite use smaller components, new technologies (e.g. MEMS), and non-traditional vendors

These differences mean that although the process used to design small and large satellites is similar, the elements and development time required to be considered are extremely different.

2 Characteristics of small satellite systems

Similar as large satellite system, small satellite system also consists of mainly two segments, space segment and ground segment. In comparison with large satellite system, typical characterises of small satellite missions include: a) reasonably short development times; b) relatively small development teams; c) modest development and testing infrastructure requirements; and d) affordable development and operation costs for the developers, in other terms "faster, cheaper and smaller".

2.1 Space segment

2.1.1 Orbital types

Upon launch, a satellite or spacecraft is most often placed in one of several particular orbits around Earth – or it might be sent on an interplanetary journey, meaning that it does not orbit Earth anymore, but instead orbits the Sun until its arrival at its final destination, like Mars or Jupiter.

There are many factors that decide which orbit would be the best for a satellite to use, depending on what is designed for the satellite to achieve.

Geostationary orbit (GEO)

Satellites in geostationary orbit (GEO) circle Earth above the equator from west to east following Earth's rotation – taking 23 hours 56 minutes and 4 seconds – by travelling at exactly the same rate as Earth. This makes satellites in GEO appear to be 'stationary' over a fixed position. In order to perfectly match Earth's rotation, the speed of GEO satellites should be about 3 km per second at an altitude of 35 786 km. This is much farther from Earth's surface compared to many satellites.

GEO is used by satellites that need to stay constantly above one particular place over Earth, such as telecommunication satellites. This way, an antenna on Earth can be fixed to always stay pointed towards that satellite without moving. It can also be used by weather monitoring satellites, because they can continually observe specific areas to see how weather trends emerge there.

Satellites in GEO cover a large range of Earth so as few as three equally-spaced satellites can provide near global coverage. This is because when a satellite is this far from Earth, it can cover large sections at once. This is akin to being able to see more of a map from a metre away compared with if you were a centimetre from it. So, to see all of Earth at once from GEO far fewer satellites are needed than at a lower altitude.

Low Earth orbit (LEO)

A low Earth orbit (LEO) is, as the name suggests, an orbit that is relatively close to Earth's surface. It is normally at an altitude of less than 1 000 km but could be as low as 160 km above Earth – which is low compared to other orbits, but still very far above Earth's surface.

By comparison, most commercial aeroplanes do not fly at altitudes much greater than approximately 14 km, so even the lowest LEO is more than ten times higher than that.

Unlike satellites in GEO that must always orbit along Earth's equator, LEO satellites do not always have to follow a particular path around Earth in the same way – their plane can be tilted. This means there are more available routes for satellites in LEO, which is one of the reasons why LEO is a very commonly used orbit.

LEO's close proximity to Earth makes it useful for several reasons. It is the orbit most commonly used for satellite imaging, as being near the surface allows it to take images of higher resolution. It is also the orbit used for the International Space Station (ISS), as it is easier for astronauts to travel to and from it at a shorter distance. Satellites in this orbit travel at a speed of around 7.8 km per second; at this speed, a satellite takes approximately 90 minutes to circle Earth, meaning the ISS travels around Earth about 16 times a day.

Individual LEO satellites are less useful for tasks such as telecommunication, because they move so fast across the sky and therefore require a lot of effort to track from ground stations. Instead, communications satellites in LEO often work as part of a large combination or constellation, of multiple satellites to give constant coverage. In order to increase coverage, sometimes constellations, consisting of several of the same or similar satellites, are launched together to create a 'net' around Earth. This lets them cover large areas of Earth simultaneously by working together.

Medium Earth orbit (MEO)

Medium Earth orbit comprises a wide range of orbits anywhere between LEO and GEO. It is similar to LEO in that it also does not need to take specific paths around Earth, and it is used by a variety of satellites with many different applications.

It is very commonly used by navigation satellites, like the European Galileo system (pictured). Galileo powers navigation communications across Europe, and is used for many types of navigation, from tracking large jumbo jets to getting directions to your smartphone. Galileo uses a constellation of multiple satellites to provide coverage across large parts of the world all at once.

Polar orbit and Sun-synchronous orbit (SSO)

Satellites in polar orbits usually travel past Earth from north to south rather than from west to east, passing roughly over Earth's poles.

Satellites in a polar orbit do not have to pass the North and South Pole precisely; even a deviation within 20 to 30 degrees is still classed as a polar orbit. Polar orbits are a type of low Earth orbit, as they are at low altitudes from 200 to 1000 km.

Sun-synchronous orbit (SSO) is a particular kind of polar orbit. Satellites in SSO, travelling over the Polar Regions, are synchronous with the Sun. This means they are synchronised to always be in the same 'fixed' position relative to the Sun. This means that the satellite always visits the same spot at the same local time – for example, passing the city of Paris every day at noon exactly.

This means that the satellite will always observe a point on the Earth as if constantly at the same time of the day, which serves a number of applications; for example, it means that scientists and those who use the satellite images can compare how somewhere changes over time.

This is because, if you want to monitor an area by taking a series of images of a certain place across many days, weeks, months, or even years, then it would not be very helpful to compare somewhere at midnight and then at midday – you need to take each picture as similarly as the previous picture as possible. Therefore, scientists use image series like these to investigate how weather patterns emerge, to help predict weather or storms; when monitoring emergencies like forest fires or flooding; or to accumulate data on long-term problems like deforestation or rising sea levels.

Often, satellites in SSO are synchronised so that they are in constant dawn or dusk – this is because by constantly riding a sunset or sunrise, they will never have the Sun at an angle where the Earth shadows them. A satellite in a Sun-synchronous orbit would usually be at an altitude of from 600 to 800 km.

So far most small satellites operate in LEO, and little of them operate in MEO, SSO and even in GEO. The orbital parameters of small satellite systems are mostly not different from those of traditional satellites. For very small satellites, such as Nanosatellites and Picosatellites, they are typically not known with a high degree of precision until late in the satellite system design due to launch opportunities as secondary payloads, and the mission objective of those satellites is some form of technology demonstration like attitude control, tether manoeuvers or simply on orbit verification of materials or electrical components, therefore they are not restricted to special orbits, as long as the communication between the earth station and spacecraft is ensured on a regular basis.

2.1.2 Space segment

The spacecraft itself is also known as the space segment, frequently described in terms of a payload and a service module or "bus". The capability of a satellite bus relates to its ability to accommodate payloads and to meet mission requirements. Payload accommodation requirements are many and include mass; geometry (volume, mechanical interfaces, fields of view); thermal interfaces; power (wattage, voltages, duty cycles); data (rates, interfaces); contamination environment; electromagnetic interference limits; and spacecraft pointing knowledge and control (slewing and settling rates, stability, jitter).

The mission architecture places further requirements on the spacecraft bus such as on-board data processing; data memory and communication links; battery capacity; and the need for propulsion (orbit insertion, orbit maintenance, formation flying, end-of-mission de-orbit). Additional mission requirements include spacecraft life (expendables, radiation dose, and solar array degradation); reliability; and degree of redundancy.

Generally, a spacecraft bus includes many subsystems: propulsion; thermal control; power and power distribution; attitude control; telemetry command and control; transmitters/antenna; computers/on-board processing/software; and structural elements.

All space missions are constrained by launch vehicle performance (mass to orbit) and fairing—i.e., the aerodynamic cover that protects the spacecraft as it travels through the atmosphere—volume. These constraints can be severe for small expendable launch vehicles and can lead to complex designs for "deployable" (such as the solar panels) in order to stow the satellite within the fairing. Within these constraints, the satellite designer generally wants to maximize resources available to the payload and minimize those required for the spacecraft bus. Consequently, much small satellite technology development effort has been directed toward reducing bus volume, mass, and power consumption, while providing robust capability by increasing battery capacity, solar array efficiency, data memory, processing rates, and so on. This trend is likely to continue in avionics as well as in the still embryonic field of microminiature electromechanical systems. Small satellite technology has already advanced to the point where a great deal of capability can be provided in a relatively small package.

2.2 Ground segment

The ground segment includes all the ground-based elements that are used to collect and disseminate information from the satellite to the user. The primary elements of a ground system include ground stations which provide telemetry, tracking, and command interface with the spacecraft, ground networks which provide connection between multiple ground elements, control centers which manage the spacecraft operations, remote terminals which is the user interface to retrieve transmitted information for additional processing.

All small satellites use some form of a ground segment to communicate with the spacecraft, whether it be handheld radios using an amateur frequency, or a large dish pulling down data on a dedicated frequency band, such as UHF, S, X, Ku and Ka etc. UHF was the band of choice for early small satellites, but in recent years, there has been more of a shift to S and X bands. Ku and Ka are the desired bands for future small satellite missions. This shift has been driven by higher data demands and frequency control. The higher frequencies permit more data to be transmitted over a given period of time, but do require the spacecraft and ground antennas to be more focused. UHF yields lower data rates and has a higher probability for interference as it is commonly used by local municipalities. It was appealing to early users, particularly universities, due to the lower cost of hardware for both the spacecraft and ground station, good link margins, and more omni-directional pattern capability with the spacecraft.

The ground segment design can depend on a number of factors which may include, but are not limited, to the following:

– Data volume to satisfy mission requirements
– Location of the ground assets relative to mission orbit parameters
– Budget limitations
– Distribution of the team
– Affiliation of who controls the spacecraft
– Regulatory requirements

The ground system is responsible for collecting and distributing the most valuable asset of the mission: the data. Using the proper ground system is key to the success of the mission.

3 Type of services and spectrum

[Editor's note: The inclusion of this section is developed in accordance with the current Radio Regulations (Edition of 2020) and may need to be updated as the frequency allocations change in conformity with the Radio Regulations. There is an intention to put all frequency allocation tables concerned into an annex in future, and as long as these allocation tables are retained, all satellite services and footnotes should be included, in order not to steer small satellite operators in the direction of particular services in the concerned region(s).]

Different small satellites, including nano- and pico-satellites, as well as other similar short-duration mission satellites shall use different frequency bands due to the different class of radiocommunication services which the satellite is planned to provide.

For examples, some administrations have used frequency bands allocated to the amateur-satellite service, Earth exploration-satellite service, meteorological-satellite service, as well as space research service and space operation service.

The most popular services with the frequency allocation fitted for small satellites are identified and introduced in this section in accordance with the current Radio Regulations (Edition of 2020).

It should be noted that each frequency band listed below is allocated to specific services along with specific conditions, it must be optioned and assigned to a specific small satellite only when the applications and operations requirements of the frequency bands be complied all.

3.1 Space operation service

The table below shows the frequency bands allocated to Space operation service, which may be suitable for operations of small satellites.

