An Coimisiún um
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Commission for
Communications Regulation

DotEcon Report

Review of the Satellite Earth Station Licensing Regime

Consultant Report

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dot·econ

Satellite Earth Station licensing review

Conclusions and recommendations

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Background

What are satellite earth stations?

Satellite earth stations (SES) comprise radio equipment located on the Earth's surface used to communicate with satellites from a fixed location. They are used by satellite operators for telephony and data backhaul, broadcast feeder links, private networks, and telecommand and control. They support a wide range of use cases for satellite communications systems.

Licences to operate SES using radio frequencies in Ireland are allocated and managed by Commission for Communications Regulation (ComReg).

Scope of project

ComReg commissioned DotEcon and Axon Consulting to conduct a review of its licensing framework for SES and provide recommendations on any changes considered appropriate.

For the avoidance of doubt, the review is in relation only to the licensing of satellite earth stations. Other components of satellite communications networks, in particular user terminals (which typically operate on a licence exempt basis) and rights to operate the satellites themselves over certain frequencies and geographic areas (which are managed by the ITU) are not within the scope of this project.

First report

Our first report was published by ComReg in December 2021[1]. It set out our provisional understanding and views in relation to:

- the current SES licensing regime in Ireland;
- use cases for satellite services;
- recent trends and developments in the satellite communications industry;
- the importance of geography for satellite operators when determining where to locate an earth station; and
- the set of emerging issues that we believed to be relevant.

Stakeholders were invited by ComReg to provide feedback on the initial assessment as part of a formal consultation process.

Second report

[1] ComReg document 21/135a

This second report builds on our preliminary views and feedback from stakeholders to formulate recommendations on appropriate adjustments to ComReg's SES licensing framework.

Use cases

In our first report we identified several use cases supported by SESs, specifically:

- earth exploration satellite services (EESS) and remote sensing;
- Internet of Things (IoT);
- broadband internet connectivity;
- mobile communications;
- broadcast and satellite news gathering; and
- navigation and positioning.

Respondents to the consultation process provide some further details in relation to the use cases identified but did not suggest any usage categories that were missing. Therefore. we conclude that these use cases form the relevant set for consideration.

The table below provides an overview of the typical characteristics of the key use cases identified.

Table 1: Summary of use cases

Use case	Typical frequency 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		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 terminals

Key issues identified

In forming our recommendations, we have identified and focussed on the following relevant issues:

- **Bands available**: there are a number of bands that are not currently available for SES in Ireland but which could potentially be opened up, in particular bands below 3 GHz, additional frequencies in the Ka-band, and (in the near future) ranges in the Q and V bands. In addition, ComReg

may consider opening the 70/80 GHz bands and/or bands >100 GHz at some point in the future.

- **Interference**: the licensing frameworks needs to provide adequate protection to users from interference. This includes interference between two earth stations, as well as between earth stations and terrestrial users, in particular fixed links and mobile. In practice we understand that coexistence between different operators and use cases can be relatively easily managed, but SES licences need to be robust to any potential issues.
- **Competition concerns**: the scope for anti-competitive behaviour through SES licences is likely to be limited given our understanding that in most cases satellite operators have a significant degree of flexibility over where their earth stations can be located and licences are geographically limited. However, we need to ensure that the licensing regime does not create any opportunities for operators to unduly block access to the market for others (either other satellite operators, or providers of competing terrestrial services) or force other satellite operators into locating their SES in other countries.
- **Licence structure**: the types and structure of licences available need to be appropriate for current use cases and technologies. In particular, we consider that there is scope for adjusting the licence structure such that an SES licence would allow for multiple antennas at a given site under a single licence, rather than requiring multiple FES licences or a teleport facility licence.
- **Licensing process**: the licensing process needs to support efficient allocation of spectrum and provide adequate protection to existing users. Whilst we do not identify any fundamental problems with ComReg's current approach to allocating SES licences, we believe that there is scope for clarifying and formalising some of the processes, in particular in relation to: operator coordination (for which we believe there is a significant role); the application process and interference protection rights. There is also scope for improved access to information about existing licensees to support coordination amongst users and avoid unnecessary interference issues.
- **Licence fees:** we have not identified any issues of scarcity in relation to either access to either spectrum available to SES or geographic sites for deploying SES. There is, therefore, no clear role for opportunity cost-based fees for supporting efficient spectrum use, and fees only need to

cover ComReg's administration costs. However, given the wide variety of use cases, a fee structure that covers administrative costs should at the same time not inefficiently choke off low value (but potentially high impact) uses, such as earth exploration and IoT applications.

Bands

SES licences are available in a range of frequency bands, as set out in ComReg's '*Guidelines for Satellite Earth Station (SES) Licences operating in spectrum above 3 GHz*' (the 'Guidelines')[2]. These are all above 3 GHz.

However, there are various frequency bands that are not currently available for SES licences in Ireland, but for which there is demand, or potential future demand, from satellite operators.

These bands fall into four broad categories:

- Sub 3-GHz spectrum
- The Ka-band
- The Q and V bands
- The E band (70/80 GHz) and frequencies above 100 GHz.

Bands below 3 GHz

At present, there are no frequencies below 3 GHz available for SES in Ireland, although several bands in that range are allocated to satellite services by the ITU.

In particular, the ITU makes the following sub-3 GHz bands available (with the primary uses in brackets):

- 401-402 MHz (EESS uplink, SOS downlink)
- 402-403 MHz (EESS uplink)
- 1427-1429 MHz (SOS uplink)
- 2025-2110 MHz (EESS uplink, SOS uplink)
- 2200-2290 MHz (EESS downlink, SOS downlink)

The 1427–1429 MHz band falls within the 1.4 GHz extension bands that have been has been allocated to ECS/MFCN in Europe. ComReg has indicated that it expects to award the 1.4 GHz band for ECS/MFCN once both the centre band (1452–1492 MHz) and extension bands are available. As there is a binding European Commission (EC) Decision allocating it to ECS/MFCN, but no CEPT framework for satellite use of the band,

[2] ComReg Document 00/64 R3

we recommend that ComReg does not make the band available for SES at this time.

Regarding the other bands, at present there are no CEPT/EC Decisions in relation to those frequencies, and our understanding is that ComReg typically does not make spectrum available without such Decisions. However, our research and engagement with stakeholders suggests that there is existing demand for these frequencies from SES operators, especially for EESS and IoT applications, and the bands are available for satellite services in a number of other European countries.

ComReg could therefore consider opening some, or all, of the sub-3 GHz bands identified above for SES in Ireland, in accordance with ITU allocations/recommendations. We are not aware of any reason why that should be problematic, although ComReg may wish to seek feedback from stakeholders on any potential issues.

The Ka-band

In the Ka-band, only 500 MHz of spectrum is formally available for SES in Ireland, compared with 2.5 GHz (27.5–30 GHz) allocated for Fixed Satellite by the ITU and the European Common Allocation (ECA). ComReg has, at its discretion, licensed more than 500 MHz in this band in the past, but the bandwidth is limited in the Guidelines. Several stakeholders have requested that the full 2.5 GHz be made available in Ireland, as it is in a number of other European countries, on the basis that the large bandwidths it offers are important for certain uses, such as satellite broadband and large earth exploration projects. Although the frequencies overlap with spectrum allocated for fixed links in Ireland (in the 28 GHz band), coexistence between SES and fixed links is expected to be manageable. Therefore, we recommend that ComReg formally opens the full 2.5 GHz in the Ka-band for SES.

The Q/V bands

The Q and V bands appear to be those that will next become important for SES operators, in particular for use with next generation High Throughput and Very High Throughput Satellites, as demand for bandwidth grows and the Ka-band (at the space level) becomes more congested. In November 2021, ECC Decision 21(01) was published, harmonising the 47.2–50.2 GHz and 50.4–51.4 GHz bands for GSO and non-GSO FSS systems (Earth-to-space) and the 51.4–52.4 GHz band for GSO FSS networks (Earth-to-space). ERC Decision (00)02, amended in March 2022, also designates frequencies in the 37.5– 9.5 GHz and 39.5–40.5 GHz bands for space-to-Earth use by FSS earth stations. ComReg should, therefore, consider opening these

frequencies for FSS in accordance with the Decisions. Further parts of the Q/V bands may be designated for SES in the future. For example, there is an ongoing ECC work item relating to the designation of the 40.5–42.5 GHz band for coordinated and uncoordinated FSS earth stations (space-to-Earth)[3]. ComReg should monitor developments in these bands.

The E-band

Stakeholders have also highlighted an interest in higher frequency bands, predominantly the E-band (70/80 GHz). We have heard differing views in terms of when satellite systems will be able to make use of these frequencies, with SpaceX suggesting it is imminent, and others indicating that it is still some way off. In any case, whilst frequencies in the E-band have been allocated to FSS by the ITU and in the ECA, our understanding is that there are no ECC Decisions in relation to use of the band for SES and that technical conditions have yet to be established. As such, we suggest that ComReg monitors developments in relation to the band and makes it available to SES if/when appropriate. In the meantime, operators wishing to use the band may be able to do so under ComReg's Test & Trial licence regime.

Frequencies above 100 GHz

Similarly, some frequency bands above 100 GHz have been identified for potential use for satellite services, but this will likely be even further in the future than for the E-band. Again, we recommend that ComReg monitors the situation with a view to making the bands available if/when the relevant decisions and technical conditions are available.

Potential for interference

Interference between SES

Our understanding is that the potential for interference between two earth stations is limited and, where it might arise, is relatively easily managed. Interference is unlikely to arise between two GSO earth stations, or between a GSO and a NGSO earth station, because of the highly directional nature of GSO systems. Between two NGSO earth stations, harmful interference is more of a risk due to the use of physically or electronically steerable antennas operating at lower elevation angle. However, this can be avoided through sufficient geographic separation and implementation of mitigation techniques such as site-shielding (natural or manufactured). We anticipate that NGSO operators should be largely capable of

[3] https://eccwp.cept.org/WI_Detail.aspx?wiid=803

coordinating with one another to avoid interference, in particular as the number of SES in Ireland could be expected to remain relatively low and operators typically have significant flexibility over where their earth stations can be located. This assessment was broadly supported by stakeholders.

Interference with fixed links

The risk of harmful interference between SES and fixed links also needs to be managed, but again we understand that this should be relatively simple. ComReg conducts interference assessments when new licences are granted, while existing operators are protected from harmful interference from new applications. Therefore, any potential interference issues should be prevented at the application stage. Furthermore, given that the endpoints of fixed links are known and the locational flexibility of SES, it should be relatively easy for satellite operators to position their earth stations such that they do not cause interference to or receive interference from existing fixed links. Making information about fixed links available to SES operators (which we understand ComReg intends to do) should support coordination between the two services.

Some concerns were raised about advanced FWA services using point-to-multipoint (P-MP) links in the 28 GHz band potentially causing interference to SES in the Ka-band, but provided ComReg's interference analysis appropriately accounts for new technologies as they arise, this should not cause any additional issues relative to current applications.

Interference with 5G

Some stakeholders raised concerns over potential interference (either in band or out of band) between SES and 5G mobile services, while others are worried about SES spectrum being taken away and given instead to mobile operators.

Our understanding is that studies on potential interference between 5G and satellite services are still ongoing, so the extent of any issue is not yet entirely clear. In any case, we do not envisage interference between SES and 5G being a large problem in Ireland, or something that can necessarily be pre-empted in this review of the licensing framework, noting that:

- Whilst recognising that rollout of 5G is still in the early stages, to date there has not been any issue of interference between SES and 5G (in the 3.6 GHz band) in Ireland that we are aware of. There is an ongoing case in the Netherlands, where the risk of harmful interference from the (planned) use of 3.6 GHz spectrum for mobile communications into an earth station operated by Inmarsat has resulted in a planned migration of the Inmarsat station

to Greece. However, this seems to be a fairly case specific problem, and there were no such issues raised at the time of the 3.6 GHz award in Ireland (in 2018), or since.

- Bands in which there might be interference (in-band or out of band) between SES and 5G in the future will typically be in the higher frequencies which we would expect mobile operators to only need in urban areas, while in most cases SES can be located rurally. Therefore, there would seem to be reasonable scope for coordination and satellite operators can position their earth stations accordingly to minimise the risk of disruption in the future.
- Guarantees over the future designation of certain frequency bands cannot be given, as ComReg is obligated to implement EC Implementing Decisions which are out of its control. Therefore, there is limited scope for what can be done by ComReg to protect SES operators against future EC Decisions that might cause disruption, and any conflict will need to be dealt with at the time in a manner that ComReg considers most appropriate (e.g. through attaching suitable conditions to 5G licences at the time of award, or ensuring existing users are given sufficient notice in the event that spectrum needs to be repurposed).

Competition issues

CEPT/ITU level concerns

The potential for competition issues in the satellite communications market seem to be primarily related to licensing at the space level, for example if operators were able to take advantage of the 'first-come-first-served' system by hoarding spectrum to preclude access to competitors. However, this is out of ComReg's remit and is a matter for the ITU/CEPT.

Limited scope for anticompetitive behaviour with SES licensing

In terms of SES licensing, we see little scope for anticompetitive behaviour as:

- there is no problem of spectrum or site scarcity at the SES level; and
- while some sites may be more desirable than others (e.g. due to proximity to other infrastructure) our understanding is that satellite operators have a high degree of flexibility over where they position their earth stations, potentially even in terms of which country they are in, so it would be very difficult for one operator to preclude access to the market for another through the positioning of its SES.

Nevertheless, it is important that the licensing framework does not adversely create opportunities for SES operators to unduly affect where/whether other SES can be located in Ireland, both from a competition perspective and to avoid lost economic benefits from satellite operators being forced to locate in a different country. We believe that this can be achieved by setting up the licensing framework appropriately, rather than requiring a formal competition assessment for each licence application. ComReg should, however, reserve the right to conduct further analysis if it considers a licence application could pose any risk to competition.

Competition with co-primary services

We also need to recognise that some satellite services might be competing for end users with terrestrial services, primarily via fixed links operating over the same frequencies (e.g. satellite broadband and FWA). Our expectation is that there should be no major competition concerns provided suitable measures (which we would expect to follow largely from relevant CEPT Decisions or recommendations) are in place to support coexistence of the two services. Given the nature of the services, any potential for anticompetitive behaviour is likely to be localised (e.g. attempts to preclude access to a business park for others via claims for interference protection), and we expect SES and fixed links operators would have a fair degree of flexibility to build their systems around those of competitors. Therefore, the scale of the potential gains from anticompetitive behaviour is likely to be low**.**

Licence structure

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).

