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DotEcon Report

Satellite Earth Station Licensing Review

Consultants Report

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Satellite Earth Station Licensing Review

Interim report

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Executive Summary

This is the first of two reports commissioned by ComReg to inform its review of satellite earth station (SES) licensing in Ireland. It summarises the current situation and provides a summary of emerging issues following a round of interviews with stakeholders.

Licence types

SES licences

SES licensing in Ireland is governed by the Wireless Telegraphy (Fixed Earth Stations and Teleport Facility) Regulations 2007 (Statutory Instrument No. 295 of 2007), with the technical conditions described in ComReg's SES licensing guidelines (ComReg document 00/64 R3).

ComReg currently offers two types of SES licence:

1. Fixed satellite earth station (FSES) licences, of which there are two sub-types:
    a. Fixed Earth Station (FES) licences, for earth stations located at a fixed location (including large earth stations and Very Small Aperture Terminals (VSAT)); and
    b. Transportable Earth Station (TES) licences, for earth stations that may operate from different locations, but remain fixed during operation (e.g. for news gathering applications).
2. Teleport Facility licences, for earth stations with more than one antenna communicating with two or more satellites over different frequencies (essentially a cluster of FES operations at one location).

FSES licences are for 12 months unless a longer duration licence (of up to 60 months) is requested.

FES licences are currently only for frequencies above 3 GHz and are both transmit and receive capabilities. TES licences are primarily used by broadcasters for mobile news gathering.

Test and trial

Satellite operators testing innovative technology or undertaking trials for a potential future service are also able to operate an earth station under ComReg's test and trial licensing scheme.

Bands

International standards

The International Telecommunication Union (ITU) makes recommendations on allocation of spectrum for satellite services,

with the Radio Regulations defining primary and secondary allocations. Within Europe, the European Conference of Postal and Telecommunications Administrations (CEPT) carries over ITU recommendations. ComReg's frequency plan aligns with applicable ITU allocations and the associated European Common Allocation (ERC Report 025).

Bands used in Ireland

At present, there are 17 distinct frequency bands for SES licences in use in Ireland. Two of these bands (12.5-12.75 GHz and 14.0-14.25 GHz) are exclusive for SES and not shared with any other service. However, most bands are shared with various other wireless services, often fixed links, either on a co-primary basis (where coordination with other services is needed) or a primary/secondary basis (where SES has priority and the other services must operate on a non-protected, non-interference basis).

Stakeholders noted that some spectrum recommended for satellite services by the ITU is not currently available for SES licensing in Ireland:

- Frequencies below 3 GHz;
- Frequencies in the Ka band where only 500 MHz is available for Earth-to-space links.

Otherwise, ComReg has fully implemented all CEPT/ECC Decisions regarding frequencies above 3 GHz.

New bands

Higher bands (Q and V bands) are likely to become important for additional capacity in future, though there is little consensus yet on likely timing.

Current charging structure

Charging for SES licences depends on whether the band in question is shared or exclusive use. For shared bands, fees depend on the band, bandwidth used and power (EIRP). Annual fees range from €50 to over €2,500 up to 80 MHz bandwidth (increasing with bandwidth beyond this). Exclusive use bands are significantly cheaper: €100 for each of the first 10 earth stations, then €25 for each additional station.

Take-up of licences

As of June 2021, there were 56 live SES licences in Ireland held by 21 different licensees. Roughly half are TES licences, mostly held by broadcasters. No Teleport licences have ever been issued.

Licences are spread between shared and exclusive bands. Typical bandwidths vary greatly, with some users needing less than 1 MHz and others in excess of 500 MHz.

Use cases and need for SESs

The need for SESs ultimately derives from use cases for satellites. These services are changing. Traditionally, the focus of satellite services has been on VSAT systems for low-capacity broadband from geostationary satellites, broadcast applications (both remote news gathering and broadcast distribution) and low capacity positioning and navigation systems.

LEO broadband services

There is current expansion into high-bandwidth, low-latency broadband services delivered from low earth orbit (LEO) satellite constellations (such as SpaceX's Starlink[1], Amazon's Project Kuiper[2] and OneWeb[3]). These providers are primarily targeting under-provided rural broadband services, but some are aiming to serve additional segments such as aeronautical and maritime connectivity. Lower orbits and large constellations require more ground stations than traditional geostationary VSAT services. However, LEO operators still have a fair degree of flexibility where they locate ground stations within a region; this flexibility may be enhanced by optical cross-links between satellites. Nevertheless, it is reasonable to expect that as demand for these new services grow, so will the need for ground stations.

Remote sensing

Remote sensing applications are growing. These may have particular needs for downlink of acquired data when passing over SESs. These applications may have particular orbital characteristics, such as polar or sub-synchronous orbits. Ireland is well located to host ground stations for such services, though Northern Scandinavia is also attractive.

IoT backhaul

Satellites are also being used to backhaul IoT applications, uplinking relatively small amounts of data over low power links, storing and forwarding this once in range of an SES. These applications may use VHF/UHF frequencies below 3 GHz. Ground stations for downlink may not require large or complex antennas and, in some cases, may be technically similar to user terminals. Some services may be able to tolerate interference on downlinks and use licence exempt or lightly licensed spectrum.

Mobile communications

Whilst there is no satellite component in mass-market mobile communications services, there are currently specialist services available to support users in remote areas. There are various potential developments afoot to bring satellite connectivity to mass-market mobile handsets.

[1] https://www.starlink.com/

[2] https://www.aboutamazon.com/news/innovation-at-amazon/project-kuiper-announces-plans-and-launch-provider-for-prototype-satellites

[3] https://oneweb.net/

The table below summarises the main use cases identified from our interviews with stakeholders.

Use case	Freq. bands	Bandwidth	Orbits	Earth stations
Earth exploration	UHF, S, X, and Ka	Large BW needs	nGSO (sun-synchronous especially relevant)	Many stations across the world
IoT	< 3 GHz	Small BW needs	Small LEO constellations	Large gateways and smaller user terminals
GSO Broadband	C, Ku, and Ka	Large BW needs	GSO	Fewer large gateways (large satellite footprint) and small user terminals
LEO Broadband	Ku and Ka	Large BW needs	Large LEO constellations	Many large gateways across the service area and small user terminals
Mobile comms	Various		nGSO	Large gateways and user devices
Broadcast	X and Ku bands		GSO	Large gateways for uplink and small terminal for downlink to users
Satellite News Gathering	Ku	Small BW needs	Various, both GSO and nGSO	Small (often transportable) terminals
Navigation and Positioning	Low frequencies		MEO	Gateways, smaller sensing stations, and user

Interference between users

Interference between ground stations

The potential for interference between ground stations is limited and fairly easily managed. This is because antennas are highly directional and generally point upwards. Coordination of elevation and azimuth angles can limit interference, as can modest separation (tens of kms). The greater use of LEO constellations may somewhat increase the need for coordination between nearby ground stations, but this was not anticipated to be a material problem by stakeholders. Therefore, there is no significant scarcity in spectrum created by interaction between ground stations.

Co-primary use with other services

Where satellite services share spectrum with other co-primary wireless services, there is the potential that those services could be

sterilised in a limited protection zone around a ground station. However, in practice these issues tend to be limited and mainly involve fixed links. It is relatively easy to consider interference between fixed links and SES during the application process for licences.

At least in principle, there is a question of how best to achieve efficient use of the contested spectrum resources that could occur between SES and terrestrial services that are co-primary. The main question for economic efficiency is whether ground stations that conflict with other co-primary services in shared bands have incentives to locate where they minimise their impact. For example, locating ground stations in rural areas may minimise the impact on other services.

Some stakeholders have expressed concern about 5G mobile services, partially in terms of the potential for spectrum in the Ka band to be taken away from satellite users and reallocated to MNOs, but also around possible 5G use of the 28 GHz fixed link band, which partially overlaps with the Ka band. However, it is difficult to see how point-to-point links within this band would cause difficulties for SES operators. In addition, some (relatively unspecific) concerns were raised about point-to-multipoint use of this band for rural FWA and the difficulties around coordinating with these use cases, but we also note that these services would compete with satellite broadband services.

There is an ongoing dispute in the Netherlands regarding existing use of the 3.5 GHz band by Inmarsat[4]. However, this centres on whether the Dutch government has been unduly pessimistic about coexistence between SES and 5G mobile services in this band and requiring Inmarsat to vacate the band. If anything, the case again suggests that coexistence is often possible.

Emerging issues

Although this study is at a preliminary stage, several issues have emerged from our interviews.

There is clear need to ensure that the SES licensing framework keeps up with technological developments. Interference management is not onerous, but SES operators need information to plan ahead.

The definition of what constitutes a ground station may need to be updated to take into account that:

- a ground station may have multiple antennas, for example to handle multiple satellites in view within a constellation, but this does not typical worsen concerns about interference;

[4] https://www.inmarsat.com/en/news/latest-news/corporate/2021/dutch-administrative-court-rules-protect-inmarsat-safety-services.html

- there is a developing market for providing SES as a service to multiple satellite operators; and
- some applications may have very light-weight requirements, with low power, low duty cycles and ability to tolerate interference, making a ground station more similar to a user terminal.

With regard to fees, opportunity costs imposed on terrestrial users within shared use bands appear modest. To the extent that conflicts do occur, and opportunity costs are material, current fees for shared bands have a broadly sensible structure, though it is not clear whether they need to be at current levels to obtain efficient outcomes.

However, an emerging concern may be that interference-protected ground stations should locate to minimise their sterilising impact on terrestrial services; this issue is not reflected in the current fee structure. Separately, the next report will assess the need for any incentive prices for spectrum efficiency reasons and it might be appropriate to look at improving information available to current and potential users in the first instance to support coordination amongst them.