Region 1	Region 2	Region 3
30.005-30.01 MHz	SPACE OPERATION (satellite identification) FIXED MOBILE SPACE RESEARCH	
137-137.025 MHz	SPACE OPERATION (space-to-Earth) METEOROLOGICAL-SATELLITE (space-to-Earth) MOBILE-SATELLITE (space-to-Earth) 5.208A 5.208B 5.209 SPACE RESEARCH (space-to-Earth) Fixed Mobile except aeronautical mobile (R) 5.204 5.205 5.206 5.207 5.208	
137.025-137.175 MHz	SPACE OPERATION (space-to-Earth) METEOROLOGICAL-SATELLITE (space-to-Earth) SPACE RESEARCH (space-to-Earth) Fixed Mobile-satellite (space-to-Earth) 5.208A 5.208B 5.209 Mobile except aeronautical mobile (R) 5.204 5.205 5.206 5.207 5.208	
137.175-137.825 MHz	SPACE OPERATION (space-to-Earth) METEOROLOGICAL-SATELLITE (space-to-Earth) MOBILE-SATELLITE (space-to-Earth) 5.208A 5.208B 5.209 SPACE RESEARCH (space-to-Earth) Fixed Mobile except aeronautical mobile (R) 5.204 5.205 5.206 5.207 5.208	
137.825-138 MHz	SPACE OPERATION (space-to-Earth) METEOROLOGICAL-SATELLITE (space-to-Earth) SPACE RESEARCH (space-to-Earth) Fixed Mobile-satellite (space-to-Earth) 5.208A 5.208B 5.209 Mobile except aeronautical mobile (R) 5.204 5.205 5.206 5.207 5.208	
267-272 MHz	FIXED MOBILE Space operation (space-to-Earth) 5.254 5.257	
272-273 MHz	SPACE OPERATION (space-to-Earth) FIXED MOBILE 5.254	

Region 1	Region 2	Region 3
400.15-401 MHz	METEOROLOGICAL AIDS METEOROLOGICAL-SATELLITE (space-to-Earth) MOBILE-SATELLITE (space-to-Earth) 5.208A 5.208B 5.209 SPACE RESEARCH (space-to-Earth) 5.263 Space operation (space-to-Earth) 5.262 5.264	
401-402 MHz	METEOROLOGICAL AIDS SPACE OPERATION (space-to-Earth) EARTH EXPLORATION-SATELLITE (Earth-to-space) METEOROLOGICAL-SATELLITE (Earth-to-space) Fixed Mobile except aeronautical mobile	
1 427-1 429 MHz	SPACE OPERATION (Earth-to-space) FIXED MOBILE except aeronautical mobile 5.341A 5.341B 5.341C 5.338A 5.341	
1 525-1 530 SPACE OPERATION (space-to-Earth) FIXED MOBILE-SATELLITE (space-to-Earth) 5.208B 5.351A Earth exploration-satellite Mobile except aeronautical mobile 5.349 5.341 5.342 5.350 5.351 5.352A 5.354	**1 525-1 530** SPACE OPERATION (space-to-Earth) MOBILE-SATELLITE (space-to-Earth) 5.208B 5.351A Earth exploration-satellite Fixed Mobile 5.343 5.341 5.351 5.354	**1 525-1 530** SPACE OPERATION (space-to-Earth) FIXED MOBILE-SATELLITE (space-to-Earth) 5.208B 5.351A Earth exploration-satellite Mobile 5.349 5.341 5.351 5.352A 5.354
1 530-1 535 SPACE OPERATION (space-to-Earth) MOBILE-SATELLITE (space-to-Earth) 5.208B 5.351A 5.353A Earth exploration-satellite Fixed Mobile except aeronautical mobile 5.341 5.342 5.351 5.354	**1 530-1 535** SPACE OPERATION (space-to-Earth) MOBILE-SATELLITE (space-to-Earth) 5.208B 5.351A 5.353A Earth exploration-satellite Fixed Mobile 5.343 5.341 5.351 5.354	
2 025-2 110 MHz	SPACE OPERATION (Earth-to-space) (space-to-space) EARTH EXPLORATION-SATELLITE (Earth-to-space) (space-to-space) FIXED MOBILE 5.391 SPACE RESEARCH (Earth-to-space) (space-to-space) 5.392	
2 200-2 290	SPACE OPERATION (space-to-Earth) (space-to-space) EARTH EXPLORATION-SATELLITE (space-to-Earth) (space-to-space) FIXED MOBILE 5.391 SPACE RESEARCH (space-to-Earth) (space-to-space)	

Region 1	Region 2	Region 3
	5.392	
7 190-7 235	EARTH EXPLORATION-SATELLITE (Earth-to-space) 5.460A 5.460B FIXED MOBILE SPACE RESEARCH (Earth-to-space) 5.460 5.458 5.459	
7 235-7 250	EARTH EXPLORATION-SATELLITE (Earth-to-space) 5.460A FIXED MOBILE 5.458	

3.2 Amateur-satellite service

The frequency bands allocated to amateur-satellite service have been used heavily by small satellites in the past twenty years. However, a number of applications and operations in these frequency bands do not comply with all the requirements for amateur use and have been authorized only for experimental operation.

The table below shows the frequency bands allocated to amateur-satellite service, including those allocated under RR No. **5.282**, which may be suitable for operations of small satellites on this purpose, noting that the requirements illustrated in the following sections must be complied with.

Region 1	Region 2	Region 3
7 000-7 100 kHz	AMATEUR AMATEUR-SATELLITE 5.140 5.141 5.141A 7 000-7 100	
14 000-14 250 kHz	AMATEUR AMATEUR-SATELLITE	
18 068-18 168 kHz	AMATEUR AMATEUR-SATELLITE 5.154	
21 000-21 450 kHz	AMATEUR AMATEUR-SATELLITE	
24 890-24 990 kHz	AMATEUR AMATEUR-SATELLITE	
28-29.7 MHz	AMATEUR AMATEUR-SATELLITE	
144-146 MHz	AMATEUR AMATEUR-SATELLITE 5.216	
435-438 MHz AMATEUR RADIOLOCATION Earth exploration-satellite (active) 5.279A 5.138 5.271 5.276 5.277 5.280 5.281 5.282	**435-438 MHz** RADIOLOCATION Amateur Earth exploration-satellite (active) 5.279A 5.271 5.276 5.278 5.279 5.281 5.282	

<table>
<tr><th>Region 1</th><th>Region 2</th><th>Region 3</th></tr>
<tr><td colspan="3">1 260-1 270 MHz
EARTH EXPLORATION-SATELLITE (active)
RADIOLOCATION
RADIONAVIGATION-SATELLITE (space-to-Earth) (space-to-space)
5.328B 5.329 5.329A
SPACE RESEARCH (active)
Amateur

5.282 5.330 5.331 5.332 5.335 5.335A</td></tr>
<tr><td>2 400-2 450 MHz
FIXED
MOBILE 5.384A
Amateur
Radiolocation

5.150 5.282 5.395</td><td colspan="2">2 400-2 450 MHz
FIXED
MOBILE 5.384A
RADIOLOCATION
Amateur

5.150 5.282 5.393 5.394</td></tr>
<tr><td>(No allocation in Region 1 for amateur-satellite service in the band 3 400-3 410 MHz under No. 5.282)</td><td>3 400-3 410 MHz
FIXED
FIXED-SATELLITE (space-to-Earth)
MOBILE except aeronautical mobile 5.431A 5.431B
Amateur
Radiolocation 5.433

5.282</td><td>3 400-3 410 MHz
FIXED
FIXED-SATELLITE (space-to-Earth)
Amateur
Mobile 5.432 5.432B
Radiolocation 5.433

5.282 5.432A</td></tr>
<tr><td>5 650-5 670 MHz</td><td colspan="2">MOBILE except aeronautical mobile 5.446A 5.450A
RADIOLOCATION
Amateur
Space research (deep space)

5.282 5.451 5.453 5.454 5.455</td></tr>
<tr><td>5 830-5 850 MHz
FIXED-SATELLITE (Earth-to-space)
RADIOLOCATION
Amateur
Amateur-satellite (space-to-Earth)
5.150 5.451 5.453 5.455 5.456</td><td colspan="2">5 830-5 850 MHz
RADIOLOCATION
Amateur
Amateur-satellite (space-to-Earth)
5.150 5.453 5.455</td></tr>
<tr><td>10.45-10.5 GHz</td><td colspan="2">RADIOLOCATION
Amateur
Amateur-satellite
5.481</td></tr>
<tr><td>24-24.05 GHz</td><td colspan="2">AMATEUR
AMATEUR-SATELLITE
5.150</td></tr>
<tr><td>47-47.2 GHz</td><td colspan="2">AMATEUR
AMATEUR-SATELLITE</td></tr>
</table>

Region 1	Region 2	Region 3
76-77.5 GHz	RADIO ASTRONOMY RADIOLOCATION Amateur Amateur-satellite Space research (space-to-Earth) 5.149	
78-79 GHz	RADIOLOCATION Amateur Amateur-satellite Radio astronomy Space research (space-to-Earth) 5.149 5.560	
79-81 GHz	RADIO ASTRONOMY RADIOLOCATION Amateur Amateur-satellite Space research (space-to-Earth) 5.149	
134-136 GHz	AMATEUR AMATEUR-SATELLITE Radio astronomy	
136-141 GHz	RADIO ASTRONOMY RADIOLOCATION Amateur Amateur-satellite 5.149	
241-248 GHz	RADIO ASTRONOMY RADIOLOCATION Amateur Amateur-satellite 5.138 5.149	
248-250 GHz	AMATEUR AMATEUR-SATELLITE Radio astronomy 5.149	

3.2.1 Specific requirements for Amateur-satellite service in the Radio Regulations

The use of amateur or amateur-satellite service spectrum, under the amateur service, is only appropriate if the definition of the amateur service (RR No. 1.56) is strictly met: "*A radiocommunication service for the purpose of self-training, intercommunication and technical investigations carried out by amateurs, that is, duly authorized persons interested in radio technique solely with a personal aim and without pecuniary interest.*".

In many ways, the approach that is taken within the bands allocated to amateur-satellite service is nearly ideal as there is a simple, clearly defined process to be followed and the costs associated with this approach are minimal.

In order to help administrations submissions of "small satellite" operating in frequency bands allocated to amateur-satellite service, the Bureau issued an ITU-R Circular Letter **CR/303** related to Amateur-satellite service and created a support web page:

http://www.itu.int/en/ITU-R/space/Pages/supportSmallSat.aspx

Small satellite systems operating in amateur and amateur-satellite spectrum are not subject to coordination procedure under Section II of Article **9** of the RR. To resolve any potential difficulties the process described at https://www.iaru.org/reference/satellites/ is used.