Licence types currently available

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).

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 & Trial licensing scheme.

FES licences should allow for multiple antennas

To operate multiple antennas at a given site, under the current framework an operator would require multiple FES licences or a teleport licence. Given that the number of antennas makes little difference to the interference environment and the opportunities for others to use the same spectrum, we propose that FES licences are adjusted such that a single licence would allow for operating multiple antennas at the same site. A "site" would be defined by an area with a given radius, which we anticipate would be in the order of 100s of metres. In the UK, Ofcom uses a 500m radius to define a site, which we anticipate could be appropriate in Ireland – we would welcome the views of stakeholders on this.

Teleport facility licences can be removed

If FES licences are changed to allow for multiple antennas, there would appear to be no further need of separate teleport facility licences as currently defined. We anticipate that those licence types could be removed, noting also that there has been no demand for them to date.

TES licences are still required

TES licences are likely to remain relevant for the foreseeable future. Although we anticipate a reduction in demand as broadcasters move towards IP-based technologies for news gathering services, this transition will occur over time and there will still be demand for TES licences in the meantime.

Licence duration

Currently FSES licences are granted for 12 months, with the option to renew annually, unless a longer duration licence (of up to 60 months) is requested. We do not see any strong reasons to deviate from 12-month licences, provided operators have reasonable expectations over being able to renew each year, and that ComReg provides sufficient advanced notice in the event that any of the spectrum frequencies currently available to SES are to be repurposed (e.g. in response to new EC Decisions on spectrum allocations). At the same time, there has been very limited use of the option to have longer licences, whilst a framework with annual licences works better with the

proposed revisions to the licensing process (see below). We, therefore, suggest that ComReg removes the option for longer licences to simplify processes.

Interference protection

FSES licences are primarily granted by ComReg for either:

- Transmit-only operation; or
- transmit and receive.

Receive only licences may be granted at ComReg's discretion

Receive-only earth stations do not create interference for others so can operate on a licence exempt basis (with no interference protection). ComReg has, in a limited number of cases, granted receive-only licences (i.e. granting interference protection for the receive only station). We recommend that ComReg continues to maintain discretion over the granting of receive-only licences, and may include a requirement for operators seeking such a licence to provide evidence for why they need receive-only protection as part of its licence application.

Low power earth stations can operate under licence exemptions

Some SES operators have indicated that they do not need the level of interference protection provided by the licences currently available and would be able to operate on a non-protected basis (i.e. as if the SES were user terminals). However, provided they operate within certain technical parameters it is our understanding that these earth stations would qualify for licence-exempt operation under the relevant CEPT Decisions and corresponding Irish regulations. We do not believe it is necessary to include provisions in the SES licensing framework to allow for these types of earth station.

Technical conditions

The technical conditions that currently apply to FSES licences are generally well aligned with those in other European jurisdictions and are, in the most part, fit for purpose. However, we suggest two modifications:

- the site clearance condition can be removed; and
- power limits around airports should be updated to align with ECC Report 272.

Licensing process

The existing satellite licensing regime is one in which there are rarely harmful interference problems between satellite earth stations or between earth stations and other users (primarily fixed links). Therefore, the regime informally operates on a first-come-first-served basis, in that the acceptability of new users is judged against the interference environment formed by existing licensees, with a presumption that existing users will have

priority. Although licences are issued for a year, it is reasonable to assume that there is a high probability of renewal (given associated physical assets).

We do not propose a significant change to the licensing process from the current situation, which is generally fit for purpose and has worked well to date. However, we believe there is scope for improvements to the licensing of fixed earth stations through formalising some of the processes and rights/responsibilities of relevant stakeholders.

Proposed adjustments to FES licensing

Our proposals are to:

- make explicit how the licence system currently operates in terms of prioritisation and protections offered to existing users;
- maximise the potential for licensees and potential licensees to resolve interference issues amongst themselves (an approach that is broadly supported by stakeholders), including through the provision of information; and
- ensure that pre-emptive licensing cannot be used to exclude competitors.

Under the proposed framework, SES licences would provide protection for existing users from potential new users (including from terrestrial services). For these purposes, a user is taken as being active from the date of first licensing. However, when an existing user comes to renew a licence it should declare whether or not its current licence has been in use. If not, the user would be considered as active only from the renewal date of its licence. Incumbents raising objections to new SES licence applications should also indicate whether they have used the corresponding spectrum in the current licence period and, if not, describe any plans for using it in the future – ComReg can take account of this information if needing to mediate in a conflict between the incumbent and the applicant. These measures are intended to avoid spectrum hoarding to claim priority and protection from potential new users, without needing intrusive monitoring of when spectrum is put into use.

Although existing earth station users enjoy protection from potential new users, we propose that the burden of proof regarding potential interference issues be split between new and existing users in the following way:

- Where a potential new SES licensee is more than a certain distance (say 20 km) from any existing earth station, the burden would fall on existing SES licensees to demonstrate that issuing a new licence would cause harmful

interference. To support this, new licence applications would need to be notified to existing licensees, who would have a short deadline to submit views with supporting evidence. ComReg would then consider those views and decide whether a licence would be issued (potentially after further enquires).

- Where a potential new SES user is within this critical distance, a new licence would only be issued if no nearby earth station licensees objected. Existing licensees would be under an obligation to negotiate in good faith with any potential licensee to see if operational adjustments by either party might allow co-existence. Potential new licensees could raise complaints with ComReg if they believed incumbents had not engaged in good faith, but the burden would initially be on the entrant to demonstrate that coexistence is feasible.

The presumption that an applicant more than some critical distance away from existing earth stations does not cause interference is intended to avoid incentives for pre-emptive licence applications aimed at preventing subsequent entry by others. This approach avoids ComReg having to consider the competition effects of each application on its merits. However, ComReg should reserve the right to conduct investigations and/or refuse an application on competitive grounds in exceptional circumstances.

Negotiation approach unlikely to work with fixed links

Note that this approach, and allowing for negotiations between parties, applies only to SES operators and would not work well in relation to other (terrestrial) users (i.e. primarily fixed links operators), so ComReg would need to continue with its current approach to interference assessment.

TES licensing would be largely unchanged

None of these changes would affect TES licences. However, it is important to prevent gaming with the licence categories – ComReg could, for example, set a time limit for how long TES can be in operation at any given site, although with some flexibility for ComReg to extend that at that the request of the operator. Around 6 months would seem to be a reasonable time limit.

Licence Fees

Fees should cover admin costs

Given the lack of scarcity in relation to SES licensing, there is no role for opportunity cost pricing for determining an efficient allocation. Therefore, the overall guiding principle is that the

fixed and common costs of the licensing and interference monitoring framework needed to support these licences needs to be recovered efficiently and equitably across very different types of users.

Need to avoid choking off low value users

The main concern is that more marginal, low-value users could be priced off if too large a share of these common costs is recovered from them. Therefore, there is an argument for applying Ramsey pricing principles to the fee structure; common administrative cost needs to be covered by users as a whole, and each user would pay at least the incremental cost to ComReg of issuing a licence, but high-value users would pay a greater share of the common costs than low-value users.

We propose a fixed fee plus a per MHz charge

It is not realistic to set different charges for specific users or use cases, so using a proxy for the value of different applications is necessary. The most obvious proxy is bandwidth in use. There are other parameters that could potentially be used as well or instead, such as frequency band or power level (as is currently the case), but these are not obviously needed.

A simple system meeting our criterion is therefore to charge in proportion to bandwidth used, on top of a fixed fee to reflect the incremental cost of processing applications.

Same fees for exclusive bands and shared bands

This would apply for all SES bands. Current fees for use of the exclusive bands are significantly lower than for the shared bands. However, there is no reason why this should be the case when there are no opportunity cost concerns or any obvious difference in administration costs associated with the different bands.

Potential for lower fees in sub-3 GHz bands

There may be some argument for a lower per MHz charge for sub-3 GHz bands (if added to the framework) to support low value uses cases that need larger bandwidths, such as some earth exploration projects. However, this is not obviously needed in the sub-3 GHz bands given the smaller bandwidths available relative to higher bands, but we would appreciate views from stakeholders.

FES and TES fees would be the same

TES licences would be charged on a similar basis to fixed earth stations. There might be some case for surcharging these licences due to the additional burden that mobility of ground stations could, in theory, cause for ComReg in policing interference. However, the use of TES for outside broadcast is diminishing, so it is unlikely that this is necessary.

Proposed fees

ComReg's administrative costs for managing the SES licensing framework are in the region of €140k per annum, with an incremental cost of ~€100 for issuing each licence. Based on the

current licences, to recover administrative costs would mean setting a fixed fee of €100 plus a per MHz charge of €30.

The charges should be indexed on an annual basis according to CPI. There may also be further need for ComReg to revise the fees in the future in response to changes in the number of licences issued and/or significant changes to its administrative costs.

Glossary

5G	Fifth-generation technology for mobile phone networks, subject to standards set by the 3rd Generation Partnership Project (3GPP).
Apogee	The highest point above the Earth in an elliptical orbit
Backhaul	A general term for links within hierarchical networks after concentration of traffic to and from end users on edge links. Backhaul links typically connect points of traffic concentration to the global Internet or other telecoms providers' core networks.
Bandwidth	The width of a continuous spectrum channel being used by a particular user. Also, more generally the information carrying capacity of a network link.
C-band	4-8 GHz
CEPT	European Conference of Postal and Telecommunications Administrations
Constellation	A collection of satellites with coordinated orbits aimed at providing continuous or near continuous service coverage on the ground as individual satellites move in and out of sight of user terminals and earth stations.
Co-primary	One of a number of primary uses for a spectrum band allocated by the ITU
Downlink	Radio link from a satellite to a earth station
ECA	European Common Allocation
ECC	Electronic Communications Committee of the CEPT
EESS	Earth exploration satellite services
ESOMP	Earth station on a moving platform (term replaced by Earth stations in-motion (ESIM) at WRC-15)
FES	Fixed Earth station (as opposed to TES)
FSES	Fixed Satellite Earth Station

FSS	Fixed satellite service
GSO	Geostationary orbit, where a satellite maintains a fixed position relative an observed on the Earth. This requires a circular equatorial orbit at an altitude of 35,786 km. Satellite broadcasting and some broadband services use geostationary satellites, enabling the use of simple fixed receiving dishes by customers.
Ka-band	26.5-40 GHz microwave band
Ku-band	12.4-18 GHz microwave band
IoT	Internet of things
ITU	International Telecommunications Union
ITU-R	Radiocommunications sector of the ITU
Latency	The time taken for a data packet to make a round trip between sender and a remote location and back again.
L band	1-2 GHz
LEO	Low earth orbit, typically defined as having an orbital period of 128 minutes or less. This corresponds to an altitude above the Earth of approximately 2,000 km or less, though highly elliptical orbits may significant exceed this at apogee. Atmospheric drag becomes significant below an altitude of about 200 km, leading to orbital decay. For example, Starlink operates satellites at altitude of around 350 km and 550k m. The International Space Station orbits at about 400 km.
MEO	Medium earth orbit (above LEO, but below geostationary orbits), for example as used for GPS satellites and some communications satellites.
MSS	Mobile satellite service
NGSO	Non-geostationary orbit
NRA	National Regulatory Authority
Polar orbit	An orbit passing over both poles.

Primary allocation	The primary use for a spectrum band allocated by the ITU. This primary use has interference protection from other potential uses of the same band.
Q band	33-50 GHz
RR	Radio regulations
S band	2-4 GHz
Secondary allocation	The secondary use for a spectrum band allocated by the ITU. This secondary use is not protected from interference and must not interfere with primary uses.
SES	Satellite earth station
SOS	Space operations service – telecommand, monitoring and position finding of satellites
Sun-synchronous orbit (SSO)	An almost polar orbit, where a satellite passes over any given point on Earth at the same time of day. Typical altitudes are around 800 km (LEO).
TES	Transportable earth station
Test & Trial	A special licensing regime to encourage innovation and development involving new radio technologies or services.
UHF	300 MHz – 3 GHz
Uplink	Link from an earth station to a satellite
V band	40-75 GHz
VHF	30 MHz – 300 MHz
VSAT	Very small aperture terminal
WLA	Wireless local loop
WRC	World Radio Conference (of the ITU)
X band	7.0-11.2 GHz

1 Introduction

1.1 Terms of reference

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 reviews 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 schedule for SES licences.

1.2 Licensing review process

This is the second report prepared by DotEcon and Axon, which contains our recommendations relating to ComReg's SES licensing framework. Alongside this report, ComReg will set out its proposed changes to the framework, informed by our recommendations, and will consult on these changes before formally adopting them.

Our first report did not include any firm recommendations, but set out our initial understanding based on interviews with stakeholders and 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.

Our recommendations, set out in this report, draw on these issues and preliminary views, as well as further input provided by stakeholders in response to ComReg's initial consultation.

1.3 Scope of review

This review covers all aspects of ComReg's SES licensing regime, including licence types, the process for issuing licences and fees. We do not make recommendations on the related issues of licensing for other aspects of satellite networks or terrestrial services.

ComReg is responsible for licensing SES, but not satellites or terminals

Satellite systems generally consist of the satellites themselves, earth stations and user terminals. Responsibility for licensing each of these parts lies with different entities:

- Satellites (and access to space resources) are licensed by the International Telecommunications Union (ITU).
- User terminals generally operate on a licence exempt basis, with licence exemptions being decided in Europe by the European Conference of Postal and Telecommunications Administrations (CEPT) and then incorporated into Irish law by ComReg.
- SES are licensed by national regulatory authorities (NRAs).

ComReg's remit therefore only covers SES licensing, so access to space resources and licence exemptions for user terminals are out of scope for this review and not the focus of our report.

SES generally operate in the fixed satellite services (FSS) or as feeder links in the mobile satellite service (MSS) or broadcast satellite service (BSS). For the most part this review is concerned with bands allocated to FSS and associated use cases, but other satellite use cases that operate earth stations, such as Earth exploration satellite services (EESS), are relevant.

In bands that are available to SES, satellite operators need to be able to access spectrum without experiencing harmful interference. This might not be feasible for some potential users if either coexistence is technically difficult or if rivals can foreclose access to spectrum. There are distinct competition and interference issues for the satellites themselves, user terminals, and SES.