1 Introduction

The Commission for Communications Regulation (ComReg) has engaged DotEcon Ltd (DotEcon) and Axon Consulting (Axon) to assist with its review of the Satellite Earth Station (SES) licensing framework in Ireland. The study will look at all aspects of the licensing framework, including (but not limited to):

- likely future developments in demand for SES licences in Ireland;
- the need, if any, for making new bands available for SES licences and/or for adjusting the current set of available bands;
- the structure of licences to be assigned as part of a future licensing regime;
- the technical conditions and guidelines for licensing SES; and
- an appropriate fee structure for SES licences.

This report is the first of two to be prepared by DotEcon and Axon, after which ComReg will, if necessary, conduct a consultation process on any proposed changes.

During the initial stages of the project, we conducted a series of interviews with various stakeholders. This document sets out our initial understanding from this feedback from stakeholders and initial desk research, in relation to:

- the current SES licensing regime in Ireland (including which aspects of satellite licensing are supranational);
- use cases for satellite services;
- recent trends and developments in the satellite industry that might impact on demand and requirements for earth stations;
- the importance of geography for operators when determining where to locate an earth station; and
- the set of emerging issues that we believe will be relevant to our recommendations on any changes to the SES licensing regime.

For the avoidance of doubt, our current thinking and list of emerging issues is still preliminary. No firm views or recommendations have yet been reached. Moreover, we recognise that (for practical reasons) we were not able to include all stakeholders in the interview process, and so it is possible that some issues or relevant considerations have not yet been identified.

We would, therefore, welcome feedback from interested parties in relation to the material presented in this report, as well as any other relevant considerations or issues that we may have missed.

2 Current licensing regime

2.1 Satellite earth station licensing

SES licensing is governed by the Wireless Telegraphy (Fixed Earth Stations and Teleport Facility) Regulations 2007 (Statutory Instrument No. 295 of 2007), with the technical conditions described in ComReg's SES licensing guidelines.[5] ComReg currently offers two types of SES licence:

1. Fixed satellite earth station (FSES) licences, of which there are two sub-types:
    a. Fixed Earth Station (FES) licences; and
    b. Transportable Earth Station (TES) licences.
2. Teleport Facility licences (which are, in essence, for a cluster of FES operations at one location).

What is an earth station?

In terms of SES licences in Ireland, an earth station (or 'gateway') means a large antenna which connects to a satellite system and is used to provide telephony and data backhaul, broadcast feeder links, private networks or telecommand and control. Earth stations are distinct from user terminals, which are small antennas and associated equipment by which the end-user receives services and which are typically licence exempt.

Transmit and receive

SES licences can be issued for transmit only (Earth-to-space) operation, and/or for receive (space-to-Earth). Any transmit operation is required to be licensed unless covered by the regulations on licence exempt use. Receive only stations can operate on a licence exempt basis, since they pose not risk of interference to neighbouring users. If licensed for transmit only, the earth station is automatically allowed to receive, but only on a non-protected non-interference basis.

Licence duration

FSES licences are typically issued with a licence duration of 12 months and are renewable annually. A longer licence duration can be requested by the licensee at the time of issue but cannot exceed 60 months. Temporary licences may be issued for periods of less than one year but are not renewable.

For a Teleport Facility licence, the licence term is 5 years, after which the licence can be renewed.

Satellite operators testing innovative technology or undertaking trials for a potential future service are also able to operate an Earth station under ComReg's test and trial licensing scheme.

[5] ComReg 00/64R3

2.1.1 Fixed Earth Stations (FES)

Fixed Earth Station (FES) licences are for earth stations used at fixed locations, including large earth stations and Very Small Aperture Terminals (VSAT).[6]

The current SES licensing guidelines define FES to be "*...earth stations which operate:*

- *in the fixed satellite service (FSS) at frequencies greater than 3GHz;*
- *as a feeder link in the mobile satellite service (MSS) at frequencies greater than 3GHz;*

or

- *as a feeder link in the broadcasting satellite service (BSS) at frequencies greater than 3GHz."*

Note that FES licences are only for frequencies above 3 GHz. The earth station must transmit/receive on specific frequencies, and are subject to other technical conditions (e.g. on site clearance).

2.1.2 Transportable Earth Stations (TES)

Transportable earth stations (also referred to as Satellite News Gathering stations) are, as defined by ComReg in the SES guidelines, "*used to transmit live or recently recorded footage from different locations*". As the name suggests, these earth stations can transmit from different locations (but remain in a fixed location during operation) and are usually mounted on a vehicle or packed for transportation. This type of station is typically used by broadcasters (e.g. for live on-site reporting of news stories).

ComReg recommends that TES transmit applications be made for frequency bands that are not shared with other primary users (see below), as TES licences often require a quick turnaround time which could be hindered by the need to conduct interference analysis before a licence is granted.

2.1.3 Teleport facilities

ComReg defines a teleport facility in its guidelines as "*two or more Non-transportable Fixed Satellite Earth Stations which collectively provide access to or from an electronic communications network, and which are located at a single, physically demarcated geographic location, and which collectively are capable of transmitting on more*

[6] The SES licensing regime no longer distinguishes between a Large Earth Station and a VSAT for licence applications.

than one frequency to more than one Space Station simultaneously using steerable antennas, follows the same licensing procedure as an individual FES, with the exception that a different fee is applied."

That is, teleport facility licences differ from FES licences in that, under a teleport licence, the holder would operate:

- more than one steerable antenna;
- on more than one frequency;
- to communicate simultaneously with multiple satellites.

The licensing procedure for Teleport facilities is identical to FSES licences (but is subject to a different fee structure).

No teleport licences have been issued

To date, ComReg has never issued a teleport facility licence. Some stakeholders suggested that the teleport facility licences as they stand are outdated and incompatible with current technology and satellite systems. We would appreciate any further views/information from stakeholders on teleport facility licences in Ireland.

2.1.4 Test and trial licences

ComReg operates a test and trial licence scheme that is designed to support innovation and development in new technologies and services, including in the satellite services market where test and trial licences may be used for operating earth stations over certain frequencies:

- **Test licences** are for carrying out tests of novel or innovative technology and do not permit the involvement of members of the public or the provision of services to third parties.
- **Trial licences** are for carrying out trials of novel or innovative radio services involving members of the public or other third parties and are available to any new service that does not fit within existing licence categories.

Both licence types are subject to a maximum term of 12 months (although may be extended following a formal request). They are issued on a non-interference, non-protected basis.

These licences are intended to be used for testing radio equipment or trialling new services, and not for providing commercial services, nor to be used as a proxy regime if a suitable licence is not available.

2.2 Bands in potential use

Role of the ITU and CEPT in determining frequencies for SES

The International Telecommunication Union provides recommendations on allocation of radio spectrum to particular use cases, including which use cases should be considered primary allocations (and given priority in terms of interference protection),

and which are secondary. The ITU's aim is to provide technical conditions that protect existing services and allow coexistence between services in different countries, although NRAs are free to deviate from the ITU recommendations in their national frequency plans (provided this does not create issues of interference for services operating in other Member States). At a European level, CEPT carries over the ITU recommendations (as appropriate) into its harmonisation decisions that may then be implemented by NRAs.

ComReg sets its own frequency plan to align with ITU allocations applicable to Ireland and the associated European Common Allocation (from ERC Report 025).

Frequency bands available for SES in Ireland

At present, there are 17 frequency bands available for SES licences in Ireland, all at frequencies of 3 GHz or higher and predominantly falling within one of:

- the C-band (4 – 8 GHz);
- the Ku band (12.4 – 18 GHz); or
- the Ka band (26.5 – 40 GHz).

There are two bands (12.5–12.75 GHz and 14.0–14.25 GHz) that are available for SES on an exclusive basis and are not shared with any other service. However, most of the bands available for SES are shared use bands, meaning they are also available for delivery of other wireless services. In the shared bands, either:

- both SES and the other services are primary allocations, in which case the frequencies are licensed on a first-come-first served basis across all primary uses, and a coordination process (at a national and/or international level) is required whenever before an application is processed whenever multiple services would be operating in the same frequencies; or
- SES is the primary allocation and the other wireless service is a secondary allocation, in which case SES has priority and the other service must operate on a non-protected non-interference basis.

The specific frequencies available in Ireland for SES are set out in the tables in Annex A .

Potential new bands

Some stakeholders have suggested that there are frequencies recommended for satellite services by the ITU that are not currently available for SES in Ireland. This relates to:

- frequencies in bands below 3 GHz (e.g. in the UHF, L and S bands) that may be particularly useful for IoT and/or earth exploration applications (and noting that ComReg does not currently make available all of the spectrum designated by the ITU for earth exploration satellite service); and
- frequencies in the Ka band, where several respondents commented on the fact that only 500 MHz is available in the band in Ireland for SES, but the full 2.5 GHz (i.e. 27.5 – 30 GHz for Earth-to-space) could be opened up.

New higher bands

We understand that some higher frequencies (in particular within the Q and V bands[7]) are likely to become useful for some satellite services in the foreseeable future, both for use with gateway earth stations and potentially for inter-satellite links. We received mixed feedback from stakeholders in terms of when these bands would be used in earnest, with some suggesting this would not be for 5 – 10 years, and others indicating that use could begin much sooner. On 5 November 2021, the CEPT published ECC Decision (21)/01[8], which harmonises parts of the Q band (47.2 – 50.2 GHz) and the V band (50.4 – 52.4 GHz) for use in the fixed satellite service (Earth-to-space), with a preferred date for implementation by member states of 5 May 2022.

Access to frequencies in the 70/80 GHz range might also be useful for innovative and experimental satellite use, but commercial services in these bands is still likely to be some way off.

Other new bands

We would welcome any further comments on the potential for opening up spectrum to SES that is not already available, in relation to either the bands mentioned above, or any other bands considered relevant (noting that this does not included frequencies for use with licence exempt terminals, which is not within the scope of this project). Views on use cases for these bands and likely time scales around demand for the spectrum would be helpful.