3.2.2 Coordination with the International Amateur Radio Union

Frequency Coordination Requests for amateur-satellite service shall be made using the specific form (see materials iaru_amateur_satellite_coordination_request_v40 in https://www.iaru.org/reference/satellites/).

With the IARU coordination team meeting every two weeks, the typical processing time for coordination requests could be less than four weeks, provided that all necessary information is being made available.

3.3 Remote sensing: Earth exploration-satellite service

The table below shows the frequency bands allocated to Earth exploration-satellite service, which may be suitable for operations of small satellites.

Region 1	Region 2	Region 3
401-402 MHz	METEOROLOGICAL AIDS SPACE OPERATION (space-to-Earth) EARTH EXPLORATION-SATELLITE (Earth-to-space) METEOROLOGICAL-SATELLITE (Earth-to-space) Fixed Mobile except aeronautical mobile	
402-403 MHz	METEOROLOGICAL AIDS EARTH EXPLORATION-SATELLITE (Earth-to-space) METEOROLOGICAL-SATELLITE (Earth-to-space) Fixed Mobile except aeronautical mobile	
1 525-1 530 SPACE OPERATION (space-to-Earth) FIXED MOBILE-SATELLITE (space-to-Earth) 5.208B 5.351A Earth exploration-satellite Mobile except aeronautical mobile 5.349 5.341 5.342 5.350 5.351 5.352A 5.354	**1 525-1 530** SPACE OPERATION (space-to-Earth) MOBILE-SATELLITE (space-to-Earth) 5.208B 5.351A Earth exploration-satellite Fixed Mobile 5.343 5.341 5.351 5.354	**1 525-1 530** SPACE OPERATION (space-to-Earth) FIXED MOBILE-SATELLITE (space-to-Earth) 5.208B 5.351A Earth exploration-satellite Mobile 5.349 5.341 5.351 5.352A 5.354

Region 1	**Region 2**	**Region 3**
1 530-1 535 SPACE OPERATION (space-to-Earth) MOBILE-SATELLITE (space-to-Earth) 5.208B 5.351A 5.353A Earth exploration-satellite Fixed Mobile except aeronautical mobile 5.341 5.342 5.351 5.354	**1 530-1 535** SPACE OPERATION (space-to-Earth) MOBILE-SATELLITE (space-to-Earth) 5.208B 5.351A 5.353A Earth exploration-satellite Fixed Mobile 5.343 5.341 5.351 5.354	**1 530-1 535** SPACE OPERATION (space-to-Earth) MOBILE-SATELLITE (space-to-Earth) 5.208B 5.351A 5.353A Earth exploration-satellite Fixed Mobile except aeronautical mobile 5.341 5.342 5.351 5.354
2 025-2 110 MHz	SPACE OPERATION (Earth-to-space) (space-to-space) EARTH EXPLORATION-SATELLITE (Earth-to-space) (space-to-space) FIXED MOBILE 5.391 SPACE RESEARCH (Earth-to-space) (space-to-space) 5.392	
2 200-2 290	SPACE OPERATION (space-to-Earth) (space-to-space) EARTH EXPLORATION-SATELLITE (space-to-Earth) (space-to-space) FIXED MOBILE 5.391 SPACE RESEARCH (space-to-Earth) (space-to-space) 5.392	
8 025-8 400 MHz	EARTH EXPLORATION-SATELLITE (space-to-Earth) FIXED FIXED-SATELLITE (Earth-to-space) MOBILE 5.463 5.462A	
13.75-14	FIXED-SATELLITE (Earth-to-space) 5.484A RADIOLOCATION Earth exploration-satellite Standard frequency and time signal-satellite (Earth-to-space) Space research 5.499 5.500 5.501 5.502 5.503	
25.5-27	EARTH EXPLORATION-SATELLITE (space-to-Earth) 5.536B FIXED 5.534A INTER-SATELLITE 5.536 MOBILE 5.338A 5.532AB SPACE RESEARCH (space-to-Earth) 5.536C Standard frequency and time signal-satellite (Earth-to-space) 5.536A	
28.5-29.1	FIXED FIXED-SATELLITE (Earth-to-space) 5.484A 5.516B 5.523A 5.539 MOBILE Earth exploration-satellite (Earth-to-space) 5.541 5.540	

Region 1	Region 2	Region 3
29.1-29.5	FIXED FIXED-SATELLITE (Earth-to-space) 5.516B 5.523C 5.523E 5.535A 5.539 5.541A MOBILE Earth exploration-satellite (Earth-to-space) 5.541 5.540	
29.5-29.9 FIXED-SATELLITE (Earth-to-space) 5.484A 5.484B 5.516B 5.527A 5.539 Earth exploration-satellite (Earth-to-space) 5.541 Mobile-satellite (Earth-to-space)	**29.5-29.9** FIXED-SATELLITE (Earth-to-space) 5.484A 5.484B 5.516B 5.527A 5.539 MOBILE-SATELLITE (Earth-to-space) Earth exploration-satellite (Earth-to-space) 5.541	**29.5-29.9** FIXED-SATELLITE (Earth-to-space) 5.484A 5.484B 5.516B 5.527A 5.539 Earth exploration-satellite (Earth-to-space) 5.541 Mobile-satellite (Earth-to-space)

3.4 Climate monitoring: Meteorological service

The table below shows the frequency bands allocated to Meteorological satellite service, which may be suitable for operations of small satellites.

Region 1	Region 2	Region 3
137-137.025 MHz	SPACE OPERATION (space-to-Earth) METEOROLOGICAL-SATELLITE (space-to-Earth) MOBILE-SATELLITE (space-to-Earth) 5.208A 5.208B 5.209 SPACE RESEARCH (space-to-Earth) Fixed Mobile except aeronautical mobile (R) 5.204 5.205 5.206 5.207 5.208	
137.025-137.175 MHz	SPACE OPERATION (space-to-Earth) METEOROLOGICAL-SATELLITE (space-to-Earth) SPACE RESEARCH (space-to-Earth) Fixed Mobile-satellite (space-to-Earth) 5.208A 5.208B 5.209 Mobile except aeronautical mobile (R) 5.204 5.205 5.206 5.207 5.208	
137.175-137.825 MHz	SPACE OPERATION (space-to-Earth) METEOROLOGICAL-SATELLITE (space-to-Earth) MOBILE-SATELLITE (space-to-Earth) 5.208A 5.208B 5.209 SPACE RESEARCH (space-to-Earth) Fixed Mobile except aeronautical mobile (R) 5.204 5.205 5.206 5.207 5.208	
137.825-138 MHz	SPACE OPERATION (space-to-Earth) METEOROLOGICAL-SATELLITE (space-to-Earth) SPACE RESEARCH (space-to-Earth) Fixed Mobile-satellite (space-to-Earth) 5.208A 5.208B 5.209 Mobile except aeronautical mobile (R) 5.204 5.205 5.206 5.207 5.208	

<table>
<tr><th>Region 1</th><th>Region 2</th><th>Region 3</th></tr>
<tr><td colspan="3">400.15-401 MHz
METEOROLOGICAL AIDS
METEOROLOGICAL-SATELLITE (space-to-Earth)
MOBILE-SATELLITE (space-to-Earth) 5.208A 5.208B 5.209
SPACE RESEARCH (space-to-Earth) 5.263
Space operation (space-to-Earth)
5.262 5.264</td></tr>
<tr><td colspan="3">401-402 MHz
METEOROLOGICAL AIDS
SPACE OPERATION (space-to-Earth)
EARTH EXPLORATION-SATELLITE (Earth-to-space)
METEOROLOGICAL-SATELLITE (Earth-to-space)
Fixed
Mobile except aeronautical mobile</td></tr>
<tr><td colspan="3">402-403 MHz
METEOROLOGICAL AIDS
EARTH EXPLORATION-SATELLITE (Earth-to-space)
METEOROLOGICAL-SATELLITE (Earth-to-space)
Fixed
Mobile except aeronautical mobile</td></tr>
<tr><td colspan="3">460-470 MHz
FIXED
MOBILE 5.286AA
Meteorological-satellite (space-to-Earth)
5.287 5.288 5.289 5.290</td></tr>
<tr><td colspan="3">1 670-1 675 MHz
METEOROLOGICAL AIDS
FIXED
METEOROLOGICAL-SATELLITE (space-to-Earth)
MOBILE
MOBILE-SATELLITE (Earth-to-space) 5.351A 5.379B
5.341 5.379D 5.379E 5.380A</td></tr>
<tr><td colspan="3">1 675-1 690 MHz
METEOROLOGICAL AIDS
FIXED
METEOROLOGICAL-SATELLITE (space-to-Earth)
MOBILE except aeronautical mobile
5.341</td></tr>
<tr><td>1 690-1 700 MHz
METEOROLOGICAL AIDS
METEOROLOGICAL
SATELLITE (space-to-Earth)
Fixed
Mobile except aeronautical mobile
5.289 5.341 5.382</td><td colspan="2">1 690-1 700 MHz
METEOROLOGICAL AIDS
METEOROLOGICAL-SATELLITE (space-to-Earth)
5.289 5.341 5.381</td></tr>
<tr><td colspan="2">1 700-1 710 MHz
FIXED
METEOROLOGICAL-SATELLITE (space-to-Earth)
MOBILE except aeronautical mobile
5.289 5.341</td><td>1 700-1 710 MHz
FIXED
METEOROLOGICALSATELLITE
(space-to-Earth)
MOBILE except aeronautical
mobile
5.289 5.341 5.384</td></tr>
</table>

Region 1	Region 2	Region 3
7 450-7 550 MHz	FIXED FIXED-SATELLITE (space-to-Earth) METEOROLOGICAL-SATELLITE (space-to-Earth) MOBILE except aeronautical mobile 5.461A	
7 750-7 850 MHz	FIXED METEOROLOGICAL-SATELLITE (space-to-Earth) 5.461B MOBILE except aeronautical mobile	
8 175-8 215 MHz	EARTH EXPLORATION-SATELLITE (space-to-Earth) FIXED FIXED-SATELLITE (Earth-to-space) METEOROLOGICAL-SATELLITE (Earth-to-space) MOBILE 5.463 5.462A	

3.5 Space exploration and other space research service

TBD

3.6 Other services

Other frequency bands have also been used for operating small satellites. For example, small satellites have occasionally used bands which are designated under RR No. **5.150** for use by industrial, scientific and medical (ISM) applications. ISM applications do not include radiocommunication services, and developers should be aware that that small satellites do not fall under the definition of ISM applications. Consequently, they cannot operate on the same unlicensed basis as ISM equipment. Small satellite operating in these frequency bands is on an unprotected basis and shall not cause any harmful interference to others.