Satellite systems can interfere with each other when different operators' satellites are roughly in line, such that the receiving terminal, earth station or satellite can 'see' the transmitter belonging to the other operator. This will become increasingly likely as multiple dense LEO constellations are deployed, as well as larger numbers of user terminals. However, the potential for issues arising due to congestion and interference is largely related to the satellites and user terminals, rather than earth stations. As we expect there will be relatively few earth stations, operating from fixed locations and with a degree of flexibility over where they can be located, coordination between earth stations to avoid interference or scarcity of spectrum should be relatively straightforward. Therefore, whilst there may well be congestion issues created by the rise of NGSO systems, these are related primarily to licensing at the space level which is not within ComReg's power to control and is not a matter for this review.

The potential problems of congestion at the space level may also lead to first mover advantages in accessing spectrum for satellite services and the licensing of space resources. The ITU procedure for authorising satellites grants protection from harmful interference on a first-come first-served basis and relies on coordination between operators (via Member States) when processing new applications. If one operator applies pre-emptively, it may not have to coordinate with other users (who are not yet ready to deploy satellites) and could attempt to use its established operator status to anti-competitively block later operators. In practice this issue might be limited if it can be resolved through later ITU coordination negotiations, but in any case falls outside of the scope of this review. Licensing of earth stations is unlikely to face the same risk of first-mover advantages given our understanding regarding the lack of scarcity of suitable sites, although any licensing framework still needs to be set up to avoid artificially creating opportunities for first-movers to unduly block access to others.

Coexistence with terrestrial services should be supported to the extent possible in the SES framework

This review also considers how satellite and terrestrial services interact and the scope for coexistence between the two. However, some coexistence issues cannot be resolved within this review. Firstly, some stakeholders are concerned about terrestrial services interfering with satellite user terminals, e.g. point-to-multipoint (P-MP) fixed links providing fixed wireless access (FWA) using 5G technology in the Ka/18 GHz band. When a band is allocated to both use cases on a co-primary basis, the technical conditions required for coexistence are set out in the relevant ECC Decisions and implemented by ComReg.

ComReg should ensure it is up to date with these Decisions and may raise issues to BEREC if it believes the process for licensing fixed links (by NRAs) and authorising licence exempt operation (by CEPT) is somewhat disjointed. However, the technical conditions on licence exemptions and use of these bands is not a matter for ComReg.

Avoiding harmful interference between earth stations and terrestrial services is a matter for this review, but coexistence will in part be protected by ComReg's actions in other licensing processes, and it does not have complete discretion in relation to this. For example, stakeholders are concerned that an increasing number of bands are open to 5G services, and that this both constrains satellite operators (who are left with a reduced amount of spectrum) and risks harmful out of band interference if the technical restrictions are not enforced. However, the allocation of bands to different use cases is decided at an international level, and the conditions under which other classes of user can operate are a matter for future spectrum awards or parallel licensing frameworks.

1.4 Key issues and report structure

Within the scope of this review, we have identified a number of relevant issues which form the basis of our recommendations on the SES licence framework.

First, there are a range of spectrum bands that are allocated to satellite services by the ITU and CEPT, or that stakeholders have expressed demand for. These fall into two broad categories – the first being those for which a number of stakeholders have indicated demand and which are already the subject of CEPT Decisions that ComReg has not yet fully implemented and the second being bands that have been identified as potentially useful in the future, but for which appropriate technical conditions have not yet been developed. ComReg should consider opening the bands where relevant harmonisation decisions/recommendations are in place, but there is little benefit to immediately opening bands where future demand and appropriate technical conditions are still unclear.

Second, there is, in principle, potential for harmful interference both between earth stations and between earth stations and terrestrial services. To date there has been very cases of interference of either type, but the increased rollout of satellite networks (in particular the new NGSO systems using steerable

antennas at lower elevations than traditional GSO systems) and the development of 5G mobile services using higher frequencies could introduce a greater risk over the coming years. In practice, we believe that demand for SES in Ireland is likely to remain low and that the interference environment should be relatively easy to manage, in particular if operators have sufficient information about existing users to coordinate their own operations.

Third, there is the related issue that, even where coexistence and interference-free operation ought to be feasible, operators have incentives to attempt to deny their rivals access to spectrum for anti-competitive gain. The fact that satellite networks are international, and operators often have a lot of flexibility over where their earth stations are positioned (potentially even being able to choose between different countries) means that there will likely be limited opportunities for gaining a competitive advantage from blocking access to sites for earth stations in Ireland. For some use cases, satellite operators may also be in competition with terrestrial operators (e.g. for rural broadband provision) but again, precluding access to the market for other types of operator to achieve any significant gains is likely to be difficult, since both classes of operator have a reasonable amount of flexibility when planning their networks plus the impact of any blocking behaviour would likely be very localised.

To be clear, neither competition nor interference issues are likely to arise frequently in practice, but they must be considered when designing the SES regime to ensure ComReg does not inadvertently increase the risk of either.

Fourth, the structure and types of SES licence currently offered by ComReg may be somewhat outdated and not aligned with use cases hoping to deploy SES in Ireland in the near future. For example, we understand that some users (in particular those operating NGSO systems) will need to use multiple antennas at a single site, but feel that the fees they would have to pay to do so under the current licence options are excessive. Although the level of fees is a separate issue, it might not be possible to define a fee schedule that promotes efficient use of the spectrum if the licences themselves are not aligned with how operators intend to use them.

Fifth, efficient allocation of SES licences is likely to be supported by allowing satellite operators to negotiate and coordinate amongst themselves to mitigate any potential interference between earth stations. ComReg has limited information on the appropriate measures required to prevent interference between

two earth stations, so letting the operators (who have better information on the technical details of their own systems) work it out between them should allow for a better outcome than if ComReg needed to enforce restrictions to avoid interference itself. This requires a licensing process that supports operator coordination, but also provides sufficient protection for existing investments, avoids giving incumbents too much power to block access for others, and is robust to any negotiations breaking down. This should be achievable with a process that clearly defines the rights and responsibilities of each party and would be supported by an information policy that provides access to information about existing users.

Finally, we see no role for opportunity cost pricing in relation to SES, so ComReg should set licence fees to simply cover the administrative costs of issuing licences and managing the licensing regime. However, given the very wide range of use cases, there is an argument for ensuring that fixed costs are distributed across operators in a way that does not inefficiently choke off demand from lower value users.

The remainder of this report follows the key issues summarised above:

- Section 2 summarises our understanding of the primary use cases for SES;
- Section 3 identifies bands that could potentially be added to the SES licensing framework, now or in future;
- Section 4 discusses the potential for interference between SES, and between SES and terrestrial services;
- Section 5 discusses competition issues relating to SES;
- Section 6 sets out proposals for amendments to the available SES licence types;
- Section 7 provides recommendations on changes to the process for issuing these SES licences;
- Section 8 describes a revised SES fee schedule; and
- Section 9 provides a summary of our recommendations.

2 Use cases

2.1 Background

Demand for earth station licences, including the frequency bands and bandwidths needed, ultimately derives from the various use cases for satellite operations. These use cases set the requirements for a SES licensing framework that can accommodate both traditional and new applications.

Traditional use cases

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

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

New use cases

Development of new technologies for satellites is expanding these use cases considerably. Satellites are increasingly using higher frequencies, particularly in the Ka-band, to provide higher capacity services, and the next generation of satellites is expected to use frequencies in the Q/V bands. Satellites in geostationary orbit (orbiting approximately 36,000 km above the Earth's surface) will continue to be important in a variety of use cases, but non-GSO satellites are becoming increasingly common.

NGSO constellations

The trend towards NGSO orbits includes constellations in both middle Earth orbit (MEO) and low Earth orbit (LEO, typically orbiting less than 1,000 km above the Earth's surface). Sun-synchronous and polar orbits are subcategories of LEO that are particularly important to certain use cases (e.g. remote sensing) as these orbits allow operators to observe the Earth under constant lighting conditions. These NGSO satellites typically use a far greater number of earth stations to support low-latency, high-capacity services, and to achieve global coverage (as an individual satellite 'sees' a smaller ground area at a lower altitude).

Technological advances

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 IoT 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.

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 the 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.

Earth station as a service

Finally, we note that SES 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 earth stations of multiple satellite users, potentially bundling in connectivity or data processing.

2.2 Primary use cases

The range of use cases for satellite services is now very broad, with varying requirements for density of earth stations, appropriate frequency bands, bandwidth, and interference protection. In the interim report, we set out six broad usage categories for key satellite operations that might require SES licences. The use cases identified in that report are:

- earth exploration satellite services (EESS) and remote sensing;
- Internet of Things (IoT);
- broadband internet connectivity;
- mobile communications;
- broadcast and satellite news gathering; and
- navigation and positioning.

The table below outlines our understanding of key characteristics of the use cases identified in the interim report.

Table 2: Summary of use cases

Use case	Typical frequency 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		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 terminals

Responses to the public consultation on the interim report did not identify any additional use categories. We are therefore of the view that the set of use cases identified in our first report, and as set out above, is the relevant set of use cases that need to be considered. However, some respondents did offer more details about the requirements of the key uses.

While certain orbits are more suited to some use cases, stakeholders pointed out that GSO and LEO constellations are both used for wide-ranging applications. LEO use is increasing, but GSO systems will continue to be vital to several services,

most notably the provision of broadband in various settings. The advent of new high throughput and very high throughput GSO satellites has solidified their importance to the modern satellite sector. In contrast, the use of LEO constellations to provide broadband services requires customer terminals with dynamically steerable antenna beams to track satellites moving relative to users.

Connectivity on the go

Various consultation responses noted that satellite communications are particularly well-suited to providing connectivity in the aviation, maritime, and travel industries. Satellite systems are used to provide onboard internet access to passengers on planes, trains, and ships, as well as providing essential safety and navigation features in the vessels' operation. Such systems are typically classified as earth stations on moving platforms (ESOMPs), which are generally covered by licence exemptions decided at a European level and are not within the scope of this review.

Fixed broadband for government / community institutions and disaster response

The consultation responses mentioned two specific services within the fixed broadband usage category that warrant extra consideration:

- **Satellite broadband for connectivity to key government and community institutions.** Governments benefit from the security and reliability of satellite connections to carry out official duties, and citizens can utilise satellite broadband to access government services. Community institutions, such as schools, hospitals, and community centres are beneficiaries of satellite broadband, particularly in very rural and remote areas where it might be the only means of connection.
- **Disaster response:** Access to broadband can be critical in times of crisis. The advantage of satellite broadband in disaster scenarios lies in operators' ability to quickly dispatch additional terminals to affected areas, where existing links might be damaged or unreliable. Connectivity is required by first responders to plan their response as well as victims needing to contact friends and family. Further, in areas beyond the reach of terrestrial services, satellite communications may be the sole option for coordinating vital relief efforts.

5G and cloud ecosystems

Respondents also highlighted the potential for satellite links to become an important component of 5G and cloud ecosystems as those infrastructures are further developed. Satellite links can serve as a complement to terrestrial communications networks, both as a reliable backup and as a primary means of providing

backhaul services to remote areas. Several satellite operators have recently entered into agreements with MNOs to provide backhaul for mobile services, especially in areas that are challenging to reach through traditional terrestrial links.[4] Private 5G networks, which are being proposed in a growing number of settings, may also utilise satellite connectivity.

[4] For example, https://www.commsupdate.com/articles/2021/10/27/verizon-project-kuiper-ink-strategic-collaboration/

https://www.commsupdate.com/articles/2021/12/09/telefonica-uses-intelsat-satellite-to-boost-mobile-connectivity/

3 Frequency bands

3.1 Current situation

Role of the ITU and CEPT in determining frequencies for SES

The ITU makes 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 should be secondary. At a European level, the CEPT carries over the ITU recommendations (as appropriate) into its harmonisation decisions and the European Common Allocation (ECA)[5].

ITU allocations and CEPT recommendations form the primary guidance to Member States on frequency allocations. Although the recommendations are widely adopted by Member States, the decisions are not binding and do not come into effect in a country until implemented by the relevant NRA. ComReg typically sets its own frequency plan to align primarily with CEPT harmonisation Decisions and the ECA, but also with ITU allocations applicable to Ireland. Stakeholders benefit from alignment in the available frequencies across countries if there are economies of scale in equipment manufacturing or if the communications networks themselves are international, as is the case for satellites.

Frequency bands available for SES use in Ireland

The current SES licensing framework in Ireland makes seventeen frequency ranges available for SES, all above 3 GHz. These frequencies primarily fall within one of the following:

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

Two of the frequency ranges in the Ku-band (12.5-12.75 MHz and 14.0-14.25 MHz) are available to SES on an exclusive basis and are not shared with any other services. Most of the bands available to SES, however, are shared use or non-exclusive 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 the national and/or international level) is

[5] https://efis.cept.org/sitecontent.jsp?sitecontent=ecatable

required 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 currently available in Ireland for SES are set out in Annex A .

Potential new bands for SES

There are several frequency bands that are not currently available for SES licences in Ireland, but for which stakeholders have indicated there is currently demand for SES operations or that are likely to become important for SES in the future.

These bands fall into four broad categories:

- Sub 3-GHz spectrum
- The Ka-band
- The Q and V bands
- The E band (70/80 GHz) and frequencies above 100 GHz.

In keeping with its general approach to spectrum management and implementing international harmonisation measures, we understand that ComReg makes effort to implement ECC Decisions in a timely manner as and when they are published. Some stakeholders have suggested that NRAs can (and sometimes do) pre-empt ECC Decisions on new bands and implement them when considered to be sufficiently finalised but not yet published, in order to make spectrum available to operators as soon as possible. One example cited was that of Germany's quick implementation of ECC (17)04). However, implementing international decisions/recommendations before they are finalised does not come without risk (i.e. there is always a possibility they will change) and is unlikely to offer any significant advantage since the need for appropriate technical conditions to be available means the window for "early" implementation would be reasonably narrow. We therefore do not recommend that ComReg implements relevant CEPT Decisions before they are finalised, which in any case would set a potentially dangerous precedent for the way ComReg could be expected to operate in general.

3.2 Sub-3 GHz bands for SES

The ITU and ECA allocate frequencies in the VHF, UHF, L and S bands to various satellite services, specifically:

- mobile satellite services (MSS);
- earth exploration satellite services (EESS)
- space research
- space operation services (SOS); and
- broadcasting satellite services.

Some fixed SES may operate in the services listed above, but commonly operate in the Fixed Satellite Service (FSS). The ITU has not allocated any frequencies below 3 GHz for FSS in Region 1[6].