We are not aware of any CEPT/ECC Decisions regarding other frequencies above 3 GHz that have not yet been implemented by ComReg, but if stakeholders believe otherwise then any supporting evidence and references to the specific decisions would be helpful.

2.3 Current fee structure

2.3.1 SES fees

As noted above, FSES (both FES and TES) licences are typically issued with a licence term of 12 months, and fees are due annually.

For the shared use bands, FSES licences vary depending on:

- Frequency band, where FSES licence fees are dependent on which (of five) discrete frequency range the band used falls into, and are typically lower for higher frequency bands;
- Bandwidth licensed, with fees increasing with the amount of spectrum used; and

[7] The Q band spans 33 to 50 GHz and the V band from 40 to 75 GHz.

[8] https://docdb.cept.org/download/3522

- Antenna power (EIRP), where higher fees are charged for higher EIRP.

Annual FSES licence fees in the shared bands range from €50 to over €2,500 (with fees increasing proportionately with bandwidth for any bandwidth in excess of 80 MHz).

For the exclusive use bands, FSES fees are (mostly) significantly lower than for the shared bands and are based on the number of FSES licences held on those bands. In particular, the annual fee is:

- €100 for each of the first 10 earth stations; and
- €25 for each additional earth station.

The detailed fee structure for SES licences in the shared bands is set out in Annex B .

2.3.2 Teleport Facility fees

Teleport Facility licences are designed to accommodate earth stations with multiple antennas that communicate with multiple satellites and are subject to higher fees than individual FESs or TESs. The fee for a 5-year teleport licence is based solely on the bandwidth (BW) licensed. For bandwidths below 80 MHz, the fees are set based on which of five ranges the bandwidth used falls into and vary from €25k (BW < 0.5 MHz) to €50k (40 ≤ BW ≤ 80 MHz). For bandwidths above 80 MHz, the fee is directly proportionate to the bandwidth used at €625 per MHz.

The current fee structure for Teleport Facility licences is set out in Annex B.

2.4 Current licensees

Current SES licensees

As of June 2021, there were only 56 live SES licences in Ireland, held by 21 different licensees. Around half of all current licences are TES licences, with broadcasters being the most common type of licenseee. The other licensees are a mix of internet services providers, private networks, and foreign embassies.

Current licences are spread between exclusive and non-exclusive bands. Sixteen are for spectrum in the 14.0-14.25 GHz exclusive band, although no live licences are approved for use of the other exclusive band (12.5 – 12.75 GHz). The remaining licences are for operations in the shared-use bands.

The majority of current licences (including all TES licences) are for spectrum in the following Ku sub-bands:

- 10.7-11.7 GHz;
- 13.75-14 GHz;

- 14-14.25 GHz; and
- 14.25-14.5 GHz.

A smaller number of FES licences have been approved for use of frequencies in the Ka and C bands, with an increase in use of the Ka band in recent years.

The typical bandwidths used with current licences vary widely. At the low end, many operators use less than 10 MHz, with some using less than 1 MHz. Other SES licences are for much larger bandwidths, up to 500 MHz.

ComReg has never issued a teleport facility licence.

Test and trial licensees

Outside of the established SES licence categories, there are four test licences and sixteen trial licences currently assigned for SES. Four licensees hold all of the live test and trial licences, one of which also has a regular SES licence. Most of the test and trial licences operate at frequencies below 3 GHz (i.e. 400 MHz or 2 – 2.3 GHz), which are not available for regular SES licensing under ComReg's current framework.

2.5 Licence-exempt terminals

Certain classes of terminals used in satellite services have been exempted from requiring a licence under the Wireless Telegraphy Act, 1926 (as amended), subject to operating on a non-protected non-interference basis and provided they comply with various technical restrictions. For the avoidance of doubt, these terminals and licence exemptions are not a direct concern of this study. However, as they form an important component of many stakeholders' satellite systems, we set out the current regulatory situation below.

Basis of licence exemption

In Ireland, licence exemptions for satellite terminals derive from ECC decisions, which ComReg then translates into the national regulations. Adoption of ECC decisions by Member States is entirely voluntary and national jurisdictions maintain the ability to choose which decisions are adopted. As a general rule, ComReg tries to adhere to ECC recommendations/decisions where relevant and is typically timely in implementing them.

In 2020, ComReg reviewed and updated its licence exemption regime to ensure alignment with all relevant (including six new) ECC decisions. The result is a single exemption order for terminals for satellite services (S.I No. 226 of 2020) and a corresponding document (ComReg document 20/47, as amended) that sets out the technical requirements for these terminals to operate on a licence exempt basis.

Types of licence exempt terminals

Many SES use cases rely on the use of terminals that are licence exempt, which typically fall into two broad categories:

- individual user terminals, which may be dishes used by consumers to receive satellite broadband or broadcast services at their homes or places of business; and
- certain transportable stations used, for example, on board aircrafts and ships.

More specifically, the types of terminal covered by S.I No. 226 of 2020, ComReg document 20/47, as amended, and the relevant ECC decisions that informed the technical conditions and frequency bands that may be used are:

- Aircraft Earth Stations (AES) – ECC Decision (05)01;
- Earth Stations on board Vessels (ESV) – ECC Decision (05)10;
- High E.I.R.P Satellite Terminals (HEST) – ECC Decision (06)03;
- Low E.I.R.P Satellite Terminals (LEST) – ECC Decision (06)02;
- Transmit only Mobile Satellite Terminals – ECC Decision (09)04
- Earth Stations on Mobile Platforms (ESOMPs) operating in geostationary satellite systems – ECC Decision (13)01;
- Earth Stations on Mobile Platforms (ESOMPs) operating in non-geostationary satellite systems – ECC Decision (15)04;
- Earth Stations In-Motion (ESIM) operating in geostationary satellite systems – ECC Decision (18)04;
- Earth Stations In-Motion (ESIM) operating in non-geostationary satellite systems – ECC Decision (18)05; and
- Satellite Mobile Terminals operating under the control of networks – ECC Decision (12)01.

As far as we are aware, ComReg is fully up to date with implementing the relevant ECC decisions relating to licence exemptions for satellite terminals.

2.6 International aspects

Some aspects of the satellite licensing process are supranational, in particular the licensing of space components. ComReg's remit covers only terrestrial licensing, and the licensing of space stations and use of frequencies in space is beyond the scope of this report.

Space component coordination is organised by the ITU

International rules for satellite operation are governed by the UN Outer Space Treaty. Frequency assignment to satellite services and coordination between satellite operators' space components is managed by the ITU. Formally, ITU Member States will apply for and hold the legal rights to use spectrum and the associated responsibilities to operate in space; the Member State then grant acquired rights to private operators. In practice, Member States act as conduits for applications from private operators; multinational operators will have a choice of Member State to approach.

Allocation process

Rights to operate a satellite network over certain frequencies and geographical area are essentially granted by the ITU on a first-come-first-served basis. An ITU Member State (referred to as a 'notifying

administration') will submit requests (filings) to the ITU on behalf of an operator, providing all information required for the ITU system to perform compatibility studies. If the ITU considers the filing to be compatible with the Radio Regulations, details of the request are made available to all other ITU Member States, and wherever necessary the new project will need to engage in coordination negotiations with existing satellite systems/project (with support/intervention from the notifying administrations and the ITU if necessary) to ensure all systems can operate without interference. In practice, we understand that this coordination process is usually straightforward, as although there may be a large number of satellites involved (in particular with the new LEO constellations) it is only a small number of affected parties (typically other satellite operators) that need to form an agreement.

Assignment of acquired rights

Following successful negotiations, the notifying administration is formally granted the rights to use the requested frequencies in space, and these rights can then be distributed to the operator via its national licensing regime. The new network is then registered in the ITU database (the Master International Frequency Register, or MIFR) and is entitled to protection from harmful interference. Priority over interference protection is given in order of registration in the MIFR; when a new network is registered it must avoid causing interference to existing networks already in the database, but is protected against interference from any systems registered afterwards.

We understand that operators can choose which Member State to apply through, but will typically choose a country with low regulatory burdens, technical competence, and the ability to provide effective support in the case of any disputes. To date, Ireland has very limited experience as a notifying administration in relation to satellite networks, having previously only submitted one filing for a non-geostationary orbit (nGSO) satellite (EIRSAT 1).

Ground components

We reiterate that these supranational procedures apply to the space component of the satellite networks, with the ground components managed by national regulators subject to (i) using spectrum allocated for that purpose under the Radio Regulations and (ii) ground stations being linked with one or more space components authorised by the ITU.

3 Use cases for satellite ground stations

In this section we set out typical use cases for satellite services. This provides a basis for considering the derived demand for ground components, and also the appropriate basis and conditions for licensing of SESs that can accommodate both traditional and new applications.

The range of use cases for satellite services is now very broad, with varying requirements for number of earth stations, appropriate frequency bands, and bandwidth. This section describes our current understanding of key use cases, but we welcome comments and feedback from stakeholders on:

- any use cases that we have missed that do not fall into the broad categories outlined below; and
- views on any of the use cases identified and our understanding of these set out below, in particular with regard to factors relating to use of satellite earth stations and licensing requirements.

3.1 Background

Traditional use cases

Satellite services have been in operation for decades, with traditional use cases primarily being:

- VSAT systems for low capacity broadband, using systems in a geostationary orbit,
- broadcasting satellites (used both for remote news gathering feeds and delivery of television channels to consumers),
- low capacity positioning and navigation systems.

In Ireland there are few live ground station licences, split evenly between broadcasting TES and FES for satellite broadband and some specialist links (e.g. for embassies).