Certain small satellite missions have planned for operations at frequencies as high as the Ku band. As use of small satellite technologies expands to support other applications, developers may seek to use additional bands. Interest in other bands may result from mission specific requirements, availability of terrestrial infrastructure to support a particular mission, or other yet to be identified factors. However, as the relatively short development cycle and reduced cost offers easier access to space to new communities (e.g., educational institutes), either through partnerships with civil space agencies or as independent satellite operators, the range of applications as well as spectrum requirements will undoubtedly expand.

4 Radio regulatory procedures for small satellite

Only relevant ITU regulations are presented in this chapter, although national regulations will need to be taken into account as well.

4.1 Brief Introduction of ITU

The International Telecommunication Union (ITU), founded in 1865, became the United Nations specialized agency for information and communication technologies – ICTs in 1947. ITU is at the very heart of the ICT sector, brokering agreement on technologies, services, and allocation of global resources like radio-frequency spectrum and satellite orbital positions, to create a seamless global communications system that is robust, reliable, and constantly evolving (see ITU website: https://www.itu.int).

ITU membership includes 193 Member States, more than 900 public and private sector companies, universities, research institutes as well as international and regional telecommunication entities, known as Sector Members and Associates. In 2011, a new category of Academia was introduced for membership of ITU which can join all three Sectors with an annual reduced fee. Nowadays, there are more than 160 universities and research institutions around the world registered to help our entire membership push boundaries on a wide range of issues.

The ITU legal regime, in the domain of international frequency management of the spectrum/orbit resources, is incorporated in the Constitution (CS) and Convention (CV), as well as in the Radio Regulations (RR) with the Rules of Procedures (RoP). Only national administrations representing ITU Member States can request, either for their own benefit or on behalf of a satellite operator, the use of frequency spectrum and orbit resources to the ITU.

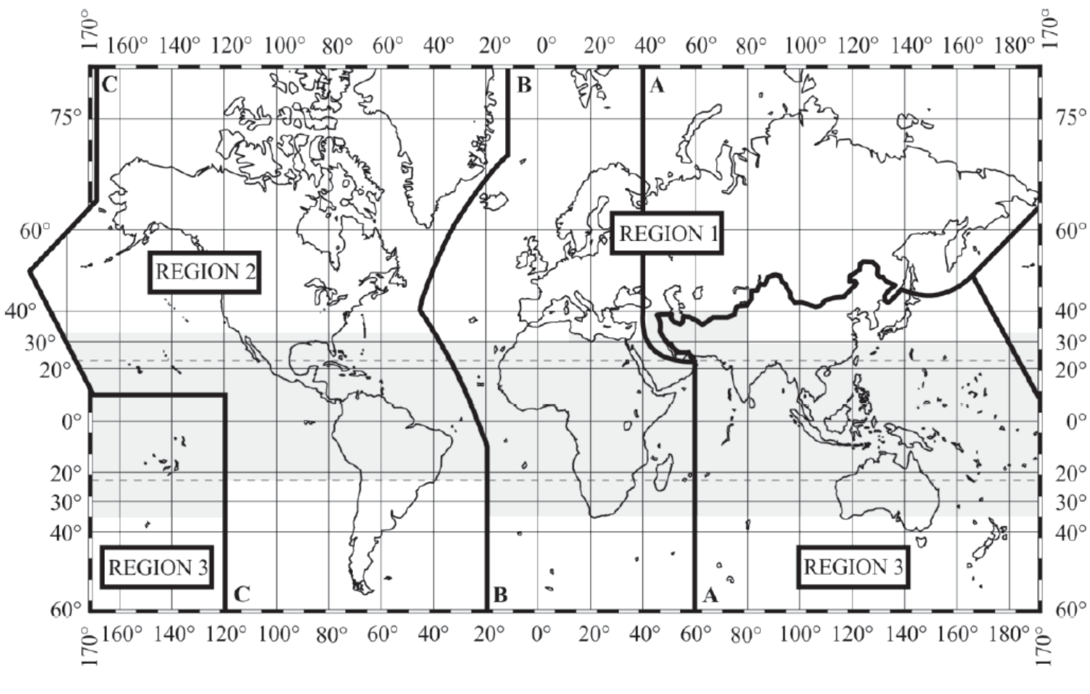
4.2 Frequency Allocations

One of the first issues to be considered in the early stages of a small satellite program is the selection of radio frequencies.

The Table of Frequency Allocation (RR Article **5**) and associated principles represent a basis for the planning and implementation of radiocommunication services. For the allocation of frequencies purpose, this Table is organized into three Regions of the world as shown on the following map (see Figure 1) and described in RR Nos. **5.3** to **5.9**. The current approach is based on a block allocation methodology with footnotes. The regulated frequency band (8.3 kHz – 3 000 GHz) is segmented into smaller bands and allocated to over forty defined radiocommunication services (RR Article **1**). The radio services are identified as primary or secondary (the latter shall cause no harmful interference to, or claim protection from, the former) and footnotes are used to further specify how the frequencies are to be assigned or used.

FIGURE 1

ITU Regions for purposes of frequency allocation of the RR



4.3 General principles for utilization of spectrum and orbit resources

When assigning frequencies to stations, Member States shall note that such assignments are to be made in accordance with the Table of Frequency Allocations and other provisions of these Regulations.

Using the Table of Frequency Allocations under RR Article **5** as a starting point, the frequency spectrum management authority of each Administration selects appropriate frequencies with a view to assigning them to stations of a given radiocommunication service in each country.

Before taking the final decision to assign a frequency to a station in a given radiocommunication service, in a given frequency band, and to issue an appropriate licence, the authority concerned should be aware of all other conditions regulating the use of frequencies in the band concerned, e.g.:

– If the frequency band concerned is allocated for the service concerned in conformity with the Table of Frequency Allocations under ITU RR Article **5**?
– Are there other ITU RR provisions governing the use of the frequencies?
– Is there a need for effecting the coordination procedure prior to notification of the concerned assignment to the ITU Radiocommunication Bureau and/or bringing into use?

Getting a frequency assignment recorded in the Master Register with a favourable finding under RR No. **11.31** acquires the right for the assignment to international recognition. For such an assignment, this right means that other administrations shall take it into account when making their own assignments, in order to avoid harmful interference (see RR No. **8.3**).

A frequency assignment shall be known as a non-conforming assignment when it is not in accordance with the Table of Frequency Allocations or the other provisions of these Regulations. Such an assignment shall be recorded for information purposes, only when the notifying administration states that it will be operated in accordance with RR No. **4.4** (see RR No. **8.4**).

If harmful interference to the reception of any station whose assignment is in accordance with RR No. **11.31** is actually caused by the use of a frequency assignment which is not in conformity with RR No. **11.31**, the station using the latter frequency assignment must, upon receipt of advice thereof, immediately eliminate this harmful interference (see RR No. **8.5**).

The use of some frequency bands and services for satellite networks are subject to coordination procedures spelt out in Section II of RR Article **9**. Before these frequency assignments of these satellite networks can be notified in the Master Register, they must undergo the coordination process. The regulatory procedures for those satellite networks subject to coordination is different from those that are not subject to coordination, and they are described in the following sections.

4.4 Determination of whether a satellite network is subject to coordination under Section II of RR Article 9

The formal coordination procedures are spelt out in Section II of RR Article **9**. To determine whether a frequency band/service used by a non-geostationary-satellite network is subject to these procedures, one should check the Radio Regulations, in particular in the footnotes to the Table of Frequency Allocations under RR Article **5**.

The coordination procedures, most common to non-geostationary satellite networks, are identified by reference to RR Nos. **9.21** and **9.11A** (including the sub provisions RR Nos. **9.12** and **9.12A**) which stems from a footnote in RR Article **5**.

One example is RR No. **5.364**: "The use of the band 1 610-1 626.5 MHz by the mobile-satellite service (Earth-to-space) and by the radiodetermination-satellite service (Earth-to-space) is subject to coordination under No. **9.11A**."

Another example is RR No. **5.286**: "The band 449.75-450.25 MHz may be used for the space operation service (Earth-to-space) and the space research service (Earth-to-space), subject to agreement obtained under No. **9.21**."

It should be noted that coordination under RR No. **9.11A** (including RR Nos. **9.12** and **9.12A**) is required not only for the service specified in the footnote, but it is also required for other services having allocations with equal rights (see Rules of Procedure related to RR No. **9.11A**). As a quick reference, Table 9.11A-1 of the Rules of Procedure provides a list of all frequency bands/direction and services that are subject to RR No. **9.11A**.

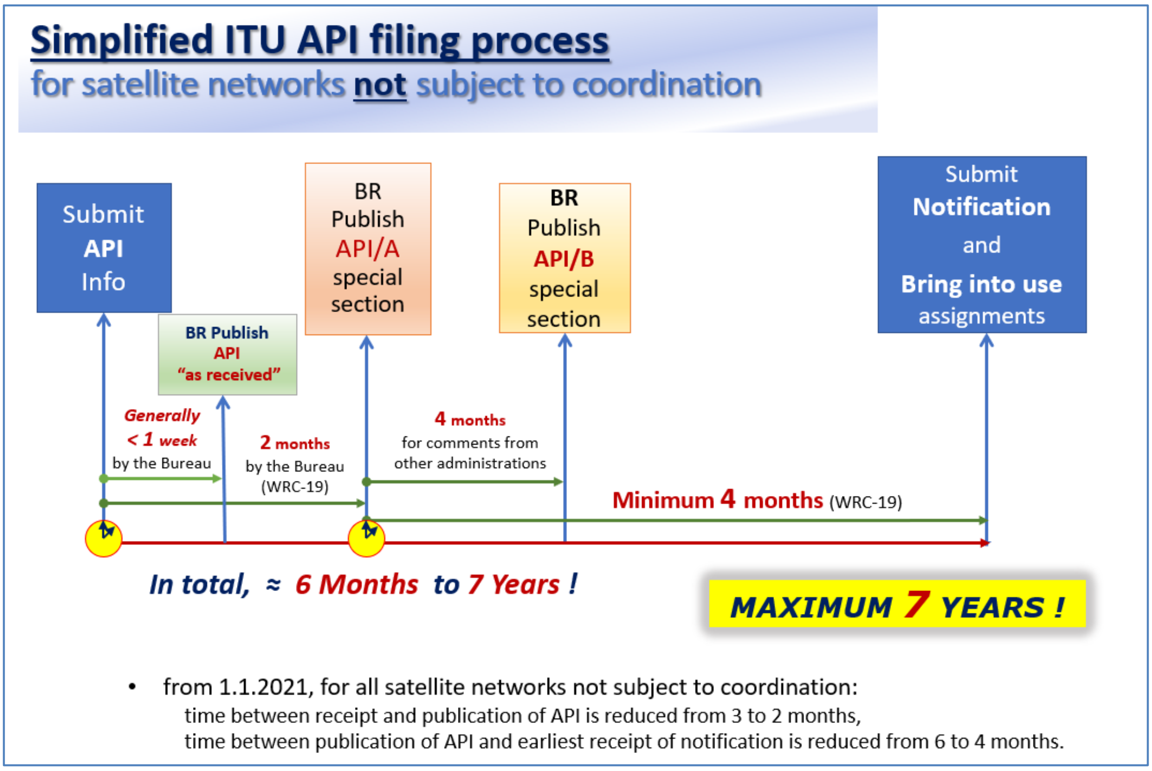
Small satellites are frequently designed to use frequency bands that are not subject to coordination.