Several stakeholders have expressed demand for sub-3 GHz spectrum for SES operations. EESS and IoT operators in particular have highlighted that their ability to deploy earth stations in Ireland is constrained by the lack of frequencies below 3 GHz. We note also that ComReg has granted Test & Trial licences to satellite operators in frequencies below 3 GHz, with three users currently holding Test & Trial licences at lower frequencies.

Use by satellite IoT operators

Satellite IoT operators primarily utilise small devices, require only limited bandwidth (e.g. 50 kHz channels), and often operate in the VHF band, including in the ranges:

- 137-138 MHz, and
- 272-273 MHz.

IoT operators are also interested in narrow bandwidths in the UHF band (e.g. 401-403 MHz) that are assigned to various satellite use cases (e.g. EESS, MSS, SOS) by the ITU or CEPT. Owing to the technical nature of satellite IoT systems, it is our understanding that many IoT applications can be accommodated through a combination of MSS allocations below 3 GHz and licence exemptions of systems belonging to named operators in those bands (i.e. as set out in ECC Decision (99)06), or existing licence exemptions implemented by ComReg for satellite terminals (summarised in ComReg Document 20/47R4), especially for space-to-Earth operation.

Use by Earth Exploration operators

Earth exploration operators have also expressed interest in frequencies around the 400 MHz and 2 GHz ranges.

[6] The ITU Region 1 encompasses Europe, Africa and the Middle East.

The following UHF frequencies are allocated to EESS and SOS as primary use cases in the ITU allocation table, and were highlighted by stakeholders as potentially useful to satellite operations:

- 401-402 MHz (EESS uplink, SOS downlink)
- 402-403 MHz (EESS uplink)
- 1427-1429 MHz (SOS uplink)
- 2025-2110 MHz (EESS uplink, SOS uplink)
- 2200-2290 MHz (EESS downlink, SOS downlink)

These frequencies are widely available for satellite services in other jurisdictions throughout Europe and the rest of the world.[7]

1.4 GHz frequencies should not be opened yet

One of the ranges brought to our attention, 1427-1429 MHz, falls within the 1.4 GHz extension bands (1427 – 1452 MHz & 1492 – 1517 MHz) that have been allocated by the CEPT for electronic communications services (ECS) and mobile and fixed communications networks (MFCN) in Europe[8]. In previous consultations on its upcoming multiband spectrum award[9] (MBSA2) and review of its fixed links licensing regime[10], ComReg has indicated that it expects to award the 1.4 GHz band for ECS/MFCN once both the centre band (1452–1492 MHz) and extension bands are available, and that the band may be closed to fixed links as part of this process. The band is allocated to satellite, fixed and mobile services by the ITU, but for satellites, the relevant CEPT Decisions only cover passive EESS (see ECC/DEC/(11)01). Given this limitation and the Commission Implementing Decision being in place for mobile use of the band, we would not recommend opening the band for SES use at this time.

Other sub-3 GHz frequencies could be opened

Regarding the other frequencies set out above we note that, at present, there are no CEPT Decisions in relation to use of these bands for SES. ComReg, appropriately, aligns its approach to spectrum management with European level recommendations/decisions, and we understand would typically not open up spectrum to services without corresponding direction from CEPT. We would not recommend that ComReg deviates from this approach without good reason.

[7] See Annex B

[8] Commission Implementing Decision (EU) 2018/661

[9] ComReg Document 19/59R

[10] ComReg Document 21/134

However, given the extent of use of the bands for SES in other European jurisdictions, the ITU allocations, and the clear demand for it from SES operators, there appears to be some basis on which the bands could justifiably be made available to SES even without a CEPT recommendation.

ComReg may therefore consider adding the following bands to its SES licensing framework, in accordance with the allocation and recommendations set out by the ITU, provided it is satisfied that there are no potential problems from doing so in Ireland:

- 401-402 MHz
- 402-403 MHz
- 2025-2110 MHz
- 2200-2290 MHz

We have not identified any reason that should prevent the bands from being used for SES in Ireland. In particular, whilst the frequencies are currently available for other uses in Ireland (the 401- 403 MHz range is used by meteorological aids, and the two frequency ranges identified between 2 GHz and 3 GHz are allocated for fixed links):

- allocating the bands for SES alongside the current uses in Ireland would be consistent with the ITU allocations, which allow for shared use (on a primary basis) between satellite services and the existing uses – we would therefore not expect any coexistence issues that cannot be mitigated; and
- as discussed in further detail below, we anticipate that interference between SES and other primary use cases in a band should not present a large problem.

ComReg may in any case like to seek feedback from stakeholders regarding potential issues from opening the sub-3 GHz bands for SES, and any technical conditions that should be imposed.

3.3 Ka-band

Currently, only 500 MHz of Ka-band spectrum is formally open to SES in Ireland

At present, 500 MHz of bandwidth in the Ka-band (specifically 29.5-30 GHz) is available to SES according to the SES guidelines. However, ComReg maintains discretion on spectrum licensing and has already issued SES licences for larger bandwidths in this band.

The ITU and ECA recommend that significantly more Ka-band spectrum be made available to fixed satellite services, allocating the full 2.5 GHz from 27.5 to 30 GHz to SES at the international

level. These frequencies are widely used by satellite operators and have been opened to satellite services by NRAs in several European countries.

Several stakeholders were strongly in favour of any revised licensing regime including the full 27.5–30 GHz range. Operators from various sectors stated these frequencies are integral to their use cases, including satellite broadband and some large Earth exploration projects, which typically require wider bandwidths that cannot be accommodated within the currently available 500 MHz or other SES bands. Satellite broadband providers argued that more bandwidth in the Ka-band is needed if they are to be competitive with terrestrial services in terms of speed and quality.

Coexistence with fixed links is possible in the Ka-band

Potential satellite use of this band would overlap with spectrum currently available for, and used by, fixed links in Ireland. Ireland's national frequency plan allocates the 28 GHz band (specifically 27.5-29.1 GHz) to primary use by fixed links operators.

One respondent to the consultation, Eir, submitted that there is no need for SES bands to overlap with those used for mobile services or fixed links, and that it is important to ensure that other use cases are not negatively affected by SES. It has not, however, experienced interference, and based on our understanding of coexistence between SES and fixed links it is not likely to encounter problems. As discussed in Section 4, interference between SES and fixed links can be managed, with stakeholders suggesting that coordination would be relatively straightforward if information about fixed link sites is available.

Where the appropriate ITU-R recommendations, CEPT Decisions and technical conditions are implemented, and coordination procedures are in place (i.e. as a standard part of the licensing framework), there is no reason the Ka/28 GHz band cannot be open to both SES and other users. The relevant CEPT and ITU recommendations include:

- Recommendation ITU-R SF.1719 on sharing between fixed links and transmitted SES in the 27.5-29.5 GHz band;
- ECC Recommendation T/R 13-02 on channel spacing for 28 GHz fixed links;
- ECC/Dec/(05)08 on SES use of 29.5-30 GHz (the SES band that is not shared with fixed links and is already included in the guidelines); whereas
- the recommendation in ECC/DEC/(05)01 to segment the band between SES and fixed links does not apply because it

is for uncoordinated SES, while coordinated SES and fixed links can share the whole 27.5-29.5 GHz band (as the Decision itself notes).

Based on the arguments above, we recommend that ComReg considers formally opening the full 27.5–30 GHz range for SES.

3.4 Q/V bands

Satellite operators, particularly those with NGSO constellations providing satellite broadband, would like ComReg to make higher frequency spectrum available as soon as possible. Congestion in space resources, as the number of satellites deployed grows rapidly, coupled with advances in satellite technology that require large bandwidths for hight throughput broadband services, are leading demand for spectrum to exceed what is available in the Ku- and Ka-bands, with the Q and V bands (33-75 GHz) being the next bands that will be used for SES.

ECC Decision (21)01, published in November 2021, identifies two ranges in the Q/V bands that ought to be allocated on a primary use basis to fixed satellite services (FSS), Earth-to-space, anticipating use of the bands by the next generation of High Throughput and Very High Throughput Satellites. These frequency ranges are:

- 47.2 – 50.2 GHz; and
- 50.4 - 52.4 GHz.

As it stands, the specific bands proposed in ECC Decision (21)01 do not overlap with any existing fixed links allocations or CEPT 5G priority bands. In any case, that Decision recognises that coordination between SES and fixed links can be effective provided sufficient technical information on existing services is available.

In addition, ERC Decision (00)02 was recently updated to designate the 37.5 – 40.5 GHz range for coordinated FSS earth stations (as well as uncoordinated FSS earth stations and uncoordinated MSS earth stations). The 37.5 – 39.5 GHz part of the band is also shared with fixed links. The Decision notes that "*…gateway stations [operating in the space-to-Earth direction]*

can be coordinated with FS stations like the case today in some parts of the 28 GHz band"[11].

We expect European NRAs to adopt the recommendations in ECC Decision (21)01 and the update to ERC Decision (00)02, and do not see any reason why ComReg should not do so.

In addition to the Decisions in place, there is likely to be further harmonisation decisions in relation to SES in the Q/V bands as the higher frequencies become more important and technology is developed. For example, we are aware that the ECC is engaging in ongoing review of coordinated FSS use in the 40.5-42.5 GHz band.[12].

3.5 E band and bands >100 GHz

Beyond the Q and V bands, the 70/80 GHz band (E band) has also been highlighted as a potentially useful band for SES operations and is set to be considered as part of the ITU's World Radio Communications Conference 2027 (WRC-27). Some stakeholders also highlighted that some frequencies above 100 GHz might become relevant.

The development timeline is not clear for systems using these bands and stakeholders have offered varied comments on when they intend to make use of them for commercial services. In its consultation response (as well as in a submission to the FCC[13]), SpaceX states its development of 70/80 GHz equipment (and that of their competitors) is well beyond the experimental phase, claiming it will be ready to deploy equipment using these bands to provide services imminently. Other stakeholders expect to see deployment within the next five years.

Our view is that ComReg should monitor developments in these bands but does not need to open them to satellite services immediately. Satellite use of the E-band was discussed at WRC-19, resulting in a number of resolutions, but studies on the band

[11] ERC Decision (00)02, Section 2.

[12] https://eccwp.cept.org/WI_Detail.aspx?wiid=803

[13] SpaceX comments filed with the FCC can be viewed at https://www.fcc.gov/ecfs/file/download/SpaceX%20Comments%20on%2070.80.90%20GHz%20NPRM.pdf?folder=1080571538794

have not yet been completed.[14] Immediate demand for these frequencies appears to be much lower than that for the Q/V bands, the technical conditions under which they could operate are unclear (e.g. regarding the bandwidths that should be available and the conditions for sharing with other user types, in particular fixed links) and ComReg's Test & Trial licence scheme may help to support the development of any technology that will eventually be used in the bands.

Competition considerations

Additionally, ComReg should be cautious of creating any first mover advantages in these bands. Early licensees might use a premature allocation to try and preclude future users in Ireland, or attempt to use an advanced allocation in Ireland as evidence in ITU filings that could be used to limit future competition. Potential first mover advantages are not a concern that can be addressed solely within the national SES licensing regime, because scarcity or congestion of sites for earth stations is unlikely, but the international system, which largely operates on a first-come, first-served bases, has broad consequences for satellite operators' use of frequencies and other scarce resources (e.g. orbital shells). This suggests a degree of caution if considering opening new bands before there is substantial demand or CEPT Decisions in place for them.

[14] See e.g. WRC-19 resolutions 178, 775, 776 and ITU-R WP5C Contribution 125 on sharing studies in the band.

4 Potential interference issues

Interference between SES users or between SES and terrestrial users has not been a significant issue in Ireland to this point. The majority of satellite operations in Ireland to date have used GSO systems that can relatively easily coexist with terrestrial users, while the low number of earth stations makes it simple for SES sites to be located in areas where they are unlikely to cause problems for, or receive interference from, other operators.

The advent of new NGSO systems, with steerable antennas operating at lower elevations, means that the interference environment around SES is becoming more complex, but we have not identified any major concerns that cannot be dealt with straightforwardly.

In our previous report, we set out our preliminary understanding that:

- interference between highly directional GSO systems (or even GSO and NGSO) is unlikely;
- interference between NGSO systems is more likely, so some measures (such as some geographical separation and/or mitigation techniques) might be required; and
- terrestrial services (in particular fixed links) operating in the same bands as SES on a co-primary basis were also unlikely to create significant interference issues, provided the locations of these were known (although some stakeholders were of the view that point-to-multipoint (P-MP) links could create a greater risk to SES than point-to-point (P-P)).

We invited further views on the potential for interference between SES and 5G, as opinions from stakeholders were divided.

4.1 Interference between earth stations

There is broad consensus among stakeholders that the only material risks of harmful interference between SES occur when the earth stations involved are both part of NGSO systems, primarily due to the use of physically or electronically steerable antennas operating at lower elevation angles. Stakeholders

agreed that harmful interference between two GSO systems, or between NGSO and GSO, is unlikely.

Interference only arises if NGSO operators have an incentive to place SES in proximity to each other

Sufficient geographic separation between SES avoids interference. If stakeholders have full flexibility as to where to position their earth stations, then we would not expect there to be any issue of scarcity (in terms of access to suitable sites and spectrum) within Ireland, in particular given expectations over the likely relatively small number of SES in operation.

There are currently fewer than sixty live SES licences in Ireland, of which only 16 are FES transmit licences. Many of the current licences belong to established use cases (e.g. broadcasting, government/community institutions), for which we expect no growth in demand. Newer LEO systems aiming to provide high-capacity broadband are likely to need more earth stations than a typical GSO satellite system because of the smaller footprints covered by lower altitude satellites. This may well lead to new SES being deployed in Ireland in the near future, but even so, the number of LEO operators is likely to remain relatively small given the significant investment costs involved. Furthermore, new technologies, in particular optical links for intra-satellite communications, should reduce the number of earth stations needed to provide a given level of coverage.

Demand for NGSO earth stations is, therefore, likely to remain relatively low, and we expect that operators will have a large degree of flexibility in their site selection, so the availability of sites in Ireland could be expected to be more than enough to accommodate the needs of all satellite operators. Even if some sites might be more attractive than others (e.g. those with access to existing fibre backhaul infrastructure), we anticipate this will be a mild constraint. Furthermore, whilst Ireland might offer some geographical benefits (e.g. given its proximity to the Atlantic), stakeholders have indicated that in most cases there are other countries nearby that would offer a suitable alternative.