New use cases

Development of new technologies for satellites is likely to expand these use cases considerably. Satellites are increasingly using higher frequencies, particularly in the Ka band, to provide higher capacity services. Satellites in geostationary orbit, which operate in orbits over 35,000 km above the earth's surface, continue to be important in a variety of use cases, but nGSO satellites are becoming increasingly common.

nGSO applications

Constellations of satellites have been launched into mid-Earth orbit (MEO) and low-Earth orbit (LEO). LEO satellites operate much closer to the earth, at distances of less than 1000km, and MEO describes any orbits at altitudes between LEO and GSO. These nGSO satellites typically use a far greater number of satellites than traditional systems, and require a greater number of ground stations, to support

low-latency, high-capacity services, and to achieve global coverage (as an individual satellite 'sees' a smaller area at a lower altitude). The lower orbits avoid the long latencies (around 250 ms) associated with geostationary satellites.

Polar and sun synchronous orbits

Polar and sun synchronous orbits are a subcategory of LEO, which pass close over the poles (but not necessarily exactly over them). These are often used for remote sensing applications. Sun synchronous orbits are useful for observing the Earth under constant lighting conditions, as position relative to the day/night terminator is controlled.

Technological developments, in terms of smaller, low-power satellites, have enabled new types of use that may have found the cost of previous satellite systems prohibitive (e.g. backhaul for remote internet of things devices). They have also improved service and cut cost for some existing use cases. For example, LEO constellations are expected to provide cheaper and lower latency internet access.

Interaction with terrestrial services

Some satellite services may participate in the same downstream markets as some terrestrial services. Improving terrestrial services may reduce demand for certain satellite services. For example, high-capacity broadband in rural areas might be provided by satellite, but improving fibre coverage and extension of the reach of fibre networks through wireless local access (WLA) and fixed links may be reducing the need for such services. Improved mobile services with increased coverage create another option for broadcasters previously reliant on TES for remote news gathering.

ESaaS

Finally, we note that SESs are not necessarily vertically integrated with satellite operations. They may be operated by specialist providers who supply several satellite operators. There is an emerging market for '*Earth station as a service*' (ESaaS), where providers operate the ground stations of multiple satellite users, potentially bundling in connectivity or data processing services.

3.2 Principal satellite uses

We have identified six broad usage categories for key satellite operations that might require SES licences, summarised below:

- earth exploration and remote sensing;
- Internet of Things (IoT);
- broadband;
- mobile communications;
- broadcast; and
- positioning and navigation.

Table 1: Use case summary

Use case	Freq. bands	Bandwidth	Orbits	Earth stations
Earth exploration	UHF, S, X, and Ka	Large BW needs	nGSO (sun-synchronous especially relevant)	Many stations across the world
IoT	< 3 GHz	Small BW needs	Small LEO constellations	Large gateways and smaller user terminals
GSO Broadband	C, Ku, and Ka	Large BW needs	GSO	Fewer large gateways (large satellite footprint) and small user terminals
LEO Broadband	Ku and Ka	Large BW needs	Large LEO constellations	Many large gateways across the service area and small user terminals
Mobile comms	Various		nGSO	Large gateways and user devices
Broadcast	X and Ku bands		GSO	Large gateways for uplink and small terminal for downlink to users
Satellite News Gathering	Ku	Small BW needs	Various, both GSO and nGSO	Small (often transportable) terminals
Navigation and Positioning	Low frequencies		MEO	Gateways, smaller sensing stations, and user

3.2.1 Earth exploration and Remote Sensing

Earth exploration and remote sensing satellites capture and transmit images of and information about the Earth's surface from space. This covers a wide range of end user applications, including scientific observation, weather mapping, climate monitoring and defence uses. Some remote sensing systems operated by inter-governmental bodies are well established, such as EUMETSAT's weather monitoring systems[9] and the EU-ESA's Copernicus programme[10]. However, the range of users and applications may proliferate as it becomes easier to deploy large numbers of low-cost, low-power satellites that nevertheless meet capacity requirements. This

[9] https://www.eumetsat.int/what-we-monitor/weather

[10] https://www.copernicus.eu/en

includes satellites for research projects (e.g. run by universities or national research funding agencies) which may be budget constrained and unlikely to operate large amounts of ground station infrastructure (potentially working with ESaaS operators instead).

Earth observation and remote sensing applications may require transmission of large amounts of data that is often time sensitive; they may require fairly large bandwidth, but this depends on the application. The satellites used for these services are typically in low earth orbit and make use of sun-synchronous or polar orbits if seeking to capture images at consistent times and lighting environments. However, given the large variety of end user objectives, sensing applications may also make use of mid-latitude orbits.

Whilst download of data from remote sensing applications may not require low latency (data is usually stored for transmission once an SES is visible), some applications may require timely information (e.g. weather observation). This will require SESs in appropriate locations around the globe so that data can be received without undue delay. The amount of delay tolerance will vary according to application.

Earth exploration and remote sensing applications now use a relatively wide range of bands, typically operating in the VHF, UHF, S, and X bands, but increasingly moving towards use of the Ka band which offers greater capacity. A significant amount of this spectrum is below 3 GHz (i.e. VHF, UHF, and part of S-band) and therefore not available under ComReg's existing licence framework. However, the ITU assigns some bands specifically for Earth Exploration Satellite Services (EESS), much of it in the S, X, and Ka bands, meaning it is likely feasible to include these bands in the SES regime under technical conditions that respect existing users. However, low frequency spectrum is relatively scarce and already heavily used, meaning the large bandwidths required may not be available in all the bands of interest to these users, unless they are able to operate on a secondary or non-interference non-protected basis (which we understand is the case for at least some EESS operators).

3.2.2 Internet of Things

Internet of Things (IoT) devices are used in a growing number of industries, such as agriculture, shipping and logistics, generally for telemetry and control purposes. Satellites (often nano-satellites in LEOs) have an advantage in use for IoT backhaul because devices are often situated in places that are difficult or expensive to reach using terrestrial services. User terminals in this instance can be small devices embedded in the relevant agriculture, transport, environmental etc. technology, often operating over simple

VHF/UHF antennas. The amount of data being transferred is typically small.

These are narrowband networks working with relatively low bandwidth, and with varying latency requirements. Sensor data's usefulness is often time-limited, but it is a case of meeting some maximum tolerable delay requirement, rather than there being a need to minimise latency. Most IoT systems operate on a store and forward basis. They use a limited number of suitably located ground stations (sometimes at ESaaS sites) and typically have significant flexibility in where these ground stations are located.

IoT operations are concentrated in sub-3 GHz bands (e.g. VHF). In some cases, the ground station may be quite simple, potentially akin to a user terminal rather than requiring large-scale SES facilities (such as steerable antennas). For VHF/UHF transmissions, a simple vertical dipole may suffice if through-put requirements are modest.

Their low bandwidth requirements, low power and limited duty cycle increase their ability to share this spectrum with other operators without interference protections. This may blur the distinction between a ground station and a terminal. We have found that some IoT satellite stakeholders favour a light touch approach to SES licensing for these reasons.

3.2.3 Broadband

Satellite technology has long provided "last mile" broadband connections to areas where other communications links do not reach. Traditionally, these broadband systems have used geostationary (GSO) satellites with large footprints. GSO broadband systems have operated mostly in the C, Ku, and Ka bands, but technological advances will likely open options to use higher frequencies in the future. GSO satellite systems for broadband are limited by the high latency that comes with communicating with satellites in very high orbits.

There are now also several large LEO constellations in development to provide broadband, with some already launched and providing services. These currently operate in the Ku and Ka bands, with the expectation that frequencies in the Q and V band will come into use in the short- to medium- term future (increasing capacity, rather than replacing the Ka band). Like the GSO broadband operators, these ISPs focus on bringing broadband to areas with limited connectivity, but with lower latency possible due to the significantly closer proximity to the earth of LEO satellites. Faster speeds and low latency will make these services competitive with terrestrial services

in remote areas (e.g. Starlink intends to provide speeds of over 100 Mbps and latency as low as 20 ms).[11]

Broadband providers, whether GSO or nGSO, provide fixed user terminals to customers, which often operate in the Ku band, and are usually licence exempt under ECC Decision 17(04). Many of these operators also provide maritime and aviation internet access (making use of various licence exemption decisions).

They also have significant ground station requirements (the subject of this report), although these vary according to the configuration of the satellite constellation. Existing (GSO) networks may be optimised to achieve coverage using a small number of gateways (e.g. covering a continent with a single figure number of ground stations, meaning a low likelihood of building one in Ireland). However, LEO systems in development expect to require a larger number of ground stations to achieve their target quality of service. Some LEO systems also plan to use inter-satellite optical links to help minimise the number of ground stations needed.[12]

3.2.4 Mobile communications

Satellite links can now serve as a complement to terrestrial communications networks, both as a reliable backup and as a primary means of providing backhaul services in some cases (e.g. from areas with no available fibre), because they are capable of the required throughputs.

A satellite component has not yet been offered within a mass-market mobile service, but mobile operators can potentially use satellite systems to fill gaps in their coverage and extend mobile communications networks to areas unreachable by fibre or microwave links. This is likely to be of benefit to existing or potential customers in the most remote areas, and as a distinct use case for disaster response, search and rescue operations, and for industries operating in remote locations such as forestry or mining. Additionally, satellites can offer reliable backup services to existing terrestrial communications networks.

There are a range of projects related to mobile communications that have the potential to develop a new use case for satellite connectivity such as:

- opportunities for satellite operators to work with MNOs in the rollout of 5G;
- development of private 5G networks in settings such as shopping malls and sporting events; and

[11] https://www.starlink.com/

[12] https://spacenews.com/spacex-adds-laser-crosslinks-to-polar-starlink-satellites/

- direct to mobile satellite links (dependent on handset development).

3.2.5 Broadcast

Broadcasting covers two related satellite use cases. First, broadcasters use satellite communications for satellite news gathering (SNG). This involves reporting live news from remote locations outside the television studio. Traditionally, a transportable earth station (e.g. mounted on the back of a van) is used to transmit to a geostationary satellite, which then relays the broadcast to the TV network's control centre for processing and distribution. SNG typically uses frequencies in the Ku band. Geographic coverage and reliability are the priorities for this use case, which is more dependent on immediate delivery than video quality.