4.5 Procedures for satellite networks not subject to coordination under Section II of RR Article 9

The simplified ITU API filing process procedures applying to frequency bands and services which are not subject to coordination procedure is described in Figure 2 below.

FIGURE 2

ITU filing process for satellite networks not subject to coordination



4.5.1 Submission of the Advance Publication Information

For such systems that are not subject to coordination, the provisions of RR Article **9**, Sub-Section IA (Advance publication of information on satellite networks or satellite systems that are not subject to coordination procedure under Section II) are applicable, and the submission of the advance publication information (API) to the Bureau is a mandatory procedure spelt out in RR No. **9.1.**

Information required for API

Information to be provided for the API is specified in RR Appendix **4** and shall be submitted in an electronic format to the Bureau (see Resolution **55 (Rev.WRC-19)**). The format for submission is the SNS database format specified in the Preface to the BRIFIC (Space Services) for the characteristics of the frequency assignments, and the GIMS mdb format for any graphical information.

To assist Administrations in capturing the required information for an API and validate the completeness of the data, the Bureau has made available the following software tools: SpaceCap, GIMS and BRSIS Validation (see also section § 4.7 of this handbook).

Administrations shall use the latest BR software SpaceCap to capture the SNS format notice database.

To submit the characteristics of the antenna radiation patterns for the space station and associated Earth station, please study the details from the Antenna Pattern Library (APL) available at the webpage http://www.itu.int/en/ITU-R/software/Pages/ant-pattern.aspx. Select an appropriate antenna pattern IDs from the APL and enter it in the SNS notice database.

However, if there isn't an antenna pattern listed in the APL that could appropriately describe the antenna used for the satellite network, the user should then submit the antenna pattern as a diagram, which shall be submitted in graphics data format compatible with BR's data capture software GIMS (graphical interference management system) in accordance with Resolution **55 (Rev.WRC-19)**.

When submitting antenna pattern diagrams as images, the following are guidelines to be taken into consideration:

– Make sure the images are captured with the correct header elements in Gims as they are captured in the SNS notice database.

– Pay more attention for the co-polar gain values, which must be provided for all off-axis angles (0 to ±180°).

Check before submission

Prior to submission, the Administration should remember to run the latest version of the BRSIS Validation software, with cross validation between the electronic notice database and the GIMS format database, to ensure that all mandatory information specified in RR Appendix **4** have been captured in both databases concerned. If there is any fatal error, it should be corrected prior to submission to the Bureau.

If fatal errors identified by BRSIS Validation could not be corrected, the Administration may request for assistance from the Bureau in the cover letter accompanying the submission (or by email to brmail@itu.int before the submission).

Submission to the BR

In accordance with the Rules of Procedure on receivability, the final electronic notice mdb file in SNS format, together with the GIMS format database, and any additional attachments, shall be submitted through the Bureau's new online submission system "e-submission of satellite network filings" (https://www.itu.int/itu-r/go/space-submission) (see BR circular letter CR/434 dated 1 August 2018 for more details).

Notices submitted using "e-Submission of satellite network filings" for space services do not require any separate confirmation by telefax or mail. However, it is a good idea to attach a cover letter for the submission together with the upload of the electronic filing, so as to highlight some pertinent points concerning the filing, e.g. the information concerning the operating agency, the address where the invoice should be issued to.

The API that has been successfully submitted to the Bureau will be published shortly in "as-received" via the e-submission system on the ITU website.

Additional points concerning submission

The following are some additional points concerning the checks concerning the receivability of the notice:

– Frequency bands/services included in the API should be not subject to coordination, otherwise the Bureau will inform the administration to submit them separately as a request for coordination.

– If a notice does not contain all of the mandatory information as defined in Appendix **4** of the Radio Regulations, further processing of the notice will remain in abeyance and a date of receipt will not be established until the missing information is received.

– If all mandatory data have been submitted and further clarification is required concerning the correctness of the mandatory data, the Bureau shall request the notifying administration to provide the required clarification within 30 days.

– If the complete and correct information is received within this 30-day period, the original date of receipt is retained, otherwise, a new date of receipt will be established when the required information is received.

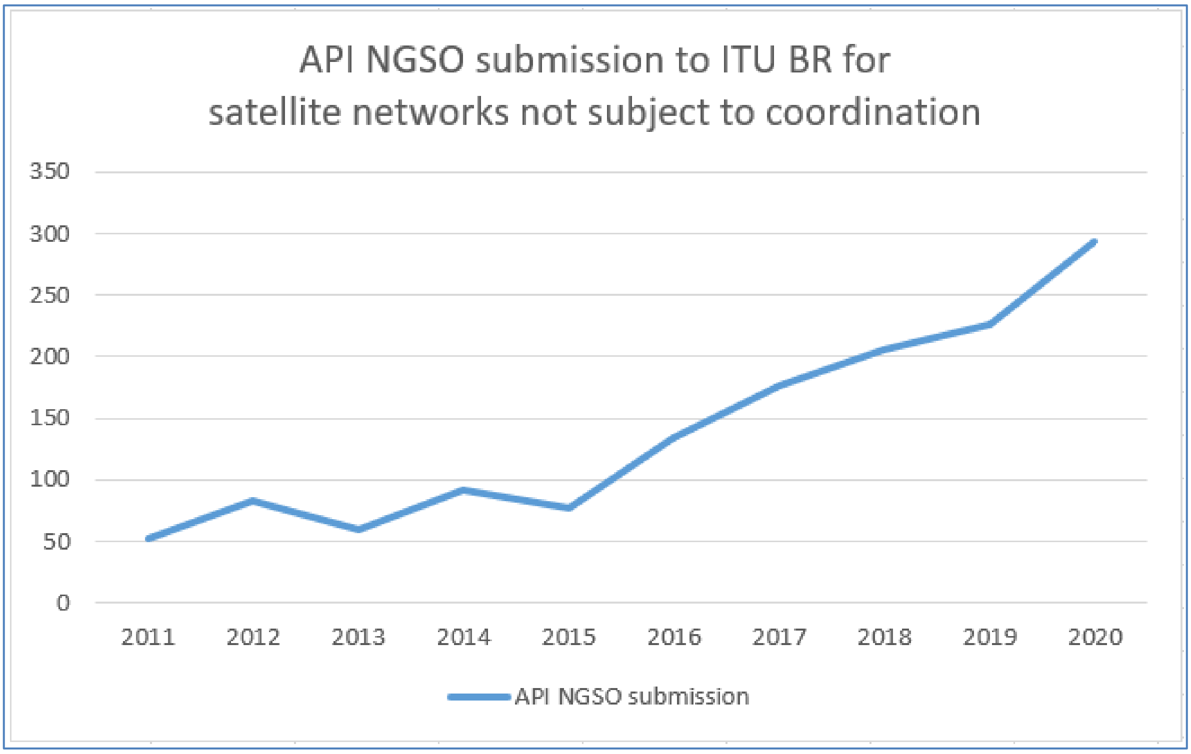
– When the Bureau has determined that the information is complete and correct, it will publish in 2 months the corresponding API/A special section in a BR IFIC.

Submission trends

Recent years have shown a dramatic increase in the number of API submissions for non-GSO satellite networks not subject to the coordination procedure. While the number of such submissions has been moderately increasing since 2011, the rate of increase has significantly accelerated since 2015, and currently, ITU BR is receiving six times the number it was receiving in 2011. This increase from approximately 50 cases in 2011 to nearly 300 cases in 2020 appears likely to continue to be growing (see Figure 3 below).

FIGURE 3

ITU API filing received for non-GSO satellite network not subject to coordination



4.5.2 Commenting procedures and resolution of difficulties

Although these satellite networks are not subject to coordination procedure under Section II of RR Article **9**, there is still a commenting procedure and resolutions of difficulties specified under RR No. **9.3**.

After the publication of the API/A special section, any administration who believes that interference which may be unacceptable may be caused to its existing or planned satellite networks or systems, may submit a comment to the notifying Administration, with a copy to the Bureau, within 4 months from the date of publication of the special section. The copy of comments to the Bureau shall be captured using SpaceCom software.

In order to implement the requirements of RR No. **9.3.1**, the Bureau makes these comments available "as-received" on the ITU website. The Bureau consolidates the comments received at the end of the 4-month period and publishes the list of administrations which have sent comments in an API/B special section of a BR IFIC.

The procedure for cooperation and resolution of difficulties is spelt out in RR Nos. **9.3** and **9.4**, as follows:

– Both administrations shall endeavour to cooperate in joint efforts to resolve any difficulties and shall exchange any additional relevant information that may be available.
– Either party can request the assistance of the Radiocommunication Bureau.
– In case of difficulties, the administration responsible for the planned satellite network shall explore all possible means to resolve the difficulties without considering the possibility of adjustment to satellite networks of other administrations.
– If no such means can be found, it may request the other administrations to explore all possible means to meet its requirements.

– The administrations concerned shall make every possible effort to resolve the difficulties by means of mutually acceptable adjustments to their satellite networks.

For satellite networks operating in the amateur-satellite service, the operator or notifying administration should contact the International Amateur Radio Union for assistance in the frequency coordination process (https://www.iaru.org/reference/satellites/).

Finally, the attention of administrations is brought to the BR Circular Letter CR/420 concerning the application of RR No. **9.3** in the bands 2 025-2 110 MHz (Earth-to-space) and 2 200-2 290 MHz (space-to-Earth).

4.5.3 Submission of the Notification for recording in the Master Register

The benefit of having a frequency assignment to a satellite network notified and recorded in the Master Register is that it has the right to international recognition. For such an assignment, this right means that other administrations shall take it into account when making their own assignments, in order to avoid harmful interference (see RR No. **8.3**).

The frequency assignments that should be notified include those of transmitting and receiving earth and space stations that are:

– Capable of causing harmful interference; or

– Used for international radiocommunication; or

– Seeking to obtain international recognition; or

– Non-conforming assignment seeking to be recorded for information purposes onl*y*

– Etc. (See Nos. **11.2** to **11.11**)

On the other hand, frequency assignments to earth stations in the amateur-satellite service are **not** required to be notified for recording in the Master Register.