Therefore, we do not see any issue of scarcity of sites for SES at present, nor any evidence that demand will increase sufficiently to create scarcity in the foreseeable future. As a result, interference between SES is likely manageable through coordination and modest geographic separation of earth stations. This could be supported through ComReg making available information on the locations and operations of existing earth stations, allowing operators to naturally coordinate and choose to locate away from each other such that interference is not a concern.

While there is no evidence of scarcity or substantial interference issues between SES, even those in NGSO systems, this does not imply that there are no risks of interference in other parts of satellite networks. In particular, NGSO systems containing large numbers of satellites and terminals at unknown locations could create interference, as the chances of 'seeing' transmission from another operator's satellites increases, but this is not a matter that can be resolved through SES licensing.

4.2 Fixed links

There is minimal risk of interference between P-P links and SES

Fixed links and SES often share the same bands but, at least for P-P links, there was again general consensus amongst respondents that coexistence between SES and fixed links is feasible. Provided that the locations of fixed links are known, it is relatively straightforward to avoid interference through coordination, with satellite operators positioning earth stations where they will not interfere with fixed links. We note that, as part of a separate review into its fixed links licensing framework, ComReg is improving the information it provides on fixed links licences (through SiteViewer) which should support coordination between SES and fixed links.

In addition, ComReg checks for potential interference and whether national coordination measures are needed when processing SES and fixed links licence applications, ensuring existing users are protected against interference from new licensees.

Some respondents to the consultation have suggested minor amendments to the licensing process for SES and fixed links:

- OneWeb suggests that SES operators should be notified of new fixed links after they have installed their earth stations; and
- SpaceX suggests a unified light licensing approach for SES and fixed links in the higher frequency bands (where licences are automatically granted if there is no risk to existing users).

In practice, we do not believe that either of these suggestions are significantly different from the existing process. ComReg checks for potential interference with existing users before granting a fixed link licence, so there is no need to specifically notify nearby existing SES users. Furthermore, new links will be added to the information provided by ComReg on its SiteViewer

system, so SES operators would be able to use that system to check for any developments without ComReg needing to actively inform them.

Regarding the SpaceX proposal for making the granting of a licence 'automatic' if there is no risk to others, we do not see any significant advantage relative to the current process. From a due diligence perspective, ComReg would always need to conduct its interference checks (even if very simple) and to ensure it has no concerns about the competitive implications of new licences. If there are no other users that might be affected then in practice the licensing process should be quick, with little delay relative to an automatic process. Operators can factor in expectations over the likely time required for a licence application to be processed in their rollout plans.

Likewise, P-MP links will not interfere with SES, although stakeholders also have concerns about the effect on user terminals

While there is agreement that coexistence between P-P links and SES is straightforward, some stakeholders are concerned about coexistence between SES and point-to-multipoint (P-MP) fixed links, particularly if these use 5G technology. We are not aware of any evidence that coexistence between SES and P-MP links could not be successfully managed through a transparent information policy and interference assessment at the application stage, just as is the case for P-P links. Although there are multiple endpoints of a P-MP link, and these may change over time (as the customers served by a P-MP FWA operator can change), these would always be known by ComReg, and interference could be dealt with in the same way as with P-P links.

On the other hand, we understand that stakeholders' concerns relate in part to coexistence between P-MP links and satellite user terminals, particularly in the lower part of the Ka-band (17.7-19.7 GHz), which overlaps with the 18 GHz fixed links band. In this case, there would be no formal interference analysis by ComReg, because the satellite terminals would be operating under licence exemptions. Coexistence between licence exempt terminals and other primary users of the band is primarily a matter for CEPT technical studies and harmonisation decisions and does not fall within the scope of this report. Currently Ireland does not have any P-MP operators in the 18 GHz fixed links band, instead most P-MP operators operate in licence exempt bands, none of which overlap with the Ka-band allocations available to SES. This may well change as a result of advanced P-MP technology, but there would have to be a significant increase in demand for P-MP licences for interference to become an issue.

Still, we recognise the need for technical studies to keep pace with changes to fixed links and satellite technology, so that decisions for licence-exempt operations (at the European level) and fixed links licensing (at a national level) are consistent in their approach to interference risk. ComReg should work on the assumption that the decisions it implements are sufficient to support coexistence between different internationally assigned uses of a band, and we do not see a case for additional restrictions on P-MP links.

4.3 Mobile/5G

Some stakeholders are concerned about potential interference between mobile/5G terrestrial services and SES, but the comments are somewhat inconsistent, and the extent of the issue remains unclear. Satellite operators' concerns around 5G fall into three categories, namely that they will:

- experience interference between SES and 5G services in the same band;
- experience out of band interference from 5G services in adjacent bands; or
- be forced to move to different bands if bands currently used by SES are repurposed for 5G.

Co-frequency interference issues are unlikely in currently open SES bands in Ireland

First, while we recognise that shared use of spectrum by 5G and SES in a given area could present significant interference issues in theory, this is unlikely to arise in Ireland. Spectrum used for 5G is generally awarded on an exclusive basis, and often in bands that are not used by SES. The only exception to this to date is the 3.6 GHz band, which has already been awarded in Ireland, and in which there is some overlap with bands included in the SES guidelines for receive operation. No significant issues in relation to this arose during the consultation on this band, nor have they arisen since.

In other countries, 5G spectrum awards (in the 3.6 GHz band) have raised potential interference issues for satellite operators, but the extent of the interference issues and how easily they can be mitigated is unclear. The advisory committee convened as part of the Dutch 3.5 GHz award process suggested that coexistence would involve Inmarsat using 80 MHz in the band on an exclusive basis, with MNOs using neighbouring frequencies, subject to additional restrictions within 15 km of the SES. Ultimately, Inmarsat intends to relocate its earth station

to Greece, and these measures will only be needed for a short period of time.[15]

Technical conditions that could support coexistence between SES and 5G need to be considered on a band-by-band basis. ComReg noted in the first consultation of this review that coexistence between SES and 5G in the 3.6 GHz and 26 GHz bands has been considered and addressed by the ECC. One of the reports referenced by ComReg, ECC Report 254, suggests two approaches to protecting incumbent C-band SES, some combination of which may apply depending on national circumstances:

- specifying permitted levels of interference, leaving MFCN operators flexibility over how to comply with these; or
- explicit restrictions on the frequencies, geographic locations and power levels available for MFCN.

The GSOA recognises that allocation of bands to 5G and guidance on coexistence measures is a matter for the ECC, but it is concerned that the implementation of the recommended technical measures has been insufficient to protect SES in some countries. It has not provided specific details of where this is a problem – we understand that it is not a particular issue in Ireland, but rather that the GSOA would welcome ComReg's support in CEPT group to protect SES access to the C-band.

Conditions for coexistence need to be reviewed as spectrum allocations change

In future, bands could be assigned to both 5G and SES as higher frequencies come into use. For example, we are aware that the ECC is currently working on various work streams for supporting coexistence of 5G MFCN and FSS earth stations in the 40.5 – 43.5 GHz range.[16] In most cases, we would expect the two uses will operate in different geographic areas. High frequency mobile spectrum is generally used in urban areas for additional capacity, whereas SES are more likely to be located on rural sites. Interest in protected SES operation in urban areas is likely to remain low, and conversely 5G services are not widely available around rural SES sites. Ubiquitous 5G mobile coverage could change this picture, but that may be reliant on lower frequency spectrum (not the Ku/Ka-bands or higher bands that could be assigned to SES or FSS in future). If this is the case, the tendency towards geographic separation could make opening

[15] https://www.rijksoverheid.nl/actueel/nieuws/2022/05/12/adviescommissie-35-ghz-band-in-2023-in-gebruik-voor-mobiele-communicatie

[16] See https://eccwp.cept.org/WI_Detail.aspx?wiid=769 and https://eccwp.cept.org/WI_Detail.aspx?wiid=803

new bands to 5G while protecting SES operating in the same bands more feasible in future.

Ultimately, the allocation of bands to ECS/MFCN, FSS or any other use is not a matter for ComReg, particularly in cases where it is bound by European Commission Decisions. Similarly, ComReg cannot give any certainty over whether SES will be able to continue operating in bands assigned to 5G until the relevant coexistence studies are available. In these circumstances, ComReg's best option for minimising disruption and uncertainty to SES is to continue with its approach of following CEPT guidance on coexistence of services and relevant technical conditions, and ensuring existing users are given reasonable notice in the event that spectrum is to be repurposed. SES operators will also be aware of ongoing ECC work that will result in potential changes to band allocations and coexistence measures and should take these into account when planning their investments.

Similarly, out-of-band emissions interfering with satellite services in adjacent bands is a matter for future spectrum awards e.g. in relation to the potential future award of 26 GHz frequencies (which neighbours the Ka-band) for 5G. There is nothing within the SES licensing framework that can constrain 26 GHz spectrum users, but we expect that ComReg will take into account relevant technical studies as and when it awards spectrum in that band, as it has for previous spectrum awards. Therefore, we again expect that this issue would be limited in practice.

5 Competition issues

ComReg's statutory objectives include promoting competition and the development of the Irish market. However, the satellite communications sector incudes various regulatory components in both the ground and space segments and only some of the competition concerns within the industry are relevant to a national SES licensing scheme.

As discussed in the previous section, the potential for interference both between SES and between SES and terrestrial services is limited, because there are few SES in operation, and we expect this to continue to be the case. Coexistence is possible, but there may be cases where operators do not have strong incentives to coordinate with other users of the spectrum, if they want to restrict competition. There could be opportunities for an operator to pre-emptively license spectrum and then deny rivals access to a band, site or other resources (if interference protection is overly generous) or conversely for later operators to interfere with existing operators (if interference protection is insufficient). In particular, competition issues arise if satellite operators can:

- block use of potential SES sites;
- gain access to new bands or space resources with the aim of precluding access to other satellite operators; or
- prevent terrestrial users competing for the same end customers from using spectrum.

Of the concerns that have been identified, most are regarding spectrum allocation or the licensing of the space segment, decisions which occur at the global/ITU level.

5.1 CEPT and ITU issues

First mover advantages in new bands and space segments

Technological advancements will lead to satellite operations eventually utilising higher frequencies, such as those in the E-band (70-80 GHz) and some above 100 GHz. One might be concerned that large operators could seek to obtain licences for this spectrum before it can realistically be used. This would present a competition issue if early licensees could attempt to use these licences to keep competitors from gaining market access, given later operators are required to coordinate with the earlier user before receiving a licence. Given that ComReg will continue to follow ITU and CEPT recommendations on

frequency allocations, concerns on the timing and requirements for high-band allocations should be addressed at the international level.

Similarly, NRA's can have little influence over the space segment licensing process. We understand that some operators are concerned that systems that launch satellites earlier could fill up orbital shells and create a large amount of space junk and space traffic, leaving later operators unable to compete effectively. While clearly important to the operation of a competitive satellite industry, such issues do not fall within ComReg's purview.

5.2 Competition with terrestrial services

In many cases, bands are shared between satellites and terrestrial services (primarily fixed links) that might compete for the same end customers, for example satellite broadband and FWA. At present, there is very little overlap in the spectrum used by P-MP FWA operators (who are concentrated in licence exempt bands) and SES operators, and there are no clear opportunities or incentives for either to act in a way that harms competition. However, deployment both of P-MP links and satellite broadband systems could increase as a result of recent technical developments.

In practice, coexistence between P-MP links and SES will remain viable provided proper information and coordination processes are in place, which should limit opportunities for operators to engage in gaming and anti-competitive behaviour. One can imagine cases at a very local level where operators could choose a specific site hoping for some anti-competitive gain (e.g. an NGSO earth station could be deployed in the middle of a business park that might contain attractive customers for P-MP broadband providers). We would expect SES to have sufficient flexibility over site choice and P-MP links to have sufficient flexibility over the topology of their networks, so that one being able to block the other is unlikely and the gains from doing so would be very limited. In any case, any anticompetitive attempts to preclude access to other types of operator are likely to be very localised meaning, again, that the potential gains are somewhat limited.

Even without any gaming or anti-competitive behaviour, satellite providers may be concerned that potential interference from licensed P-MP links into licence exempt satellite terminals

could prevent satellite broadband providers from competing effectively. However, as set out in the introduction, ComReg has an established policy of implementing CEPT licence exemptions and changes to these are beyond the scope of this review.

5.3 Options for SES licensing

The primary concern regarding competition that is strictly relevant to SES licensing would be that operators might use interference protection rights that come with SES licences to preclude others from deploying earth stations in Ireland (or certain parts of Ireland). While there may be some practical limitations to the geographic placement of earth stations (existing infrastructure, access to fibre) there does not appear to be a shortage of suitable sites in Ireland, and operators typically have significant flexibility over location.

In this context, anticompetitive behaviour would only be feasible if the interference protection granted by SES licences is not aligned with operators' technical needs and creates artificial scarcity that can be exploited. That could lead to some SES operators needing to locate in other countries, which would also deny Ireland the economic benefits that would come with the rollout of new earth stations.

In practice we anticipate that the risk of this occurring would be relatively small; there would be limited benefit to blocking access to sites in Ireland, given most earth stations could be deployed in neighbouring countries so keeping competitors out of the market would be very difficult (and likely very costly). Even so, we still believe that there is benefit from avoiding a situation where the licensing regime gives existing operators undue power to unilaterally block access to new earth stations. In that respect, there are two broad approaches that can be taken:

- an **active approach**, carrying out a competition assessment as part of every SES licence application process; or
- a **licence definition approach**, making it clear that the right to interference-free operation does not extend to the right to block future users.

Ofcom's active competition checks are unnecessary in this setting

Some NRAs are taking active approaches to protecting competition. The UK communications regulator (Ofcom) has recently launched a review of its own NGSO licencing process, in which it has identified competition concerns. Ofcom has

opted to implement a "competition check" on all new NGSO licence applications (both for earth stations and 'network licences' needed to deploy terminals). The check will "*take account of the technical constraints that the gateway or user terminals could create in future licensees*."[17]

We do not recommend detailed and routine competition checks on every SES licence application, as proposed in the United Kingdom. First, because opportunities for anti-competitive use of SES licences are limited, a licence definition approach (i.e. not granting blocking rights to incumbents) is sufficient. Second, competition issues are more likely to arise in relation to terminals (because of the far greater number of them), but unlike Ofcom, ComReg does not issue satellite network licences. If it introduced these, then either there would be a significant probability that ComReg would deny satellite operators the opportunity to deploy terminals (which might be inconsistent with ComReg's general approach of aligning closely with CEPT/ECC licence exemptions), or the licences would simply create an additional administrative burden for no clear gain.