In our interviews, we heard that news organisations are making less use of SNG as mobile networks provide faster services and better coverage. Operating a fleet transportable earth stations is costly, so there are good incentives to limit use of SNG where possible, even if some TESs are kept as backup. Broadcasters may use specialist equipment that can bond IP connections using several mobile networks for greater through-put and reliability. We understand that the primarily requirement for broadcasters is fast deployment to obtain video footage quickly while events are occurring, with the quality of video being less important than its timeliness.

Second, households and businesses receive television distributed via satellite broadcast, usually provided via GSO systems in the X and Ku bands. Broadcasters need Earth stations to uplink the broadcast to a geostationary satellite, which is then downlinked to a terminal installed on the customer's premises. Although the prevalence of video on demand has shifted content distribution towards IP based systems running over terrestrial networks, there is still a large installed base of satellite TV receivers; therefore, the service is expected to remain important for the foreseeable future.

3.2.6 Positioning and Navigation

Positioning and navigation systems are an established use case. The largest satellite positioning systems have been set up and run by governments, such as Galileo (EU)[13] and GPS (US)[14], offering global positioning using many satellites in MEO, spread across multiple orbital planes. Positioning applications typically require at least three satellites to be in view of the device to operate, and the accuracy

[13] https://www.euspa.europa.eu/european-space/galileo/What-Galileo

[14] https://www.gps.gov/

increases with the number of satellites seen. Due to the global nature of such services, the systems need a network of earth stations for telemetry and control that can ensure worldwide coverage.

These applications are frequently used in automobiles, marine navigation, aviation tracking, defence applications and timing/synchronisation. There is also a growing list of industries adopting satellite navigation technology for innovative projects, such as precision agriculture and commercial fishing.

Positioning and navigation satellites use the L band (i.e. sub-3 GHz spectrum that is not currently available in Ireland), and we are not aware of earth stations serving this kind of use in Ireland, nor do we expect significant ground station demand to arise for this use, but welcome feedback from stakeholders on these uses and their needs.

3.3 Recent trends

Significant variance in demand for ground stations across use cases

Owing to the changing use cases of the satellite industry and related technology developments, demand for earth stations can potentially change quite suddenly as a result.

Certain traditional use cases are declining. In part, this is because widespread roll out of high quality terrestrial mobile services has made some previously important satellite use cases out-dated. For example, the prevalence of SNG is declining as areas become better connected with other means of communications that are less costly and easier to maintain than satellite links, although TES licences may be retained as a backup, given the importance of reliable connections in this case.

New delivery methods are likewise making satellite television broadcast outdated. We expect the number of satellite television subscribers to continue falling, but providers will likely keep the option and the infrastructure to support it for some time until all customers can be served by newer technologies.

At the same time, we expect demand for emerging uses of satellite communications to increase significantly. New demand for SESs will mostly come in the areas of remote sensing, EESS and IoT, as well as LEO-based high-capacity broadband. However, not all of the growth of new use cases will translate into SES licence demand in Ireland; many applications only require a small number of ground stations and there may be considerable flexibility where to locate these.

As coverage of new satellite constellations (many of which are still in development) expands, operators will require more infrastructure on

the ground. Starlink[15] and Project Kuiper[16] each expect to launch thousands of satellites, with other operators like OneWeb[17] planning smaller but still significant constellations. This growth will lead to new ground stations being installed to meet quality of service standards, as data demands increase, companies offer connectivity in more areas and their customer bases grows. Inter-satellite links within LEO satellite constellations (such as announced by Starlink) are in their infancy, but have the capacity to reduce the number of distinct ground stations needed. Nevertheless, as data throughput grows through these constellations, we would still expect increased need for ground stations to provide reliable services.

Technological changes affect demand for spectrum

Technological evolution will also fundamentally change earth station requirements. For example:

- IoT operators may only need very small, lightweight, and low power earth stations that behave more like traditional user terminals than other large earth stations. These may operate below the traditional 3 GHz lower cut-off for the definition of SESs within current regulations. As IoT systems become more prevalent and advanced, regulators might need to re-think the distinction between earth stations and user terminals, with obvious consequences for SES licence demand.
- Optical crosslinks, could further diminish the geographic importance of earth stations. Operators will have less need to locate stations close to users and the economics are likely to favour consolidating earth station operations into fewer sites with greater throughput.
- Innovation and congestion will likely lead to expansion into higher frequencies, especially the Q and V bands, among broadband providers. Experimental use may even reach the 70-80 GHz bands.

The nature of a ground station may change

The definition of a what is covered by a single ground station licence will need to be fit for purpose for the likely satellite uses. For some use cases, building and maintaining terrestrial infrastructure is too costly or troublesome, in particular for smaller (EESS or IoT) users, who may instead rely on SESaaS. An SESaaS provider takes over all the technical requirements for operating an SES and offers services to multiple users. Thus, the specific technical requirements for SESaaS depend on the kind of services they cater to.

These stations will often have multiple antennas operating from the same site, which, depending on the licensing regime might be considered individual SES or fall under a different, multi-antenna licence category. This development could renew commercial interest

[15] https://docs.fcc.gov/public/attachments/FCC-21-48A1_Rcd.pdf

[16] https://www.aboutamazon.com/news/company-news/amazon-receives-fcc-approval-for-project-kuiper-satellite-constellation

[17] https://oneweb.net/launches

in the teleport facility licence category currently offered by ComReg (or some future variation of it).

Even ground stations serving a single constellation/satellite network may look very different to earlier SESs, possibly with multiple antennas at a given site collectively acting in a similar way to large antennas at traditional Earth stations.

It is important that the licensing regime is broadly neutral to these different operating models. In particular, certain models should not be disfavoured or even made infeasible through unintended consequences of the licensing regime.

3.4 Geographical aspects

The number of ground stations required varies across constellation types

The number of SES needed by an operator depends on the use case and the orbit of the satellites. Some of the interviewees said they needed only one site to cover all of Europe and North Africa, while others needed multiple sites within a single country. Satellites operating at higher orbits have a greater field of view – GSO systems can achieve global coverage with just a few satellites in orbit (in theory, only three are required), whereas LEO networks need many more satellites to cover the same area. With nGSO systems, connectivity and latency requirements also play a role, as applications requiring constant contact with a satellite throughout its orbit require more earth stations. In summary, the geographic position of earth stations can have varying degrees of importance to different operators, with some operators having much more flexibility than others.

Ireland may be a favourable location

Ireland benefits from some locational advantages as both a far northern and western point in Europe adjacent to the North Atlantic, but these advantages tend to be specific to certain use cases.

Northern latitudes are important when it comes to connecting with satellites in polar and sun-synchronous orbit. As these orbits become more common (through their use in earth observation), earth stations in Ireland could relieve some of the congestion in other far north areas already used for downlink from polar orbits, such as Svalbard and Sweden. Although the Scandinavian locations may be preferable as they are further North, Ireland retains some advantage if operators want to avoid densifying sites, or use different types of orbits to benefit from different revisit rates (e.g. an operator using both mid-latitude and sun-synchronous orbits in its constellation may be suited to Ireland, which is a reasonable location for both).

As a far western point, Ireland offers a good location for backhauling aviation services over the North Atlantic. Again, there will be a measure of flexibility in location choices even for LEO systems.

Stakeholders expressed that while geographic location is a consideration when situating an SES, it is one of many. Companies will look at the existing infrastructure, especially the backhaul connections, and the regulatory and legal environment as well.

Regulatory environment affects SES location choice between neighbouring countries

A country's regulatory regime emerges as a particularly important driver of these decisions. This includes the frequency bands available to satellite services (both earth-to-space and space-to-earth), the licensing fees, and the timeline for obtaining permission to start operations. As the timeframe for a satellite project is many years, investors need to know that the regulation will be suitable several years into the future. Interviewees noted that in the trade-off between good geography and a friendly regulator, it often makes sense to prioritise the latter (especially within a broad area, where geographical conditions are similar and a marginally better location is outweighed by a significantly better regulatory environment).

Among regulating authorities, there appears to be some trans-national competition in hosting ground stations, with some jurisdictions being particularly flexible when it comes to SES licensing or even offering tax benefits and other incentives to attract satellite operators.

4 Emerging issues

In this section, we outline our views on the issues that have emerged from our initial research and interviews with stakeholders. These are preliminary and we welcome any comments, especially in regard to any further issues of significant relevance to the SES licensing regime.

4.1 Interference amongst ground stations

In principle, it is possible that satellite ground stations could cause or experience interference from other ground stations, or terrestrial services using the same spectrum (or spectrum in neighbouring bands, but out of band emissions are generally dealt with well by existing technical conditions e.g. guard bands). This interference between ground stations needs to be considered insofar as it affects the appropriate technical conditions for SES licences, or implies an opportunity cost that needs to be reflected in SES licence fees to the extent that other users are precluded by the need to protect ground stations.

Interference between ground stations

First, we consider interference amongst satellite ground stations – we understand this is unlikely, as both receivers and transmitters on ground stations are highly directional and pointing up. Most stakeholders have not indicated that they are concerned about interference between ground stations and that interference between ground stations is avoidable (e.g. by using elevation masks). As a result, it is unlikely that there is any significant opportunity cost due to a ground station precluding the use of spectrum by other SES operators, at least between GSOs, or between a GSO and nGSO ground station.

Where there is significant geographical separation between a given operator's Earth stations, this is to maximise footprint at a low cost, not a result of interference concerns. The availability of infrastructure such as fibre for backhaul of data may lead to a clustering of different operators' ground stations at a site.