Information required for the submission of a notification for recording is spelt out in RR Appendix **4**. The capture, validation and submission procedure described for the API in section §4.5.1 of this handbook also applies to the notification submission.

From 1st January 2021, for notification submission, the earliest date that it can be considered receivable is 4 months after the date of publication of the corresponding API/A special section (this period was of 6 months until 31 December 2020). If it is received by the Bureau earlier, it will be given an official date of receipt that is equal to this earliest date. Due to the need to open to comments and to go through the process of cooperation and resolution of difficulties described in sections §4.5.2 of this Handbook, administrations are advised not to submit notification for recording before this earliest date.

Information received for a notification submission will first be published in a Part I-S of a BR IFIC, as an acknowledgement for the receipt of the complete information. The notification will then be examined in details and a finding will be established, which will be published in a Part II-S if the finding is favourable, and in a Part III-S if the finding is unfavourable. The examination of the satellite networks not subject to coordination will be conducted only with respect to its conformity with the Table of Frequency Allocations and other provisions (e.g. power limits) listed in the Rules of Procedure related to RR No. **11.31**. There will be no examination against coordination requirements (RR No. **11.32**) or probability of harmful interference (RR No. **11.32A**).

It should be noted that if the frequency assignments are published with unfavourable findings, any subsequent request to change the notified characteristics towards attaining a favourable finding will be considered as a modification to the notification, treated with a new date of receipt, and a new cost recovery invoice will be issued.

4.5.4 RR No. 4.4 (non-conformity with the Table of Frequency Allocations under RR Article 5)

When assigning frequencies to stations, Member States shall note that such assignments are to be made in accordance with the Table of Frequency Allocations and other provisions of these Regulations (see RR No.**4.2**).

As stated in the provision RR No. **4.4** that "*Administrations of the Member States **shall not** assign to a station any frequency in derogation of either the Table of Frequency Allocations in this Chapter or the other provisions of these Regulations, except on the express condition that such a station, when using such a frequency assignment, **shall not** cause harmful interference to, and **shall not** claim protection from harmful interference caused by, a station operating in accordance with the provisions of the Constitution, the Convention and these Regulations.*"

In accordance with the Rules of Procedure related to RR No. **4.4**, Administrations, prior to bringing into use any frequency assignment to a transmitting station operating under RR No. **4.4**, shall determine:

a) that the intended use of the frequency assignment to the station under RR No. **4.4** will not cause harmful interference into the stations of other administrations operating in conformity with the Radio Regulations;

b) what measures it would need to take in order to comply with the requirement to immediately eliminate harmful interference pursuant to RR No. **8.5**.

When notifying the use of frequency assignments to be operated under RR No. **4.4**, the notifying Administration *shall provide a confirmation* that it has determined that these frequency assignments meet the conditions referred to above in item a) and that it has identified measures referred to above in item b) to avoid harmful interference and to immediately eliminate such in case of a complaint.

4.5.5 Bringing into use of notified frequency assignments

The information concerning the date of bringing into use (DBIU) is to be provided in the following occasions:

– in Appendix **4** notice forms when submitted under RR No. **11.15**; and

– in the confirmation of the date of bringing into use under RR Nos. **11.47**, **11.44B, 11.44C, 11.44D** and **11.44E**.

The first information of the DBIU should be provided in the submission of the Notification for recording under RR No. **11.2**, as part of the Appendix **4** information, and should be provided for each assignment or group of assignment.

The DBIU indicated in the notification for space stations should not be more than 3 years later than the date of receipt of the notification information by the Bureau (see RR No. **11.25**). Where the DBIU indicated in the notification notice is before the date of receipt of the notice, it is considered as an actual DBIU.

If the notification for recording has not been submitted to the Bureau, any information concerning the bringing into use received by the Bureau will not be processed.

Provisional recording

For notification of a frequency assignment to a satellite network under RR Article **11** having a DBIU later than the date of receipt of the notice, the DBIU is considered as a foreseen date. The frequency assignment is processed under RR No. **11.47**, leading to a provisional entry in the Master Register if these assignments are recorded with a favourable finding.

Confirmation of bringing into use of a provisionally recorded frequency assignment

For those assignments that have been provisionally recorded, when the assignments to the satellite network have been actually brought into use, the Administration shall communicate the information to the Bureau, thus providing the actual DBIU.

For assignments that are provisionally recorded, the information on the actual bringing into use of assignments must be received by the Bureau no later than 30 days after the end of the 7-year regulatory period and the DBIU must of course be within the regulatory 7-year time-limit.

For assignments that are provisionally recorded, if the Bureau does not receive the confirmation of bringing into use on time, it will send a reminder to the notifying administration no more than fifteen days before the end of the 7-year regulatory period.

If the Bureau does not receive that confirmation within thirty days following the end of the 7-year regulatory period, it shall cancel the entry in the Master Register.

Frequency assignments to space stations of a non-GSO satellite system in the fixed-satellite service, the mobile-satellite service or the broadcasting-satellite service

For a frequency assignment to a space station in a non-GSO satellite network or system in the FSS, MSS or BSS, there are additional considerations regarding the bringing into use that are spelt out in RR Nos. **11.44C**, **11.44.2**, **11.44C.1, 11.44C.3, 11.44C.4**.

The Bureau will process the information on bringing into use in two steps: initial information and confirmation.

The initial information is the communication that a frequency assignment to a space station was brought into use and that the continuous 90-day period described in RR No. **11.44C** is not yet passed. Where the initial information has been provided, a reminder for the confirmation under RR No. **11.44C** will be sent to the administration 90 days after the communicated DBIU.

The confirmation of bringing into use of the frequency assignment will be considered as communicated to the Bureau when the administration informs the Bureau that a space station with the capability of transmitting or receiving that frequency assignment has been deployed and maintained on one of the orbital plane(s) of the non-geostationary satellite network or system for a continuous period of 90 days, irrespective of the notified number of orbital planes and satellites per orbital plane in the network or system, as described in RR No. **11.44C.**

The notifying administration shall inform the Bureau of the confirmation of bringing into use as stated above within 30 days from the end of the 90-day period, as described in RR No. **11.44.C.** The notified DBIU of a frequency assignment to a space station of a space station or system shall be the date of commencement of 90-day period, as described in RR No. **11.44.2**.

For cases where the frequency assignment was brought into use more than 120 days prior to the date of receipt of the notification information, this frequency assignment shall be considered as having been confirmed brought into use if the notifying administration confirms that a space station in a non-geostationary-satellite orbit with the capability of transmitting or receiving that frequency assignment has been deployed and maintained on one of the notified orbital planes for a continuous period of time from the notified date of bringing into use until the date of receipt of the notification information for this frequency assignment, as described in RR No. **11.44C.3**.

When the notifying administration informs the Bureau of the bringing into use, it shall identify the orbital plane number as in the latest notification information received by the Bureau that corresponds to the orbital plane in which the space station has been deployed to bring into use the frequency assignments, as described in RR No. **11.44C.4**.

Frequency assignments to space stations of a non-GSO satellite system operating in services other than in the fixed-satellite service, the mobile-satellite service or the broadcasting-satellite service

For a frequency assignment to a space station in a non-GSO satellite network or system **not** in the FSS, MSS or BSS, there are additional considerations regarding the bringing into use that are spelt out in Nos. **11.44D, 11.44D.1, 11.44D.3, 11.44E**.

For a network or system with "Earth" as reference body, the confirmation of bringing into use of the frequency assignment will be considered as communicated to the Bureau when the administration informs the Bureau that a space station with the capability of transmitting or receiving that frequency assignment has been deployed and maintained on one of the orbital plane(s) of the non-geostationary satellite network or system, irrespective of the notified number of orbital planes and satellites per orbital plane in the network or system, as described in RR No. **11.44D.**

When the notifying administration informs the Bureau of the bringing into use, it shall identify the orbital plane number as in the latest notification information received by the Bureau that corresponds to the orbital plane in which the space station has been deployed to bring into use the frequency assignments, as described in RR No. **11.44D.3**.

For a network or system with a reference body that is not "Earth", the confirmation of bringing into use of the frequency assignment will be considered as communicated to the Bureau when the administration informs the Bureau that a space station with the capability of transmitting or receiving that frequency assignment has been deployed in accordance with the notification information, as described in RR No. **11.44E.** Since information concerning the orbital planes are not required for such network or system, there is no requirement to identify the orbital plane id.

Extension for BIU frequency assignments by the Radio Regulations Board

In cases of *force majeure* or co-passenger delay concerning the launch of the satellite, the notifying administration may submit a request to the Radio Regulations Board (RRB) to consider an extension of the regulatory time-limit for bringing into use frequency assignments.

4.5.6 Modifications to the characteristics of the satellite network

Any amendments to the information published in an API/A special section should be sent to the Bureau as soon as they become available. It is a good practice to submit a modification to the API including any change in characteristics like orbital characteristics, service areas, addition of associated earth stations, etc. because this will allow other administrations and operators to submit comments before the modifications are notified for recording in the Master Register.

In particular, amendments to the following information for Non-GSO satellite filing shall require a new API:

– Additional frequency band;
– Modification of the direction of transmission;
– Modification of reference body.

If, in the notification submission, there are other changes in the characteristics as compared to the information published in API/A, other administrations can submit comments following the publication of the Part I-S (RR No. **11.28.1**).

4.5.7 Resolution 32 (WRC-19) for non-GSO satellites with short-duration missions

In recent years, an increasing number of academic institutions, amateur satellite organizations and government agencies have been developing non-GSO satellite systems with short duration missions using nano and picosatellites. Considering that non-GSO satellites with short-duration missions (NGSO-SDM) utilizing low-Earth orbits are being used for a wide variety of applications including remote sensing, space weather research, upper atmosphere research, astronomy, communications, technology demonstration and education, and therefore may operate under various radiocommunication services, and that advances in the field of satellite technology have resulted in non-GSO satellites with short-duration missions becoming a means for developing countries to become involved in space activities, WRC-19 adopted the new procedures spelt out in Resolution **32 (WRC-19)** for non-geostationary-satellite networks or systems identified as short-duration mission.

When submitting such a network, the administration must identify it in the notice database, by checking the indicator for data item No. **A.1.g** of RR Appendix **4** via the BR capture software SpaceCap for the API as well as the notification notices.