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

6 Licence structure

6.1 Current situation

For the purpose of ComReg's SES licence, an earth station 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. Licence exemptions are based on CEPT Decisions, which ComReg implements.

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.)

FSES licences are for 12 months unless a longer duration licence (of up to 60 months) is requested. Teleport licences are for five years, but none have been issued by ComReg.

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 & Trial licensing scheme.

SES licences are more commonly issued for transmit-only (Earth-to-space) operation, or for receive (space-to-Earth) and transmit than for receive-only. Any transmit operation is required to be licensed unless covered by the regulations on licence exempt use. Receive-only stations pose no risk of interference to neighbouring users so can operate without licensing, but are then not protected from interference. ComReg has, in limited cases and at its discretion, licensed receive-only operations on a protected basis. If licensed for transmit-only, the earth station is automatically allowed to receive, but only on a non-protected basis.

6.2 Fixed and transportable licences

The majority of the use cases discussed in Section 2 rely on FES licences, and we expect that FES will make up the majority of applications for new licences. The use of TES licences is expected to decline over time as broadcasters move to newer IP-based technologies, although TES licences are still likely to play a significant role for the foreseeable future during the transition and potentially for use as backup systems. Therefore, there is no case for ComReg to consolidate or otherwise change the distinction between FES and TES licences.

Annex C sets out a review of the technical conditions set out in ComReg's SES Guidelines. It shows that ComReg is generally well aligned with best practice throughout Europe, but recommends some minor updates to the Guidelines:

- the site clearance conditions should be removed; and
- power limits around airports should be updated in line with ECC Report 272.

Aside from these relatively minor technical points, we propose three changes to the licence structure:

- FES licences should cover sites with multiple antennas (meaning Teleport Facility licences may be redundant);
- receive only licences may be allocated, but only at the discretion of ComReg and evidence for why a receive-only licence is needed should be provided on application; and
- licences running for longer than a year are not necessary.

6.3 Earth station definition

Allowing multiple SES at a site to operate under one licence could cut the administrative burden on ComReg and licensees

Stakeholders are generally supportive of treating multiple antennas at the same site as a single earth station, which therefore only requires one licence. This consolidated licence would allow the holder to operate any number of antennas using the same frequencies within a given area and the application process would be sped up by not requiring ComReg to separately process licence applications for each antenna. This is reasonable given that the interference environment will not be affected by an additional antenna operated by the same user (and therefore additional checks/coordination procedures by ComReg are largely redundant).

If multiple antennas at a site are covered by the same licences, this requires ComReg to determine the appropriate size of the licence area. In principle, this area should be small enough that:

- the interference environment can be assumed to be the same (which might not be constant between bands); and
- ComReg can reasonably inspect the whole site in a single visit should interference issues arise.

This will be in the order of hundreds of metres, and we note, for example, that Ofcom uses a 500m radius to define a site which may well be reasonable in Ireland. We welcome views from stakeholders on the appropriate area size.

These more flexible FES licences could make teleport licences redundant

As a result of this development, we believe that the teleport facility licence category would no longer be necessary. We have received mixed views from stakeholders on whether the teleport licences are fit for purpose, with some support for retaining the category (at least if fees are reduced). However:

- teleport licences have not been used at all to this point;
- there is no clarity on whether they would be used in future; and
- all potential benefits of teleport licensing that we are aware of could be achieved with the more flexible FES licence.

Therefore, we recommend removing the option for teleport licences from the SES framework if the definition of an FES licence is expanded to cover multiple antennas at a site. While the argument for a more flexible FES structure does not preclude charging more in licence fees for multi-antenna sites, we do not see the need to make licence fees dependent on the number of antennas.

6.4 Interference protection

Most FSES licences are granted by ComReg for either:

- transmit-only operation; or
- transmit and receive.

Interference protection is not needed for most receive only operations

Receive-only operation is usually implemented on a licence-exempt, and therefore non-protected, basis. Licence-exempt operation is preferable to having to apply and pay for a licence for most receive only SES operators, but there are some use cases (e.g. weather services where reliable up to date information is important) that may require interference

protection. ComReg has granted protected, receive-only licences in the past, but does so at its discretion.

Receive-only stations do not create harmful interference for nearby spectrum users. However, ComReg still needs to take licensed, protected receive-only users into account for its interference assessments when processing applications e.g. for fixed links. This creates an administrative cost for ComReg and additional coordination needs for other users of the band if receive only SES licences are taken up.

Therefore, we recommend some additional conditions on receive only SES licences to ensure that they are only held by operators who cannot operate effectively under the existing licence exemptions. In particular, an applicant for a receive-only SES licence should submit evidence showing that it needs interference protection. It would then be entirely at ComReg's discretion whether this user needs interference protection and should be granted a receive-only licence or should instead operate a licence exempt receive-only station.

Existing licence exemptions are sufficient for operators who do not need interference protection

On the other hand, some SES operators have indicated that they do not need the level of interference protection offered under ComReg's licences and are happy to operate on a non-protected basis, provided that they have sufficient information on neighbouring users. In effect, this would involve treating some low power earth stations (e.g. for IoT applications) or other users (e.g. with low duty cycles) as if they were user terminals, provided they fit certain technical specifications.

CEPT decisions (once implemented by ComReg) permit satellite providers to operate on a licence-exempt basis if they operate within certain technical parameters. Different use cases might rely on different licence exemption decisions (e.g. some IoT operators are named in ERC/DEC/(99)06), but we do not expect that any use cases would be excluded if ComReg's implementation of these decisions is up to date. We expect that these European harmonisation decisions would form the basis of licence-exempt, non-protected operation for SES that present a particularly low interference risk.

Therefore, allowing licence-exempt operation for some (low power, low duty cycle) systems does not require any provisions in the SES framework, only clarification that it is acceptable to operate 'earth stations' on a licence exempt basis if they adhere to the relevant technical parameters.

In terms of interference protection and the implication for SES licensing, we see three broad scenarios:

- the earth station is suitable for licence-exempt operations under the relevant CEPT Decisions (and corresponding Irish Regulations), in which case a SES licence is not required;
- the operator wants to use its earth station on a receive-only non-protected basis, in which case a a SES licence is not required; or
- the earth station needs to operate with interference protection and/or potentially creates interference for others, in which case a SES licence would be required and all operators needing a licence should be treated the same under the SES licensing framework.

6.5 Licence duration

At present, FSES licences typically run for 12 months (with the option to renew on licence expiry), but longer licences (up to 60 months) may be granted on request from the operator.

However, allowing for only annual licences would support the proposed licensing process set out below, that is designed to encourage operator coordination (where interference between earth stations might arise) whilst mitigating the risk of spectrum hoarding (in particular over long periods that might keep competitors from deploying SES in Ireland). We are, therefore, of the view that ComReg may consider removing the option to grant licences of more than 12-months with little impact.

To date, take-up of longer licences has been low, and operators appear to be comfortable with an annual renewal system, so we do not envisage any significant issues from making the proposed change. We appreciate that security over long term access to spectrum (which can be given through granting of long-term licences) is important to operators, especially when making large investments in infrastructure that cannot be quickly and easily adapted to use alternative frequencies (such as satellites). This point was raised by several stakeholders in the interviews/consultation responses. However, there should not be any particular problem with 12- month licences, provided operators have reasonable expectations of being able to renew their licence and maintain protection from interference from newer users, which prioritisation of existing users provides.

7 Licensing process

7.1 Current situation

The existing licensing regime is one in which there are rarely interference problems between satellite earth stations or between earth stations and other users (primarily fixed links). Therefore, the regime informally operates on a first-come-first-served basis, in that the acceptability of new users is judged against the interference environment formed by existing licensees, with a presumption that existing users will have priority. ComReg's guidelines set out the steps involved before it grants an SES licence:

- ComReg offers an optional pre-application consultation aimed at understanding the services licensed in a band the locations of those deployments at a point in time;
- the SES operator submits an application (listing the site, frequencies etc. it intends to use);
- ComReg evaluates the application based on whether it would be efficient use of spectrum, technical requirements, coordination between users, and compliance with international obligations and other regimes; and then
- a licence is issued following payment of the licence fees.

SES licences are issued for a fixed duration (generally one year) but are renewable.

To help licence applicants, ComReg provides information on existing users through its eLicensing and SiteViewer[18] platforms, although SES are not yet included on this service. SiteViewer is publicly available and contains information on a site's location, the operator's name and contact details, and the service provided. ComReg has recently expanded the information available on the system, with a particular aim of supporting fixed links users (who are more likely to face congestion in some bands/locations). Applicants' access to expanded information will make SES operator coordination smoother and more effective.

[18] https://siteviewer.comreg.ie/

7.2 Potential for operator coordination

We understand that:

- it is difficult to define precise technical conditions for efficient coexistence of earth stations, and we expect operators have better information on their systems than ComReg, which suggests that opportunities for users themselves to coordinate through agreement should be encouraged to make use of that private information;
- there will be a relatively small number of NGSO earth stations in Ireland, again suggesting potential for self-coordination; and
- it is unlikely that there will be scarcity of sites for earth stations. Even if operators are not indifferent between sites (e.g. locations with reasonable access to fibre backhaul may be more desirable), the number of feasible sites will likely far exceed reasonable expectations of future demand. Therefore, even where operators are competing in downstream markets, in many cases it should not be possible to foreclose competitors through locating earth stations, as they would still have many sites to choose from, provided interference protection for existing licensees is not excessive.

We, therefore, agree that ComReg should formally incorporate operator coordination into its SES licensing framework as a means of avoiding harmful interference. In this section we set out our view on the implications of this approach for the licensing framework.

7.3 Framework for operator coordination

In a framework where licensees' rights to transmit and to be protected from harmful interference are well-defined and not too many parties are involved, there are good prospects for efficient arrangements to be agreed amongst those parties (potentially using side payments if necessary). However, in these circumstances, it is bargaining amongst the parties that creates efficient arrangements for parties to co-exist, with the design of licence terms being incidental.

SES licences should provide clear rights to interference free operation

Providing there is clarity where rights and responsibilities lie, the conditions on licences primarily act as the starting position for users to strike agreements where they interact. If a user has a

right to protection from interference, then other parties might make a compensating payment to infringe on that right if it saves them sufficient cost (leading to an efficient outcome). Conversely, if there is a right to transmit (within technical limits) that might interfere with other parties, then those other parties might pay to avoid that interference (again leading to an efficient outcome). Clearly the equity consequences are quite different in the two cases in terms of who must incur cost to mitigate interference, as this depends on who has the 'right' that needs to be curtailed to achieve an efficient outcome and the direction of any associated compensation payment. However, the outcome should be efficient regardless, as otherwise there would be unexploited opportunities for the parties to negotiate an improved outcome.

In practice, this argument may break down and there could be limits on what can be achieved through coordination:

- Where many parties are involved, it may be difficult to agree common solutions to interference (bargaining inefficiencies);
- Where users are competitors in downstream markets, there may be incentives to foreclose access to spectrum for anticompetitive reasons.
- We may be concerned about equitable treatment of different users and want licence terms to establish a reasonably efficient outcome to minimise both the need for further negotiation and the magnitude of any side-payments needed to achieve efficient overall outcomes.
- We may have a situation in which users are flexible (e.g. with the location and design of their facilities) prior to investment, but there is much less flexibility post investment, creating an asymmetry between existing and potential users. It might create significant risk for investors if they faced subsequent potential users who they needed to 'buy off' to protect their existing investment.

First-come-first-served interference protection supports investment

A simple approach to defining licence rights would give an earth station operator a limited geographical exclusion zone to protect against significant interference on a first-come-first-served basis. This would recognise that, once investment in an earth station is made, if there was no protection this leaves the operator at risk of having to negotiate with new licensees who want to locate close-by and potentially even having to make payments to protect their prior position. However, there is no reason that operators could not agree to locate closer together if they wished (for example, there might be efficiencies in

sharing backhaul or other facilities). Our understanding is that there is no minimum distance below which earth stations would very likely conflict; this is highly specific to how earth stations are used.

This approach avoids creating excessive risk for new investments in earth stations. It also facilitates negotiation between a small number of potentially interacting users (who are close enough) but on the basis of a simple prior allocation of rights and responsibilities (i.e. a limited geographical exclusion zone). However, in most cases there will be little if any interaction between licensees.

The only residual concern with this approach is that if existing licensees had excessive protection from interference, say, the power to exclude new licensees within a large radius (such as several hundred kms), then this could have an anticompetitive effect. Licensees could negotiate to allow new users to locate closer than this radius, but might have poor incentives to do so if they were competitors in downstream markets.

Competition is protected by aligning the burden of proof with the likelihood of interference

Ofcom's approach to this issue is to include a competition test when granting licences. However, this has the disadvantage that it is rather discretionary. In our view, a similar effect could be obtained by changing the burden of proof on operators when determining whether there is harmful interference:

- Beyond some radius (likely 10's of kms) there would be a presumption that any new earth station licensee would not cause interference. However, existing operators should be notified of new applications to allow objections to be raised. The burden would be on the existing licensee to demonstrate that there would be problem.
- Within some radius of an existing licensee, new licences would not be issued without the agreement of the existing licensee. Therefore, there would be nothing to prevent the new licensee for striking some agreement with the existing licensee (which could be contractual), but the existing licensee would have the protected right.

Under this approach, existing licensees are always protected, but there is a presumption that new earth station licences far enough away from existing licensees are non-interfering.

Coordination works because of the limited number of SES

This self-coordination approach would apply to coordination among SES operators only. It cannot be expected to work well between earth stations and fixed links as there is a large number of fixed links, with a diverse range of users and deployment changes significantly over time, in contrast to there being a

small and stable community of satellite operators able to negotiate coordinated interference solutions.

7.4 Application process

Implementing the framework described above requires ComReg to make some changes to its process for issuing SES licences.

Earlier operators have a right to interference free operation

First, it formalises the first-come, first-served (FCFS) principle that is already in the guidelines by making clear that a licence grants earlier operators the right to operate free from interference from later operators. The ordering of operators is defined by when their licence was first issued. Although SES licences are issued for a fixed duration, they are renewable and there is a high probability that a licensee will be able to roll it over continuously, subject to the holder fulfilling the licence conditions (e.g. timely payment of fees) and provided ComReg does not need to make any changes for spectrum management purposes.