On the other hand, some stakeholders have suggested that there is a greater potential for interference between ground stations for different nGSO constellations, and that significant geographical separation is necessary to manage this (at least tens of km). The multi-directional antennas used to communicate with various satellites in the constellation from the same ground station mean that the techniques available to limit interference between neighbouring GSOs (or an nGSO and a neighbouring GSO) are not effective. However, the geographical separation required to avoid interference and the demand for SES for nGSOs are not sufficient to create any spectrum scarcity in Ireland. There is little practical

limitation on the number of SESs within Ireland arising from interference between them, but it may be important that SESs, especially those servicing nGSO constellations, coordinate if close enough to each other.

We are aware that the UK NRA, Ofcom, issues both 'gateway licences' (similar to ComReg's SES licences) and 'network licences', which are required to provide satellite user terminals in the UK, and that it has proposed changes to these to mitigate the (in its view) greater risk of interference posed by nGSO systems.[18] For example, it will require technical cooperation between operators, and include in its licensing decision a check on whether licensing one operator could create barriers to entry that would limit competition in satellite services in the future. Irrespective of whether similar features of the licensing regime are appropriate in Ireland, ComReg should consider the more general principles of ensuring satellite operators have the necessary information to manage interference between each other's Earth stations should it arise, and the obligation to do so where reasonable (i.e. where the efficient use of spectrum is to have multiple operators, not a first mover who is able to restrict competition).

4.2 Interference from terrestrial uses

Similarly, we understand that in many cases interference between terrestrial uses and satellite services is easily managed/avoided (i.e. because SES antennas point up whereas, say, fixed links run horizontally). However, the characteristics of any interaction are significantly more uncertain than for interference between SES.

Except in the two satellite exclusive bands, SES share frequency bands on a co-primary basis with other services, often fixed links, or with the other uses operating as a secondary service. Stakeholders have also raised concerns that the expansion of 5G services could limit the spectrum available to satellite operators. In both cases, either the technical licences conditions should be such that satellite and terrestrial services can coexist, or fees should support efficient use of the spectrum where some users are to be excluded from using certain spectrum in a given geographical area.

Who needs interference protection?

Interference protection is provided for transmit/receive operations, and receive only stations currently operate on a licence exempt basis. In principle, there could be some potential need for receive protection for SES, but this is very case-specific and easily incorporated into a licensing framework. The only difference to

[18] https://www.ofcom.org.uk/consultations-and-statements/category-2/non-geostationary-satellite-systems

existing licences should be that receive only licences would cover smaller bandwidths as they would not require transmit channels.

Conversely, some (transmit and receive) use cases, particularly IoT or EESS, are designed to tolerate a certain amount of interference and therefore might warrant a more lightweight approach than currently offered, either:

- being a secondary user in the band; or
- having ground stations permitted to operate on a licence exempt basis, because they are indistinguishable from user terminals (and therefore covered by CEPT licence exemptions – this may already be the case, but should be made clear in the SES guidelines).

4.2.1 Fixed links

Existing fixed links can interfere into ground station receivers, as they often share bands with SES (e.g. the 28 GHz fixed links band overlaps with the Ka band used by SES). Actual instances of harmful interference are uncommon, and ComReg already assesses potential interference with existing users when processing fixed links and SES licence applications. Even though the difference in angles will often prevent interference occurring, it is important to understand any opportunity cost arising from preventing other users when setting SES fees. However, when they do arise, opportunity costs are likely to be low as fixed links would only be precluded from operating in a narrow area, often in rural locations (where there is no scarcity in the fixed links bands).

Therefore, we do not believe there is a material conflict between satellites and fixed links operating in the same bands, except if

- SES are in urban areas where there is a risk of congestion in fixed links bands; or
- in bands important to both fixed links and satellites if 5G technology/backhaul requirements change the nature of interference between SES and fixed links.

A minority of SES could be located in or close to cities because of the availability of infrastructure and proximity to existing facilities. This scenario appears to be the most relevant one for interference.

Therefore, our expectation is that point-to-point (P-P) fixed links should not create any significant interference risks, because both the P-P links and SES are at fixed locations, and it is easy take one into account when installing the other. However, we have heard conflicting views from stakeholders on this. Some satellite operators are concerned that the use of 5G technology across fixed links use cases (e.g. P-P mobile backhaul and point-to-multipoint (P-MP) for FWA), particularly in the 28 GHz fixed links band. This overlaps with Ka band, which could significantly increase the risk of interference

between fixed links and SES. On the other hand, it has been suggested that although 5G will increase mobile backhaul throughput, it will not fundamentally change P-P backhaul services in any way that threatens SES.

We have also heard that P-MP fixed links could be a greater cause for concern to satellite operators than P-P links, because it is potentially more difficult to plan SES operations around P-MP links (i.e. if the hub of the P-MP system is known, but the other points change frequently). At present, a large majority of P-MP fixed links in Ireland are operated by rural FWA operators using licence exempt spectrum. They do so precisely because they are unconcerned about interference (and so opt to not pay for interference protection that comes with using a licensed band).

We note that FWA operators also serve a similar market to satellite broadband operators. We have no evidence that there is a particular interference risk in this case, and should be careful not to restrict competition for the same end user demand from operators using different technologies.

4.2.2 5G

In most cases, 5G services themselves will operate in bands assigned to mobile and there should not be significant interference between mobile terrestrial services and SES in neighbouring bands (e.g. 26 GHz and the Ka band), provided that technical conditions to limit out of band emissions are enforced.

However, many SES operators have much broader concerns that the process of making spectrum available to 5G will result in SES losing access to that spectrum, potentially unnecessarily. There is a question as to how well satellite and terrestrial operators can share a band, and what measures (e.g. geographic exclusion zones) are needed to support this, if coexistence is indeed viable.

In the Netherlands, Inmarsat disputes that SES must vacate a band for it to be used for 5G

We are aware of the ongoing dispute in the Netherlands, ahead of the proposed 3.5 GHz award, following which satellite services would be required to vacate the band, but Inmarsat has suggested that this would be costly and unnecessary, and has challenged the proposal.

Inmarsat has a satellite ground station located at Burum in the north of the Netherlands, which it uses for the provision of free-of-charge "globally essential"[19] maritime safety services. Feeder links between the ground station and two geostationary satellites operate over frequencies in the 3.5 GHz band. Communication between the satellites and user terminals run in the L-band.

[19] https://www.inmarsat.com/en/news/latest-news/corporate/2021/inmarsat-administrative-court-date-proceedings-set.html

The Dutch Ministry of Economic affairs set out plans to adjust its National Frequency Plan (NFP) that would reallocate the 3.5 GHz spectrum currently used by Inmarsat to 5G telecoms from 1 September 2022. This would require Inmarsat to move its services to another country to continue its operations.

In response, Inmarsat sought an Administrative Court ruling to suspend the update to the NFP, arguing that it would put lives at risk and in any case is unnecessary, given that technical studies have shown that satellite services and 5G telecoms can coexist within the band. The hearing took place in June 2021 and ruled in Inmarsat's favour, suspending the update to the NFP and recommending that the Dutch Government hold talks to find a solution or risk full court proceedings annulling the NFP altogether.[20]

It is currently unclear to us exactly what the coexistence mentioned by Inmarsat would involve (e.g. to what extent satellite services and 5G could use the same frequencies, what measures might be required to avoid interference), but a study by TNO on co-existence of 5G mobile networks with the Burum satellite access station operating in the C-band[21] suggests that:

- 5G service operating in the C-band outside the frequencies used by Inmarsat can be deployed nationally, except for within an exclusion zone of 21km from the Burum ground station;
- for 5G services to operate in the same frequencies as used by the Burum ground station with a similar exclusion zone, a significant mitigation effort would be required; and
- interference from 5G networks in Germany using the same frequencies as the Burum ground station may be an issue.

We also note that ComReg awarded similar spectrum in its 3.6 GHz award without such issues arising, and there are no awards expected in the immediate future that include spectrum currently being used by SES (e.g. the upcoming MBSA2 only includes sub-3 GHz spectrum). Nevertheless, the general options when there is demand from terrestrial services and 5G are:

- SES retains exclusive use of the bands;
- terrestrial services are assigned exclusive use of the band;
- terrestrial services use the band except in an exclusion zone around SES; or
- both services use the spectrum without geographical restrictions, but subject to some technical criteria.

Various satellite operators have told us that they need long run, international protection for the bands they currently operate in, otherwise the uncertainty around spectrum availability will limit

[20] https://www.inmarsat.com/en/news/latest-news/corporate/2021/dutch-administrative-court-rules-protect-inmarsat-safety-services.html

[21] https://repository.tno.nl/islandora/object/uuid:a580ee69-5683-4e9c-8771-64751de67b87

investment. However, some satellite operators only need a commitment that they will not be excluded from bands currently used, rather than full interference protection.

We would appreciate views on the potential impact of 5G on satellite services, and in particular in relation to the scope of interference and any mitigation measures that might be required. References to any relevant technical studies would be helpful.

4.2.3 Implications for incentive pricing

Issues with interference between ground stations and terrestrial users revolve around who has the rights to use a band at a given location, and how these rights may change over time.

There is some possible opportunity cost imposed on terrestrial users within a close distance of ground stations (we suspect no more than 10-20km) in certain specific cases (e.g. when a mobile operator wishes to rollout a national network but must avoid geographic exclusion zones around SES). This impact on precluded terrestrial users is likely minimal in rural areas, but could be more significant in urban areas. Therefore, there is a question of principle whether – to the extent that there is potential interference into ground station receivers by terrestrial users, which is not a given – ground stations have an incentive to locate to minimise any sterilising impact on other users.

Approximate a Coasian model by giving SES long term rights, and charging higher fees if terrestrial users are excluded

The view of SES operators is, quite reasonably, that they should have a protected right to operate given a Primary Allocation in the Radio Regulations. Without these rights, they may be discouraged from investing in ground stations for fear that they will lose access to the spectrum, either through being ordered to vacate the band at some future date (as proposed in the Dutch case), or because they feel unable to operate without interference protection.