For NGSO-SDM, there are several additional constrains listed in the Resolution, including the following:

– NGSO-SDM shall operate under any space radiocommunication service in the frequency bands that are *not subject to the application of Section II of Article* ***9***;

– The total number of satellites in NGSO-SDM shall not exceed 10 satellites;

– The maximum period of operation and validity of frequency assignments of the NGSO-SDM shall not exceed 3 years from the date of bringing into use of the frequency assignments, and further extension is not allowed, after which the recorded assignments shall be cancelled;

– NGSO-SDM system shall have the capability to cease transmitting immediately in order to eliminate harmful interference;

With respect to the notification for recording for satellite networks:

– An additional commitment (item **A.24.a** of RR Appendix **4**) is required from the Administration that, in the case that unacceptable interference caused by NGSO-SDM is not resolved, administration shall undertake steps to eliminate the interference or reduce it to an acceptable level;

– The notification information can only be submitted after the launch of a first satellite, but not more than 2 months after the date of bringing into use of the frequency assignments;

– The date of bringing into use of the frequency assignments of NGSO-SDM shall be defined as the launch date of the first satellite;

– Provisions relating to modifications of characteristics of recorded assignments and suspension of assignments (RR Nos. **11.43A**, **11.43B** and **11.49)** cannot be applied for NGSO-SDM;

– At the expiry date of period of validity, BR shall publish a suppression of the related Special Section and cancel the recording in the Master Register.

The above constrains are in addition to others that normally apply to all satellite networks. Note that although any non-geostationary satellite network that is using any space radiocommunication service in any frequency bands that are not subject to the application of Section II of RR Article **9** may be submitted as NGSO-SDM, it may not be beneficial to do so due to the additional constraints listed above.

On the other hand, the following bands: 137.025-138 MHz (space-to-Earth) and 148-149.9 MHz (Earth -to-space) are allocated to the space operation service on the condition that they are submitted as NGSO-SDM in accordance with Resolution **32 (WRC-19)**. Such usage is exempt from coordination procedures under RR Nos. **9.11A** and **9.21**, but comes with some conditions as spelt out in RR Nos. **5.203C** and **5.218A**, Resolution **660 (WRC-19)** in addition to those listed in Resolution **32 (WRC-19)**.

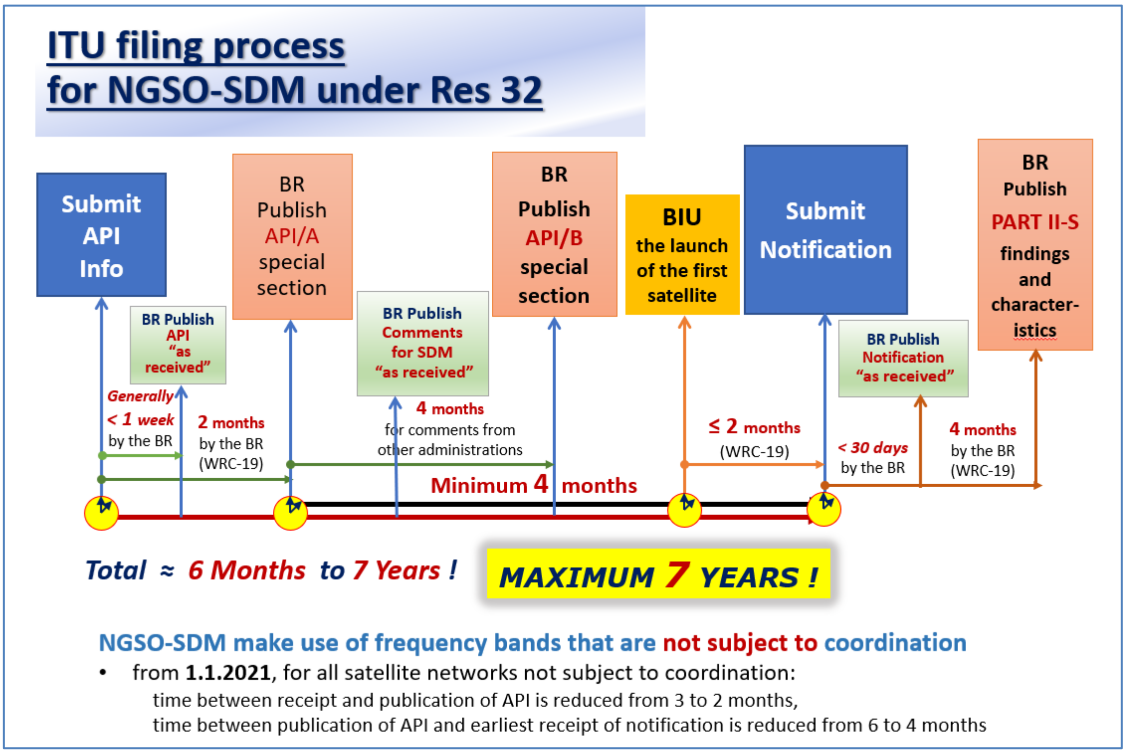
For NGSO-SDM satellite networks, the findings and the characteristics of the system will be published in the BR IFIC and on the ITU website within 4 months from the date of receipt of complete notification information.

Comments to API/A special sections for NGSO-SDM satellite networks are also made available "as-received", on the ITU website, in accordance with RR No. **9.3.1**.

The ITU filing process for NGSO-SDM satellite networks not subject to coordination under Resolution **32 (WRC-19)** is shown in the Figure 4 below:

FIGURE 4

ITU filing process for NGSO-SDM satellite networks submitted under Resolution 32 (WRC-19)

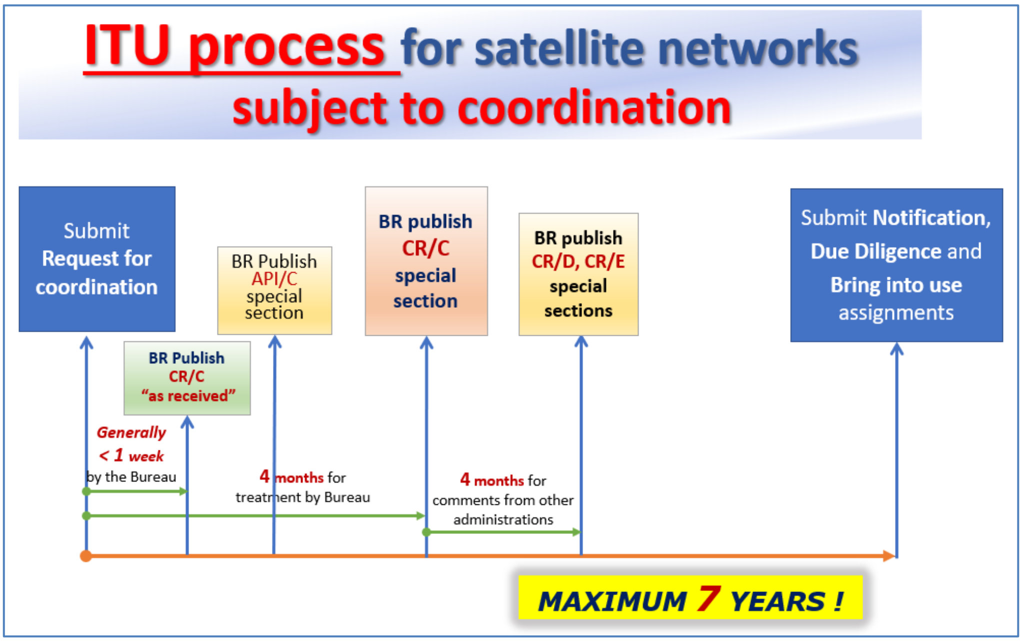


4.6 Brief description on procedures for satellite networks subject to coordination under Section II of RR Article 9

In brief, the ITU filing process procedures applying to frequency bands and services which are subject to coordination procedure is shown in Figure 5 below:

FIGURE 5

ITU process for satellite networks subject to coordination



As shown in Figure 5 above, for satellite networks subject to coordination under Section II of RR Article **9**, it is required to first submit a request for coordination (CR).

Upon receipt of the complete CR information, the BR will extract the basic characteristics from the CR and publish them in the API/C Special Section.

The BR will carry out examination of the satellite network in accordance with RR No. **9.35**, identify in accordance with RR No. **9.36**, any administrations with which coordination may need to be effected, and publish the result of the examinations in a CR/C special section within 4 months.

There is a 4-month commenting period from the date of the publication for other administrations to submit comments under the various coordination provisions. At the end of the 4 months, the BR will consolidate and publish all comments from other administrations in the relevant CR/D and CR/E special sections.

Within 7 years from the date of receipt of the CR, the Administration must submit the notification, the due diligence and bring into use the frequency assignments accordingly, otherwise the satellite network will be suppressed.

The due diligence (Resolution **49**) information is required for FSS, BSS, MSS subject to coordination.

As it is not common for small satellite projects to make use of frequency bands subject to coordination, the details will not be covered in this Handbook.

4.7 List of the BR software used for filing of space notices to the Bureau

The latest BR software used for filing of space notices to the Bureau is shown in the webpage below:

https://www.itu.int/ITU-R/go/space-software/en

BR Software Tools & Aids	Description
Space Capture Software (SpaceCap) (mandatory)	PC-based software for the electronic capture of information identified in the RR Appendix 4 in SNS format for API, Coordination and Notification notices
Graphical Interference Management Software (Gims) (mandatory)	Software package which allows the capture and modification of graphical data relating to the electronic notices of satellite networks
Space filing Validation Software (BRSIS-Validation) (mandatory)	PC-based software for validating electronic notices captured by the SpaceCap and Gims software
Space data Query Software (BRSIS-SpaceQry)	PC-based software package which allows the query/access to any SNS formatted database
Space Publication Software (SpacePub)	PC-based software utility for printing satellite networks / earth stations data from a SNS formatted database. It creates a RTF (Rich Text Format) file readable by Microsoft Word. It also allows the user to specify that the associated graphical data taken from the GIMS database be included in the document.
Capture system for comments on Special Sections (SpaceCom)	SpaceCom software package is a stand-alone application designed to assist administrations and the Bureau in the management of the comments on four types of Special Sections: CR/C, API/A, AP30-30A Part A, AP30-30A/F/C

4.8 Cost recovery principles and fees for the processing of satellite network filings

The ITU Council determines the cost recovery principles and fees for the processing of the satellite network filings by the Radiocommunication Bureau (BR).

Satellite network filings concerning advance publication and notification for recording of frequency assignments in the Master International Frequency Register are subject to cost-recovery charges, as defined in Council Decision 482 (Modified 2020), available at the webpage:

http://www.itu.int/ITU-R/go/space-cost-recovery/en

For a non-GSO satellite networks or systems not subject to coordination, the fees are described as follows:

– For non-GSO API: 570 CHF

– For Notification: 7 030 CHF for recording in the MIFR of frequency assignments to a satellite network not subject to coordination under Section II of Article 9, or to a non-GSO satellite network subject to RR No. **9.21** only.

There is no cost recovery charge for a submission of satellite notice in the Amateur-satellite service.