Therefore, there will always be a clearly identified first licensee. However, ComReg should also avoid situations where operators are hoarding spectrum without using it, but claiming protection rights and prohibiting access to others.

Priority over interference protection may be lost if spectrum is not used

We therefore propose that:

- whenever a licence is up for renewal, the licensee should be required to declare whether the associated spectrum was used in the previous year (if not, the default approach would then be for their incumbency status on the licence to be reset to start from the date of renewal, and potentially conflicting applications for the same spectrum received within the last year *may* then be given priority over the renewal of the incumbent's licence, at ComReg's discretion); and
- if an incumbent raises an objection to a new licence application for a site within the defined distance, ComReg could require the incumbent to (i) indicate whether it has used the relevant spectrum within current licence term; and (ii) if not, describe its plans for using the spectrum in the future.

Whilst it could be expected that not using the spectrum might lead to priority being given to other operators, this decision cannot be entirely rule-based. There may be valid commercial reasons for holding unused spectrum (e.g. ensuring access to

spectrum to support plans to expand in the near future) and we need to make sure that any redistribution of incumbency rights is reasonable and proportionate.

ComReg should therefore retain flexibility over determining who is given priority under these circumstances, which should consider the incumbent's lack of usage to date along with any demonstrated plans for using the spectrum in the future. For example, it may be appropriate to maintain priority for the incumbent if it can show that work and investment is underway for introducing the spectrum into its system in the near future. Only when the spectrum has not been used by the incumbent, an application had come in for a neighbouring site in the previous year, and the incumbent had objected to this application, would ComReg need this flexibility. Where no conflicts arise, operators would still be able to renew a licence regardless of whether they have used it.

Incumbents must present evidence of interference if new operators are far enough away

Second, ComReg needs to determine the critical distance beyond which earth stations can be assumed not to interfere with each other, and therefore the burden of proof switches to the incumbent beyond this point. When an operator submits an application, ComReg will notify existing SES operators and give them a fixed amount of time to voice concerns. This notification should contain key technical information (similar to what would be available on existing SES, discussed below), and applicants should commit to that information being valid until the end of the commenting period. Then:

- any operators more than the critical distance away from the proposed site would need to demonstrate that issuing a new licence would create harmful interference. Only if an operator demonstrates this will ComReg consider the objection and make a decision (potentially after further enquires); whereas
- if any incumbent operators within the critical distance object within the timeframe, ComReg would not issue the licence. However, existing licensees would be under an obligation to negotiate in good faith, and the applicant could raise a complaint with ComReg if it believed that had not occurred. In that case the burden would initially be on the incumbent to demonstrate that coexistence is feasible.

The value of the critical distance itself is not especially important, because it is intended only to provide a clear starting point for operator coordination, without creating competition concerns. However, we suggest that approximately 20 km is a reasonable distance. This is based on distance to the horizon

calculations, with 20km being roughly the distance required to avoid line-of-site between two systems with 10m high antennas[19] pointing at each other.[20]

The critical distance maintains incumbents' incentives to negotiate

SpaceX highlights that some first-come, first-served systems give incumbents no incentive to negotiate, and an opportunity to claim more protection than necessary. We agree in principle that this could be a problem, and suggest that this critical distance, and the framework around it, would not create such incentives and opportunities for incumbents.

To address its concerns with a first-come, first-served system, SpaceX proposes that, rather than assigning all requested spectrum to the first user and rejecting conflicting applications, a better fallback position for the coordination process would be to assign a smaller amount of spectrum that applied for to all users if conflicts arise. It refers to this as a 'spectrum splitting backstop' and recommends the additional condition that the more efficient operator be entitled to first choice of the spectrum. SpaceX submits that the FCC is the only regulator to formally consider this proposal so far and has adopted it.

We understand that the FCC spectrum splitting backstop relates to broader licences than ComReg's SES licences (i.e. NGSO FSS licences or grants of market access – both of which permit more than the operation of a single earth station), that are allocated in 'processing rounds' – where a number of applications are considered simultaneously and stakeholders are able to comment on these. The FCC is considering formally restricting the spectrum splitting backstop to applications in the same processing round (as requested by SpaceX) and the extent of protection that NGSO operators should receive from systems authorised in later processing rounds (e.g. whether there should be 'sunsetting' such that the protection is time limited).[21]

Therefore, it would be difficult to implement the proposed backstop unless licence applications were processed simultaneously. If ComReg were to use some form of this backstop, then:

[19] LEO earth stations (where interference issues are more likely to occur) operate with smaller antennas than GEO systems, with 10m being at the upper end of the antenna size used.

[20] Distance to the horizon (in km) from a height of *h* metres above the Earth's surface is approximately equal to $3.57 \cdot \sqrt{h}$.

[21] https://www.fcc.gov/document/facilitating-satellite-broadband-competition

- adapting it to a sequential approach could be severely disruptive to existing users, who may be 'less efficient' by virtue of deploying before the latest technology was available, and would be severely disrupted by the prospect of losing access to spectrum;
- assigning smaller than efficient amounts of spectrum would not be in any user's interest (consider, for example, that many users now want access to the full 2.5 GHz of the Ka-band). Of course, the point on the backstop is that the undesirable default position is to encourage operators to cooperate, but we may end up in the backstop because of genuine technical issues (i.e. not operators refusing to cooperate for competition reasons). In that case it could be a more efficient use of spectrum even to assign the less technically efficient operator all of the spectrum, than to assign both operators half; and
- there would be perverse incentives when applying for licences, because operators could deliberately not cooperate, knowing the precise rules ComReg would use to resolve conflicts. Operators could end up intentionally requesting far more spectrum than necessary.

ComReg retains powers to resolve conflicts, but these would not be needed very often

The process we propose gives a clear starting point for operators to negotiate from, and a default position for ComReg. When conflicts/complaints are raised, these will by definition relate to cases where the appropriate interference management conditions are unclear or contentious. This means that setting out a further rules-based approach to deal with complaints would not be helpful, but ComReg has a range of options for dealing with conflicts when complaints arise, including acting as a mediator or imposing its own solutions (given that it would be a licensing matter, rather than a contractual one). However, earlier operators always have a right to operate without harmful interference from later operators, and if interference occurs, ComReg would require the later operator to amend or cease operation. Therefore, we believe that there are strong incentives for later operators to avoid causing harmful interference and we would expect interference to remain uncommon.

Nevertheless, ComReg should reserve powers to investigate some applications in more detail, e.g. where it suspects there may be a threat to competition, or where it has particular concerns about interference. However, this would not be expected to form a routine part of the licensing process.

Operator coordination only works between FES, but FCFS rights apply across use cases

None of these changes should apply to TES licence applications. TES often need to be deployed at relatively short notice, and do not belong to a specific site, so the process described above would clearly be ineffective. However, ComReg should not create opportunities for gaming, where operators deploy FES under TES licences. Although this is fairly unlikely, ComReg should disincentivise it by limiting the amount of time that TES licences can be used at a site, but with flexibility for this time limit to be relaxed if requested by the licensee, and at ComReg's discretion.

Although operator coordination is only likely to be effective between satellite operators, and should generally be straightforward except for rare cases between NGSO earth stations, FCFS rights to interference protection should apply between different users in a band (i.e. typically between SES and fixed links). All types of users have a significant amount of flexibility prior to investment, but considerably less once equipment is installed – for satellite operators the flexibility may be over the location of SES, whereas for fixed links it may be over the band used. Therefore, similar arguments apply for all users, and other types of licences issued by ComReg should be on the basis that they must not interfere with existing users of any kind. This is, in effect, already how ComReg's licensing procedure works for cases where it is actively involved in coordinating users. Therefore, ComReg would predominantly be clarifying what various operators' rights are.

7.5 Information policy

Information about existing SES and terrestrial operators supports efficient coordination

Providing information on existing satellite and terrestrial spectrum users' sites is essential if SES licence applicants are expected to plan around existing users and if private operator coordination is to be key to avoiding interference. ComReg already publishes information on fixed links that should make this coordination and planning possible and could add SES data to the same system.

Stakeholders agree that information on existing licensees is important, with site location, frequencies used, power levels and antenna angles all having been mentioned as potentially useful. There is probably a case for a very transparent approach to the data made available, especially if we expect private negotiations, or even unilateral design choices to locate away from users in the same band. However, the amount of

information necessary for this is also probably limited to an earth stations location, frequency, power and type of orbit. These, alongside the contact details of site operators, may suffice. On the other hand, ComReg may need to go slightly further for NGSO operators (e.g. including azimuth and elevation angles), and the same level of information would need to be included in notifications to existing operators.

In some cases, there may be security concerns around publishing SES details, but these are limited to national security and potentially critical infrastructure related use cases – commercial sensitivity cannot be a reason not to publish SES information if negotiations between operators are the means of avoiding interference. Moreover, these limited security concerns could be dealt with by only providing certain information to logged in users, rather than making it fully public (i.e. as it would be on SiteViewer).

8 Licence fees

8.1 Current situation

Currently there are three cases in terms of the variables that affect SES licence fees:

- teleport licence fees depend only on the total bandwidth in use;
- SES fees in satellite exclusive bands depend on the number of SES (€100 each for the first ten, then €25 each for additional SES); and
- SES fees in non-exclusive bands vary according to bandwidth, frequency, and EIRP.

Annex A contains the full table of current fees.

8.2 Lack of material opportunity cost

Opportunity cost of SES licences is low or zero

Opportunity costs associated with new SES appear to be low (or even zero), given that:

- interference between SES is limited, and in any case the flexibility over location for earth stations and expectations that the number of earth stations in Ireland would be relatively low suggest that scarcity is unlikely; and
- coexistence with other use cases (in particular fixed links) appears to be manageable with limited concerns over interference.

If material opportunity costs were to arise, this would be most likely in urban areas. However, very few SES are likely to be located in cities (e.g. because of the high degree of flexibility over locations for SES), and even those that are located in high population density areas can probably coexist with terrestrial use cases well enough that opportunity costs would still be minimal.

ComReg should not assume that opportunity costs would always be close to zero, or set the expectation that SES licensees have an indefinite right to cheap use of the spectrum. If opportunity costs arise due to unforeseen changes, ComReg may need to review fee levels in the future. We would not expect this to be necessary for several years and the review process might therefore just fall under ComReg's periodic

reviews of its licensing framework. Moreover, we think that scarcity is sufficiently unlikely that we do not see any need to account for potential opportunity costs in the fee schedule. This is in contrast with our proposals for fixed links fees.[22] In that case, congestion has already arisen in and around Dublin, there is a large number of users of the spectrum with growing demand for bandwidth, and there is a chain of substitutable bands that these users should be efficiently spread out across. Whereas:

- demand for SES licences is low – although new use cases require a large amount of spectrum, there is not a continuous growth in demand;
- while the number of SES deployed in Ireland might increase, we expect the SES demand to remain well below the level that would create scarcity of sites/spectrum or material opportunity costs for the foreseeable future;
- it is not feasible to incentivise the small number of satellite operators to spread out across bands, because they are often dependent on a specific band; and
- it is easier to resolve conflicts between SES by operator coordination, given the smaller number of users and the fact they are not reliant on key sites/paths.

Therefore, there is no efficiency role for the fees in terms of ensuring licences are allocated to the highest value users when there is a conflict in demand, and the overall level of fees does not need to be any higher than necessary to cover ComReg's administrative costs.

8.3 Implementation of administrative cost pricing

Administrative costs should not be split evenly between users

While there are no efficiency grounds for setting the overall level of fees significantly above administrative costs, there may be efficiency arguments around ensuring that:

- each licensee covers the incremental costs incurred by ComReg as a result of its licence; and
- fixed costs are distributed to avoid inefficiently choking off demand.

[22] ComReg Document 21/134a

In particular, the use cases for satellite services vary significantly in terms of the level of fees at which operation would be economically viable, ranging from very high value satellite broadband services (e.g. those offered via the emerging LEO systems) to low value applications, such as earth exploration, telemetry, and university research projects. If, for example, we simply split the administrative costs evenly across all licences, there may be several applications that are priced out of the market with zero benefit. Therefore, there is an argument for applying Ramsey pricing principles to the fee structure; administrative cost still needs to be covered, but high-value users would pay a greater share than low value users, ensuring that prices for smaller users are kept low enough to enable them to operate.

Explicitly setting different fees for different use cases is complex and unnecessary

ComReg is somewhat limited in the extent to which it can set up a fee structure that accounts for the wide range of satellite use cases (current and future). A use case specific approach would involve setting strict definitions on the use cases and which fees would apply, which is likely to be difficult to set up and manage on an ongoing basis, especially in an environment of changing technologies, applications, requirements and value. Furthermore, it is unnecessary if use cases are reasonably well captured by other licence parameters (e.g. frequency band and/or bandwidth). Therefore, we do not recommend an approach that sets different fees for specific use cases.

To differentiate between high and low value users for the purpose of distributing administrative costs, we propose using bandwidth as a proxy for use case value.

Varying fees by bandwidth is sufficient

Our international comparisons and stakeholder input have identified a range of variables that are potentially relevant to setting SES fees, including frequency band, bandwidth, power, area covered, constellation/orbit type (i.e. whether GSO or NGSO), number of paths (SES to satellite) and whether the SES is transmit/receive only or both. ComReg's current fee structure depends on three of these, namely frequency band, power, and bandwidth.

However, we suggest that varying fees (linearly) according to bandwidth is sufficient. The current fees vary across different ranges of bandwidth but are fixed within each range, until bandwidth reaches 80 MHz. A linear approach (i.e. a fee per MHz) would offer better flexibility for varying fees in accordance with use case value. It also avoids arbitrary cut-off points at which fees jump up (or down) that might create incentives to licence different bandwidths than ideally required (e.g. an

operator might licence less spectrum than optimal to keep fees lower if the saving is substantial, but that might come at the expense of service quality). Including the other parameters found in the existing fee schedule (i.e. frequency band, EIRP and, implicitly, the number of antennas) is not necessary.

Differentiating fees across bands

At present, the fees vary depending on the frequency range used and whether the band is an exclusive use band or a shared band. However, there does not appear to be any good reason to maintain this approach in a revised fee structure, at least for the bands above 3 GHz. In general, differentiating fees by band (e.g. through 'band factors' that set a per MHz charges depending on band) would be appropriate if:

- scarcity of spectrum (current or potential) varies across bands and there is a benefit from reflecting opportunity cost in the prices to promote efficient spectrum use;
- the band(s) used provide information about use case value that is not fully captured by other parameters and can improve the distribution of administrative costs amongst operators (e.g. if low value users concentrate in one set of bands, and high value users operate in other bands); or
- administrative costs to ComReg associated with managing the licensing are higher for some bands than others.