A Coasian approach[22] to property rights (i.e. that it is clear that the SES operator has a right to be protected from interference), can be compatible with an efficient outcome where there is a potential for a small number of affected parties to bargain amongst themselves to form an agreed solution. For example, mobile operators could pay a ground station operator to locate in a rural corner rather than an urban area. However, in practice there could be some impediments to reaching efficient outcomes, as:

(i) affected terrestrial users might not know about new ground stations and have an opportunity to negotiate an efficient location (with ground stations not being moveable once built); and

[22] R Coase (1960) "The problem of social cost", Journal of Law and Economics, Vol 3 (Oct) pp 1-44.

(ii) there might be multiple affected terrestrial users, making negotiated outcomes possibly inefficient due to bargaining failures (e.g. multiple fixed link users with an exclusion zone around a ground station, creating free-riding problems amongst the fixed link operators).

If this Coasian model of private bargaining cannot be relied on, there may be some case for charging SES operators more for licences if an exclusion zone is needed for interference protection and more if that falls into urban areas where the opportunity cost might be greater. However, this opportunity cost of precluded terrestrial uses is quite speculative (as the cases in which SES does preclude terrestrial use appear very limited). The Coasian model may also have some mileage even if there are some impediments, so it may not be necessary to charge SES operators the full opportunity cost to terrestrial users to achieve reasonably efficient outcomes. Outcomes might also be improved by ensuring that information about ground station location and potentially interfering terrestrial users is readily available.

Overall, incentive pricing may not be necessary given the limited number of parties involved and the low probability of interference issues in most cases. However, if full incentive pricing were applied to SES fees, it should as far as possible be reflective of the actual excluded use. Therefore, it is natural for fees to be lower in rural areas. SES fees are currently lower in SES exclusive bands, but it is unclear whether there is a case for this, if there is no scarcity even when a band is shared.

4.2.4 Information policy

There is no overall scarcity for SES spectrum, and it is more likely that coordination problems occur than congestion, suggesting that the information policy may be more important than opportunity cost pricing in achieving efficient resolution of the limited conflicts that might occur between users.

In some cases, there is a realistic possibility of interference between SES and either terrestrial or other satellite operators, but this can be easily managed if the operators themselves have access to sufficient information. For example, there is possible additional protection from encroachment by terrestrial users provided by international registration of ground station users with the ITU (though this is not a licensing requirement imposed by ComReg).

Stakeholders have also suggested that ComReg should make available details from its own licensing database, and that this would often be sufficient for operators to resolve interference without ComReg having to intervene. Increased information of the location and frequencies in use by existing SES is also essential if the Coasian model for interference management is adopted to some extent,

although there is a case for an expanded information policy in its own right (i.e. to resolve coordination issues between nGSOs in cases where there is no genuine spectrum scarcity).

ComReg has made improvements to its information it provides as part of its fixed links licensing process – it is possible that publishing related information, or adding information on satellites to the same system (although there are a far greater number of fixed links installed in Ireland than SES), could assist satellite operators in planning deployment.

We invite views on what information would help operators resolve coordination problems and the extent to which this reduces the risk of interference (both between SES and between SES and terrestrial services).

4.3 Possible implications for fees

The level of SES fees will have an administrative cost floor

As a minimum requirement, SES licence fees need to be high enough for ComReg to recover its administrative costs relating to:

- processing applications for and issuing SES licences; and
- maintaining the regulatory functions for interference management to a sufficient degree to be able to resolve problems expeditiously (even if these seldom occur).

Under both of these categories, ComReg's administrative costs can be split into fixed costs (e.g. licences for interference modelling software) and those incremental to each SES licence. If incremental costs make up a large proportion of overall administrative cost, vary across different licences (e.g. by licence type, band, location), and incremental costs can be estimated with a reasonable degree of certainty, then fees should reflect the contribution to administrative costs of each specific licence. Otherwise, administrative costs can be recovered by charging the average administrative cost of each licence.

The (minimum) level of the fees will be reviewed based on an estimate of ComReg's administrative cost in a subsequent report.

SES opportunity costs

For the reasons set out above in relation to the low risk of interference now and in the future, opportunity costs of the spectrum used by SES will in most cases be close to zero. However, there are some exceptions to this where SES might sterilise spectrum for terrestrial services in some small exclusion zone. When this is the case, there is an argument that the fees should reflect the value of the excluded use within that exclusion zone, but this is likely to be relatively low for SES in rural areas whether there is little chance of other users being affected.

Fees might not vary with bandwidth or number of satellites

Various stakeholders highlighted that fees can play a role in determining where (i.e. which countries) ground stations are installed, noting that the level and/or structure of the fees can make operation of a SES uneconomic in some jurisdictions. In particular, NRAs may set fees:

- per earth station, per satellite constellation served or per antenna; and
- related to bandwidth.

We do not think it is likely that either administrative costs or opportunity costs vary significantly with either the number of constellations served from a given ground station, or the number of antenna used at a given location. Therefore, there is no obvious rationale for these charging structures.

ComReg's current fee schedule is based on:

- whether the frequencies used are in a satellite exclusive band or a band that is shared with other services;
- the bandwidth licensed; and
- antenna power (EIRP).

All of this appears to be sensible in principle as proxies for opportunity cost imposed on other users, but it can be simplified if opportunity cost are negligible.

There is, however, a case for setting different fees for different licence types. The nature of the interference analysis required from ComReg to process an application differs between TES and FES licences, because TES are not used at a fixed location. There is also a distinct rationale for a teleport licence (or similar) as there is no incremental risk of interference of an additional station at the same site, operated by the same SES user in the same band, so separate interference modelling is not necessary. Therefore, Earth stations within a limited area may be charged as if they were a single Earth station.

We recognise that some licensees would be particularly strongly affected by high or poorly structured fees (e.g. ground stations for low cost EESS and IoT users and SESaaS might not be economically viable). Any concerns from such stakeholders on the level of fees are likely to be resolved by administrative cost pricing, provided it reflects incremental administrative costs, and by not charging where no additional interference analysis/management is necessary.

Therefore, in summary, we see the key questions as being:

- the proper definition of SES to apply for licensing purposes given the potential for 'light-weight' ground stations being used for some applications (such as IoT downlinks);
- the relevant approach to allocating administrative costs to difference licences, especially given that some SESs may need little or no interference protection;

- how to account for terrestrial users that might be precluded from using spectrum in exclusion zones around earth stations needing interference protection and whether/how to reflect the opportunity cost in the fees so that new ground stations are located efficiently.

4.4 New bands

All of the bands currently included in ComReg's SES licensing framework are between 3 and 30 GHz, but as part of this review it is considering adding bands, particularly below 3 GHz. Stakeholders have indicated interest in additional spectrum being made available for SES both in low and high frequency bands, with demand for sub-3 GHz spectrum seeming to be more immediate.

We invite views on the precise bands that stakeholders believe should be opened to SES in Ireland, along with supporting international harmonisation measures for these bands.

4.4.1 Sub-3 GHz

EESS and IoT users would like sub-3 GHz bands to be opened to SES as soon as possible, and indicate that the lack of availability of low frequency spectrum has limited their ability to operate in Ireland thus far.

We expect that demand for sub-3 GHz bands would be limited to these use cases, and that others would either continue to use the bands they currently have access to (e.g. Ka), potentially also making use of higher frequency spectrum (if/when available) as bandwidth requirements increase and technology is developed.

Many of these bands have been identified as bands for EESS by the ITU. Therefore, we expect that suitable technical conditions for use of the bands would be available, and that coexistence with uses in neighbouring bands should therefore be straightforward. If these are also included in CEPT decisions, there is likely to be a strong case for adding them to the SES regime.

Nevertheless, there is significant variance in the demand for bandwidth among these EESS and IoT users (ranging from under 1 MHz to several hundred MHz). Lower frequency spectrum is relatively scarce and carving out large bands for exclusive use by SES in an area could have a large opportunity cost. However, we understand that these users do not require stringent interference protection and are in fact designed to be able to cope with some level of interference. Therefore, they are likely to be able to work effectively as secondary users in the band.

4.4.2 Higher frequencies

Other types of SES operator (e.g. for satellite broadband) have increasing demand for bandwidth, and are interested in making use of higher frequencies where more bandwidth is available. In the next two to four years, the Q and V bands could be used for ground stations, and there is some indication that even higher frequencies (70-80 GHz) will be used for experimental satellites, although commercial users are probably some way off. The needs of experimental users can be met by the test and trial scheme, and do not require premature addition of high frequency bands to the SES framework.

Satellites are manufactured to work with specific bands and cannot switch between bands once deployed. Operators can only switch between bands when new satellites are deployed, and the lifetime of these satellites is over ten years (though launches are more frequent because of technology improvements or to meet growing demand). This creates significant lead times and a need for clarity on what bands are available well in advance. Therefore, ComReg should adopt CEPT decisions that recommend the use of certain bands for coordinated SES without undue delay.

4.5 Regulatory environment

Stakeholders also made a range of general comments about the importance of a stable regulatory environment, noting that how burdensome the regulation is affects whether an operator will set up a SES in a country. They identified some areas where improved clarity in ComReg's guidelines would help, but did not suggest that ComReg's application/licensing process prevented them from operating in Ireland.

4.5.1 Adoption of CEPT decisions

Satellite services are fundamentally international, and most stakeholders highlighted the importance of implementing CEPT harmonisation decisions as quickly as possible. ComReg already endeavours to do this and we understand that ComReg is relatively effective in doing so. However, stakeholders have suggested ComReg go further by:

- establishing a (near) automatic process for adopting CEPT decisions; or
- incorporating provisional CEPT decisions into Irish regulation before they are finalised.