Each Member State is entitled to the publication of special sections or parts of the BR IFIC (space services) for one satellite network filing each year without the charges referred to above. Each Member State in its role as the notifying administration may determine which network shall benefit from the free entitlement.

The nomination of the free entitlement for the calendar year of receipt by the Bureau of the satellite network filing based on the formal date of receipt of the filing shall be made by the Member State no later than the end of the period for payment of the invoice. The free entitlement cannot be applied to a filing previously cancelled for non-payment.

If payment for the invoice is not received by the due date, the satellite network will be cancelled. It should be noted that even after the cancellation of the satellite network, the invoice remains payable.

4.9 ITU Publications and References

[1] The International Telecommunication Union (ITU) website:
https://www.itu.int

[2] ITU Constitution, Collection of the Basic Texts of the International Telecommunication Union adopted by the Plenipotentiary Conference, Edition of 2019:
https://www.itu.int/pub/S-CONF-PLEN\

[3] ITU Radio Regulations, Edition of 2020:
http://www.itu.int/pub/R-REG-RR/en

[4] ITU Rules of Procedure, Edition of 2017 (+rev.6):
http://www.itu.int/pub/R-REG-ROP/en

[5] ITU Preface to the BR IFIC (Space services):
http://www.itu.int/ITU-R/go/space-preface/en

[6] ITU Council Decision 482 (Modified 2020) on Satellite Cost Recovery:
http://www.itu.int/ITU-R/go/space-cost-recovery/en

[7] Latest BR Software:
https://www.itu.int/ITU-R/go/space-software/en

[8] ITU API support page:
https://www.itu.int/en/ITU-R/space/Pages/API.aspx

[9] ITU Small Satellite Support web page:
http://www.itu.int/en/ITU-R/space/Pages/supportsmallsat.aspx

[10] ITU-R Reports:
https://www.itu.int/pub/R-REP/

[11] ITU Amateur and Amateur-satellite service Handbook:
http://www.itu.int/pub/R-HDB-52/en

5 Types of missions

TBD.

5.1 Scientific missions

5.2 Education missions

5.3 Experimental missions

5.4 Commercial missions

5.5 Earth-based, moon-based, inter-planetary or deep space missions

5.6 Short duration missions under Resolution 32 (WRC-19)

6 Space object registration

Legal issues relating to responsibility and liability at a national and international level should be considered at the “Project Definition” stage of a satellite mission design process.

Under the provisions of the 1967 Outer Space Treaty[1], a State bears “international responsibility” for national activities in outer space, including the Moon and other celestial bodies, whether such activities are carried on by governmental agencies or by non-governmental entities. A State is also required to authorize and continually supervise the space activities of non-governmental entities.[2] In addition, a State is “internationally liable” for damage caused by a space object that it launches or procures the launching of or from whose territory or facility an object is launched.[3] The issues of liability for damage caused by space objects are expanded upon in the 1972 "Liability Convention".[4]When a space object is launched into Earth orbit or beyond, a State is required to register it with the Secretary-General of the United Nations under the 1976 "Registration Convention" or in accordance with General Assembly resolution 1721B (XVI).[5]

The Registration Convention requires that when a satellite is launched into Earth orbit or beyond, the State of registry shall provide relevant information to the Secretary-General of the United Nations for entry in the United Nations Register of Objects Launched into Outer Space. The term State of registry means a launching State on whose registry a space object is carried in accordance with Article II of the Registration Convention. Article II stipulates conditions for when a launching State is to be considered a State of registry. The registration of a satellite may be part of a State’s authorization/licensing mechanism.

If a State is not Party to the Registration Convention, meaning that it has not acceded to or ratified the Convention, it can voluntarily provide registration information on the space object under General Assembly resolution 1721B (XVI) of 20 December 1961.

In cases where a satellite mission uses “foreign” launch services or when there is more than one State involved in the mission, the Registration Convention requires that the involved States jointly determine which of them should be the State of registry. In general, States providing launch services do not register satellites launched on behalf of foreign clients.

Those requirements also apply to an international intergovernmental organization which conducts space activities and has declared its acceptance of the rights and obligations under the Registration Convention.

It should be noted that only one State of registry should exist for a particular satellite.

General Assembly resolution 68/74 stipulates in paragraph 6 that a national registry of objects launched into outer space should be maintained by an appropriate national authority; operators or owners of space objects for which the State is considered to be the launching State or the State responsible for national activities in outer space under the United Nations treaties on outer space should be requested to submit information to the authority to enable the State on whose registry such objects are carried to submit the relevant information to the Secretary-General of the United Nations in accordance with applicable international instruments, including the Registration Convention, and in consideration of General Assembly resolutions 1721B (XVI) and 62/101 of 17

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[1] Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies.

[2] Article VI of the Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies.

[3] Article VII of the Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies.

[4] Convention on International Liability for Damage Caused by Space Objects.

[5] Convention on Registration of Objects Launched into Outer Space.

December 2007; the State may also request information on any change in the main characteristics of space objects, in particular when they have become non-functional.

Upon launch of a satellite into Earth orbit or beyond, the national competent authority of the State of registry should send the relevant information to the Secretary-General through a Diplomatic Mission accredited to the United Nations.

It should be noted that registration information submitted directly to the United Nations by national agencies, private corporations, academic institutions or individuals will not be considered valid submissions, and only information provided through Diplomatic Missions accredited to the United Nations will be considered valid registration submissions. The information should be addressed to the Secretary-General of the United Nations and sent to oosa@unvienna.org or soregister@unoosa.org.

Article IV, paragraph 1 of the Registration Convention requires specific information to be provided to the Secretary-General. In addition, Article IV, paragraph 2 allows the State of registry to provide additional information on a particular satellite. The 2007 General Assembly resolution 62/101 on"Recommendations on enhancing the practice of States and international intergovernmental organizations in registering space objects" expands upon the types and formats of such additional information. Article IV, paragraph 3 requests that information on when a satellite is no longer in Earth orbit (date of decay/reentry) be provided.

To assist States submitting registration information, the Office for Outer Space Affairs of the United Nations (UNOOSA) has produced registration forms in all official languages of the United Nations, see the UNOOSA website:

http://www.unoosa.org/oosa/en/spaceobjectregister/index.html

The form indicates what information is required under the Registration Convention, recommended units of measure, additional information recommended in resolution 62/101 and other voluntarily information that will facilitate the use of the United Nations Register of Objects Launched into Outer Space.

7 Launch considerations

Since launch vehicle capability usually exceeds primary customer requirements, there is typically mass, volume, and other performance margins to consider for the inclusion of a secondary small spacecraft. Small spacecraft can exploit this surplus capacity for a relatively inexpensive ride to space. A large market of adapters and dispensers has been created to compactly house multiple small spacecraft on existing launchers. These technologies provide a structural attachment to the launcher as well as deployment mechanisms. This method, known as "rideshare," is still the main way of putting small spacecraft into orbit. As these adapters and dispensers have become more developed, dedicated ridesharing, where an integrator books a complete launch and sells the available capacity to multiple spacecraft operators without the presence of a primary customer, has taken on more popularity. Additionally, nanosatellite form factors are increasing in dimension, which require larger dispensers to accommodate larger CubeSat sizes.

Although not a new idea, using orbital manoeuvring systems to deliver small spacecraft to intended orbits is another emerging technology. Several commercial companies are developing orbital tugs to be launched with launch vehicles to an approximate orbit, which then propel themselves with their on-board propulsion system to another orbit where they will deploy their hosted small spacecraft.

In the future, the expanding capabilities of small satellites will also demand dedicated launchers. For missions that need a very specific orbit, interplanetary trajectories, precisely timed rendezvous, or special environmental considerations, flying the spacecraft as a primary spacecraft may be the best method of ascent. Technology developers and hard sciences can take advantage of the quick iteration time and low capital cost of small spacecraft, to yield new and exciting advances in space capabilities and scientific understanding.

8 Space debris mitigation

Depending on national legislation, satellite missions may require licensing/authorization by a national authority. This agency may be the national radio-telecommunications regulatory entity, the national space agency or the national science and technology entity. For a list of online national legislation relating to space activities, see the UNOOSA website:

http://www.unoosa.org/oosa/en/ourwork/topics/space-debris/compendium.html

General Assembly resolution 68/74 of 11 December 2013 "Recommendations on national legislation relevant to the peaceful exploration and use of outer space", provides elements for consideration, as appropriate, by States when enacting regulatory frameworks for national space activities, in accordance with their national law, taking into account their specific needs and requirements. The resolution covers the scope of space activities targeted by regulatory frameworks; national jurisdiction for regulating the space activities of governmental and non-governmental entities; procedures for authorization and licensing of national space activities, including to ensure continuing supervision and monitoring of authorized space activities; registration of objects launched into outer space and establishment of national registries; liability and indemnifications procedures; and procedures with regard to the change in status of the operation of a space object in orbit.

As part of the authorization mechanism, national authorities may also require implementation of space debris mitigation measures based on national standards and/or on the Space Debris Mitigation Guidelines of the Committee on the Peaceful Uses of Outer Space (ST/SPACE/49). For a compendium of national space debris mitigation standards, see the UNOOSA website:

http://www.unoosa.org/oosa/en/ourwork/spacelaw/nationalspacelaw/index.html

This compendium and the resources on the dedicated webpage of the website of the Office for Outer Space Affairs, serves as a collection of relevant regulative information provided by States and international or intergovernmental organizations, as well as relevant international instruments.

Implementation of space debris mitigation measures should be considered at the "Preliminary Design Review" stage, especially for missions that require deorbiting/passivation of on-board systems during the mission termination phase.

As agreed by the General Assembly in its Resolution 62/217 of 22 December 2007, the Space Debris Mitigation Guidelines of the Committee on the Peaceful Uses of Outer Space reflect the existing practices as developed by a number of national and international organizations. From a technical point of view, the guidelines are applicable to mission planning and the operation of newly designed spacecraft and orbital stages and, if possible, to existing ones. There is a total of seven guidelines:

a) to limit debris released during nominal spacecraft/orbital stages operations;

b) to minimize the potential for break-ups during operational phases;

c) to limit the probability of accidental collision in orbit;

d) to avoid intentional destruction and other harmful activities;

e) to minimize the potential for post-mission break-ups resulting from stored energy;

f) & g) to limit the long-term presence of spacecraft and launch vehicle orbital stages in the low-Earth orbit (LEO) region/geosynchronous Earth orbit (GEO) region after the end of their mission.

The guidelines are not legally binding under international law, but under this Resolution the General Assembly invites Member States to implement those voluntary guidelines through relevant national mechanisms, to the greatest extent feasible, and through space debris mitigation practices and procedures.

9 Current practice for satellite networks or systems

TBD.

Attachment 1 – List of abbreviations

Attachment 2 – List of references

TBD