Although it is important that ComReg continues to follow these decisions with minimal delay, we do not see a case for adopting these further measures. There is clearly a significant risk that by adopting provisional versions of European regulations ComReg might reduce the predictability of its regulation (as it would have to make frequent changes until the formal decisions are adopted by CEPT). There are no benefits to promoting innovation from going ahead of neighbouring countries as Ireland is a small part of the international market and in any case ComReg's test and trial scheme is already able to support innovative use.

Moreover, ECC decisions are subject to national requirements. Therefore, it is not possible to implement them automatically, as ComReg must perform checks against national policy. In our view pre-empting possible future decisions could make the overall process longer, as it only creates additional steps and ComReg would still have to check and apply the decision itself.

Provided ComReg continues to adopt these decisions and process applications in a timely manner, we cannot see that there would be any excessive technical conditions or regulatory burdens placed on potential operators. Similarly, this would ensure that suitable spectrum is available (i.e. as there is no case for opening bands not covered by CEPT decisions, as equipment to use the bands is unlikely to be developed if similar spectrum is not also available elsewhere).

Nevertheless, we welcome views on the above matters.

4.5.2 Licence types

There is a need to ensure that the licence types available are fit for purpose. For example, there are currently no teleport licences in operation, and no indication that any operator intends to use these in future in their current form. However, there is an interest in multiple ground stations at the same site (or within a given area) being treated as one entity and subject to one application. Even serving a single LEO constellation may require simultaneous use of a number of antennas at the same site, so there should be clarity about what exactly is allowed within a single licence and at what point multiple licences are necessary.

In general, the licence types available should not preclude any particular use case. Definitions of the licences should be clear and based on the effect that the SES has on others. Then, operators should be able to select between licence options based their needs. For example:

- A receive only SES could choose between licence exempt operation (as available currently) and a receive only licence (with the same terms as other FES licences because the interference protection offered would be the same);

- users that met certain technical conditions that ensured they posed little risk of interference to other could choose between being fully licensed and operating on a licence exempt basis (as per terminals – this may already be the case, but should be clarified), or a light licence basis just with registration requirements, if willing to operate on a non-interference, non-protected basis; and
- the definition of a FES licence could be expanded such that any number of antennas at a given site was covered by one licence, replacing the existing teleport licence category which may be too restrictive.

In general, the licence regime should be suitable for emerging and established technologies; it should not create perverse incentives or favour one operating model over another without justification. This may require some clarification/revision of the guidelines (for example to ensure definitions and technical conditions are appropriate) and consideration of whether any additional types of licence are necessary.

5 Conclusions

This report sets out our current understanding on emerging issues. These views are still provisional. We would welcome feedback from interested parties in relation to any aspects of this report, but especially:

- our factual understanding of the current framework for licensing satellite services;
- our understanding of the use cases, and whether there are any key use cases that are missing, particularly where this may have implications for the SES licensing framework;
- expectations over future demand for SESs in Ireland, and any relevant developments that might impact on that;
- expectations over the future need for transportable earth stations given increasing use of IP based technologies for news gathering services;
- the importance of geography when determining locations for ground stations and any advantages/disadvantages that Ireland may enjoy in this regard;
- the suitability of the current licences available in Ireland, including (but not limited to) the useful of teleport facility licences (either in the current state or with some modifications);
- the potential for opening frequencies for SES in Ireland in bands below 3 GHz, including potential use cases, timeframes for demand, and references to any relevant ECC decisions that stakeholders believe ComReg has not yet implemented;
- the potential for opening frequencies for SES in Ireland in bands above 3 GHz (such as the Q band and V band), including potential use cases, timeframes for demand, and references to any relevant ECC decisions that stakeholder believe ComReg has not yet implemented;
- the extent to which interference between ground stations might be a significant issue;
- any anticipated problems of interference between satellite services and 5G, and potential mitigation measures (reference to any public positions on this and/or relevant technical studies would be appreciated);
- the extent to which interference between earth stations and other (non-5G) terrestrial uses is a significant issue;
- whether SES operators should be provided with incentives to locate ground stations aware from areas in which potential interfering terrestrial services might be more intensively used;
- whether there is additional information that could realistically be provided to stakeholders that would be helpful for coordinating amongst existing users;
- any other specific aspects of the ComReg licensing regime that stakeholders believe could be improved.

Annex A SES frequency bands

The specific frequencies available in Ireland for SES are set out in the tables below, distinguishing between those available for transmit (Earth-to-space) and those that can be used for receive (space-to-Earth). Other services allowed to operate in the shared bands are also listed.

Table 2: Frequency bands applicable to SES transmit operation

Frequency (GHz)	Other Primary (bold) and Secondary (plain) Sharing Services
5.15 – 5.25	
5.25 – 5.35	Short Range Devices (SRD)
5.35 – 5.47	
5.47 – 5.57	Meteorological, Amateur, Short Range Devices (SRD)
5.725 – 5.85	Amateur, SRD, FWA (5.725–5.875 GHz)
5.85 – 5.925	SRD, FWA (5.725–5.875 GHz)
5.925 – 6.7	L6 & U6 GHz P2P Links
6.7 – 7.075	U6 & L7 GHz P2P Links
7.9 – 8.4	L8 & U8 GHz P2P Links & Meteorological Satellite & Earth Exploration Satellite
10.7 – 11.7	11 GHz Point to Point Links
12.5 – 12.75	Satellite Exclusive Band
12.75 – 13.25	13 GHz Point to Point Links
13.75 – 14.0	Short Range Devices (SRD) (movement detection and alert equipment)
14.0 – 14.25	Satellite Exclusive Band (14.0 -14.5GHz VSAT uplinks)
14.25 – 14.5	
17.3 – 18.1	Feeder link bands for BSS

29.5 – 30.0	

Source: ComReg 00 / 64 R3

Table 3: Frequency bands applicable to SES receive operation

Frequency (GHz)	Other Primary (bold) and Secondary (plain) Sharing Services
3.4 – 3.6	FWPMA & FWALA (3.4 – 3.8 GHz)
3.6 – 4.2	FWALA (3.4 – 3.8 GHz)
4.5 – 4.8	
6.7 – 7.025	U6 & L7 GHz Point to Point Links
7.25 – 7.3	L7 GHz Point to Point Links & Meteorological Satellite
7.3 – 7.45	L7 & 7 GHz Point to Point Links
7.45 – 7.55	7 GHz Point to Point Links & Meteorological Satellite
7.55 – 7.75	7 GHz Point to Point Links
7.9 – 8.025	L8 GHz Point to Point Links & Meteorological Satellite
8.025 – 8.175	L8 GHz Point to Point Links & Meteorological Satellite
8.175 – 8.215	L8 GHz Point to Point Links & Meteorological Satellite
8.215 – 8.4	L8 GHz Point to Point Links & Meteorological Satellite
10.7 – 11.7	11 GHz Point to Point Links
11.7 – 12.5	MMDS (if interference protection is required the tabulated fee applies.)
12.5 – 12.75	Exclusive (interference protection not required as this band is exclusive to satellite services)
13.7 – 17.7	Feeder link bands for BSS.
19.7 – 20.2	

Source: ComReg 00 / 64 R3

Annex B SES licence fees

The tables below set out details of the current licence fees for SES in the shared bands and for teleport facilities.

Table 4: Fee calculation for SES licences in the Non Exclusive frequency

		Annual Fee Payable (€)		
Frequency (GHz)	**Bandwidth (MHz)**	**eirp < 50 dBW**	**50 dBW ≤ eirp ≤ 75 dBW**	**eirp > 75 dBW**
3-10	BW < 0.5	1000	1250	1500
	0.5 ≤ BW < 2	1250	1500	1750
	2 ≤ BW < 11	1500	1750	2000
	11 ≤ BW < 40	1750	2000	2250
	40 ≤ BW ≤ 80	2000	2250	2500
	BW > 80	2000 + (BW-80)x25	2250 + (BW-80)x25	2500 + (BW-80)x25
10-15	BW < 0.5	500	750	1000
	0.5 ≤ BW < 2	750	1000	1250
	2 ≤ BW < 11	1000	1250	1500
	11 ≤ BW < 40	1250	1500	1750
	40 ≤ BW < 80	1500	1750	2000
	BW > 80	1500 + (BW-80)x25	1750 + (BW-80)x25	2000 + (BW-80)x25
15-20	BW < 0.5	125	375	625
	0.5 ≤ BW < 2	375	625	875
	2 ≤ BW < 11	625	875	1125
	11 ≤ BW < 40	875	1125	1375
	40 ≤ BW < 80	1125	1375	1625
	BW > 80	1125 + (BW-80)x25	1375 + (BW-80)x25	1625 + (BW-80)x25
20-30	BW < 0.5	100	350	600
	0.5 ≤ BW < 2	350	600	850
	2 ≤ BW < 11	600	850	1100
	11 ≤ BW < 40	850	1100	1350
	40 ≤ BW < 80	1100	1350	1600
	BW > 80	1100 + (BW-80)x25	1350 + (BW-80)x25	1600 + (BW-80)x25
>30	BW < 0.5	50	300	550
	0.5 ≤ BW < 2	300	550	800
	2 ≤ BW < 11	550	800	1050
	11 ≤ BW < 40	800	1050	1300
	BW > 80	800 + (BW-80)x25	1050 + (BW-80)x25	1300 + (BW-80)x25

Source: ComReg 00 / 64 R3

Table 5: 5-year Teleport Facility licence fees

Total BW of Radio Spectrum Used (MHz)	5 Year Licence Fee Payable (€)
BW < 0.5	25,000
0.5 ≤ BW < 2	31,250
2 ≤ BW < 11	37,500
11 ≤ BW < 40	43,750
40 ≤ BW ≤ 80	50,000
BW > 80, per MHz BW or part thereof	625

Source: ComReg 00 / 64 R3