Even if there is more spectrum in the higher frequencies, there is no obvious scarcity of spectrum for SES in any of the bands, nor are any material opportunity costs likely to emerge in the near future. Therefore, there is no need to have per MHz charges that differ across bands to capture relative scarcity (or potential scarcity) of spectrum.

We recognise that there may well be a small number of use cases where the assumption about the value/bandwidth relationship does not apply to the same extent as for other use cases. The most significant example is the case of a low value, high bandwidth user (some Earth exploration applications, for example, may fall into that category). If some bands are expected to be used predominantly by those lower-value, high bandwidth users there may be a case for setting lower per MHz fees in these bands, likely sub-3 GHz in this case. This of course only helps to the extent that operators can access sufficient bandwidth in those bands, which might not be feasible for some applications. We have heard, for example, that some EESS applications use up to 375 MHz of contiguous spectrum, but bandwidths of that scale are not available in the sub-3 GHz bands and those operators may therefore be restricted to using higher frequencies.

As limited bandwidths are available in the sub-3 GHz bands (meaning fees will be low in any case) we do not recommend any different band factor for these bands. However, we would welcome input from stakeholders on whether a lower per MHz fees for the sub-3 GHz bands relative to fees for higher frequencies is likely to help mitigate the impact of a per MHz charge on high-bandwidth, low-value users.

The current discount in exclusive bands is too large

Currently, ComReg sets a separate flat fee for licences in the two SES exclusive bands. This fee is very low and effectively gives licensees in the exclusive bands a discount in the order of 90% relative to fees for the shared bands. Differences in fees across bands would typically be relevant if there is a need to reflect relative scarcity between the different bands and incentivise efficient use of the spectrum through opportunity cost-based pricing. As discussed, the arguments for setting fees based on opportunity cost do not apply in this case and we are primarily concerned with recovering administrative costs.

There may be a case for retaining lower fees for the exclusive bands:

- if we believed low value users had self-selected into the bands because they are cheaper;
- if processing licences in these bands imposed significantly lower administrative costs on ComReg; or
- as an interim measure to avoid sharp, sudden increases in the fees faced by users of these bands.

However, current users of the exclusive bands tend to have lower bandwidth needs, such that fees will remain relatively low. There is also no reason to believe exclusive band users are particular low value (the only obvious difference in use cases not captured by bandwidth is that exclusive band licences are more likely to be for TES) or impose significantly lower administrative costs – incremental costs are low for all bands, even if ComReg has to perform additional checks (e.g. coordination with fixed links). Under this reasoning, we propose that ComReg eliminate the exclusive band discount and instead apply the same fee structure to these licences as used in the non-exclusive bands.

Fees should not depend on the number of antennas used at a site

In Section 6, we recommend that SES licences be amended to cover any number of antennas operating within some area. Although opportunity cost-based arguments relating to multi-antenna licences do not apply (i.e. the fact that the interference environment for other users in not affected by an additional antenna is not relevant if we are not concerned about

interference), nor is there any reason to suggest that multi-antenna sites serve higher value use cases. Indeed, low value users may have an incentive to group together at sites to spread substantial infrastructure costs between each other. Similarly, an extra antenna is unlikely to impose further administrative costs on ComReg. Following this, we recommend that SES fees do not depend on the number of antennas operated under the licence.

We note that varying fees by power level does not appear to have much of an effect under the current fee schedule, with most operators falling in the middle fee band for EIRP. It is not likely to be a reliable proxy for user value, and we do not include it in our proposal for fees.

FES and TES face the same fees

At present, the fees for TES are applied in exactly the same way as for FES. We suggested in our first report that there may actually be a case for setting TES fees higher, on the basis that there might be additional interference assessment costs associated only with TES due to the fact that they are not used at a fixed location (and might be needed anywhere in Ireland and at relatively short notice).

We understand, however, that there is no tangible difference in administrative costs associated with TES relative to FES. When a TES application is received, ComReg will first check if the frequencies applied for are being used by any other party. If they are, then ComReg will assess the potential for interference and determine whether the licence can be granted. However, the interference analysis is relatively simple, and does not lead to any difference in effort required to process TES applications compared with FES applications.

On that basis, TES and FES licences can continue to be charged under the same fee structure.

8.4 New fee schedule

We propose a simple, two-part tariff for the annual SES licensing fee consisting of an incremental cost and a per-MHz cost based on bandwidth. This proposed structure uses bandwidth as its sole parameter. Administrative cost recovery forms the basis of our recommendation, with consideration granted to Ramsey pricing principles and the aim of not pricing out certain classes of users- either by size or use case. As discussed in the preceding sections, this structure would apply

to all licence applicants and does not vary by band or licence type (i.e. TES and FES licences have the same fee structure).

Our proposed fees schedule applies the following fee calculation to all users, with *BW* representing the bandwidth applied for in MHz.:

$$annual\ fee\ (in\ €) = 100 + 30(BW)$$

The values of the floor and per MHz charge are based on ComReg's estimates of its administrative costs. The first part, a constant applied to all licences, reflects the incremental cost of any SES licence application to ComReg. Based on ComReg's costs, the true incremental cost of processing any SES licence application comes out to about €100. The constant in the fee calculation will also act as a floor for the potential range of fees and even users applying for very small bandwidths will need to pay at least €100.

The second part of the tariff calculation is a per-MHz charge that distributes ComReg's fixed costs in proportion to bandwidth. Beyond the initial floor, fees in this scheme will increase linearly with the bandwidth used by the operator. To avoid inefficiently choking off demand, high-value and high-intensity (proxied here by bandwidth) users should pay more of the total costs than smaller users. The per-MHz charge listed above (€30 per MHz) has been derived to fully recover the current costs of the SES licensing scheme to ComReg. SES licence revenues are already broadly in line with total administrative cost, so this change is a redistribution of fees among users.

The majority of current licensees would see their fees decrease under the proposed pricing regime, except those:

- in the exclusive bands; or
- with very high bandwidth needs.

Exclusive band fees increase because the current discount is unjustified

The increase in exclusive band fees follows from our conclusion that the current discount applied in these bands (which effectively amounts to a 90% discount) is both unnecessary and unreasonable given the lack of scarcity of SES spectrum. Current licensees in these bands have typically used smaller bandwidths, so these fees will remain relatively low even if the proposed system were to be implemented. The fee increase for most exclusive-band users will be in the order of hundreds of euros, which is unlikely to choke off demand. Further, some users holding multiple licenses will see their total SES fee bill decrease because as their exclusive band licences get more expensive,

their other licences in the non-exclusive bands will likely become less expensive.

Very high bandwidth fees increase because the floor falls

The largest users (according to bandwidth) will also see fees increase under this structure. This change is primarily reflecting a decrease in the effective "floor" built into the different fee structures. The current structure, while not implementing a floor by name, results in a very high minimum fee for most types of licences. The lowest any project falling in the mid-power range (in which nearly all SES projects fall) can pay under the current scheme is €300. The lowest fee any project could pay in the new scheme would be just over €100. The proposed price floor is meant to reflect the minimum administrative cost to ComReg of processing an SES application. Using administrative cost recovery as our guiding principle, it would not make sense to set this constant any higher than the true incremental cost. Additionally, a lower price floor avoids unnecessarily excluding smaller users from SES operation, as they will be able to access lower fees.

Fees should be indexed for inflation

ComReg needs some way for fees to increase in line with its administrative costs over time, but we know that SES operators benefit from being able to form accurate expectations on future fees. Therefore, we propose that fees are indexed for inflation (using CPI), which is consistent with ComReg's current general approach to applying annual licence fees. Indexing in this manner should prevent the need for ComReg to review and potentially change fees frequently, even if administrative costs do increase at times. Operators face less uncertainty when planning investments if fees are indexed rather than updated in line with new administrative cost estimates, because they are likely better able to forecast inflation than they would be able to predict changes in ComReg's costs.

ComReg can continue to review SES fees as part of its usual and systematic licensing review process and respond to changes in SES demand and use cases if these arise as part of that process.

Stakeholders support administrative cost pricing but are concerned about per MHz charges

Consultation respondents are generally supportive of administrative cost pricing – some explicitly, others through a general request for low fees (recovering administrative costs gives the lowest level that ComReg can reasonably set). Some stakeholders have also commented on the structure of fees, suggesting that ComReg should not charge:

- per antenna; or
- according to bandwidth.

In particular, there is some suggestion that demand from emerging use cases relying on multiple antennas and high bandwidths could be choked off. Such users will benefit from one aspect of the fee changes, but could see fees increase if they use very large bandwidths. However, our changes are grounded in economic principles as described above. Of course, assuming a linear relationship between bandwidth and value (as opposed to some more complex increasing relationship) is a simplification, but we see no clear alternative that would not involve complicated and difficult to implement assumptions about use cases.

9 Summary of recommendations

Our recommended adjustments to the SES licensing framework in Ireland are largely based on formalising and supporting several processes that are already in place, plus some adjustment to the structure of fees.

To summarise briefly, our recommendations are as follows:

- Some frequency ranges below 3 GHz (in particular 401-402 MHz, 402-403 MHz, 2025-2110 MHz and 2200-2290 MHz) could be opened to SES in accordance with the ITU allocation.
- ComReg should consider making the full 27.5–30 GHz range in the Ka-band available for SES.
- ComReg should implement ERC Decision (00)02 and ECC Decision (21)01 regarding use of the frequency ranges 37.4 - 40.5 GHz, 47.2 - 50.2 GHz and 50.4 - 52.4 for FSS.
- Developments in relation to other parts of the Q/V-bands, the E-band, and frequencies above 100 GHz should be monitored and any relevant CEPT Decisions implemented as appropriate in a timely manner.
- FES licences should be adjusted such that a single FES licence would allow the holder to operate any number of antennas/earth stations within a given radius at a single site.
- FES licences should be granted for a period of 12 months, with the option to renew annually.
- TES licences should continue to be available for the foreseeable future.
- Teleport facility licences do not appear to be necessary or useful, particularly if FES licences will cover multiple antennas, and can be removed from the framework.
- Receive only licences may be granted but should only be available to operators who provide sufficient evidence that they cannot operate under licence exemptions. The issuing of receive-only licences should be entirely at ComReg's discretion.
- The licensing process for FES should be adjusted, in line with the recommendations set out in Section 7, to support coordination between SES operators to maximise the potential for efficient arrangements. This formalises the first-come-first-served approach that gives priority of interference protection based on when licences were first issued. The process needs to provide sufficient protection for existing users, but should avoid giving incumbents

excessive power to anticompetitively block access to others and needs to be robust to negotiations breaking down.

- ComReg will need to maintain its current approach to assessing harmful interference in relation to terrestrial users, such as fixed links operators.
- The TES licensing process would remain largely unchanged, although a limit on how long a TES can be used at any given location could be applied to minimise the risk of gaming across licence categories. The time limit could be extended following a request from the operator.
- Making available information about existing SES systems and fixed links should support coordination and coexistence between earth stations and between earth stations and terrestrial services.
- Licence fees need only to cover ComReg's administrative costs, although there are arguments for applying Ramsey Pricing principles to distribute costs across operators such that higher value users pay a greater share.
- We propose using bandwidth licensed as a proxy for use case value. The fee for a SES licence would be in the form of a two-part tariff comprising:
    1. A fixed fee of €100 to cover the incremental cost of processing a licence application; plus
    2. A charge of €30 for each MHz licensed.
- The same fee structure would apply for both FES and TES licences and would be the same across all SES bands (including the exclusive use bands).

Annex A Current fees and bands

This annex contains the fees and SES bands set out in ComReg's existing guidelines.

Table 3: Current SES annual fees

Frequency (GHz)	Bandwidth (MHz)	Fees (EUR)		
		eirp < 50 dBW	50 dBW ≤ eirp ≤ 75dBW	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	1625 + (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 4: Frequency bands available for SES transmit operation

Frequency (GHz)	**Other 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 5: Frequency bands available for SES receive operation

Frequency (GHz)	**Other 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 Summary of SES licensing regimes elsewhere

B.1 ITU frequency allocations

In general, Ireland seeks to align its national frequency plan with the allocation recommendations of the International Telecommunications Union (ITU).

ITU guidelines designate frequency ranges for satellite communications on either a primary or secondary basis. Ranges are typically designated to specific satellite uses. Yet member countries retain control over their own frequency allocations and choose when and whether to implement ITU decisions, giving rise to differences in the frequencies available for satellite projects internationally.

ComReg is particularly concerned with the potential opening of frequencies below 3 GHz for licensed SES operations in Ireland. The current restriction to frequencies above 3 GHz is peculiar to Ireland, with many other countries offering licensing to SES operators in the UHF, L and S bands. The ITU allocates a total of 427.85 MHz of spectrum between 100 MHz and 3 GHz to satellite earth station use on a primary or secondary basis. These allocations include Earth Exploration Satellite Services (EESS), Space Operations Service (SOS) and Broadcasting Satellite Service (BSS). The ITU does not make allocations for Fixed Satellite Services (FSS) in this range. Table 6 provides a summary of theses ITU allocations below 3 GHz .

Table 6: ITU satellite allocations below 3 GHz

Band	Spectrum allocated (primary and secondary)	Allocations
VHF 30-300 MHz	2 MHz	• Space Operation (space-to-Earth)
Sub-1 GHz UHF	12.85 MHz	• Earth Exploration-

300 MHz – 1 GHz		satellite (space-to-Earth) • Space Operation (space-to-Earth)
L 1 – 2 GHz	88 MHz	• Meteorological-satellite (Earth-to-space) • Space Operation (Earth-to-space, space-to-Earth) • Broadcasting-satellite
S 2 – 3 GHz	325 MHz	• Earth Exploration-satellite (space-to-Earth, Earth-to-space) • Space Operation (Earth-to-Space, space-to-Earth) • Broadcasting-satellite

As technology advances, we expect to see satellite systems designed to use higher frequency bands, in particular the Q/V bands. ECC Decision (21)01, adopted in November 2021, allocates two frequency ranges in the Q/V band to use by fixed satellite services, Earth-to-space. The decision cites congestion in lower bands and evolving satellite technology as the primary drivers.

B.2 National frequency allocations

This survey reviews the national frequency plans of nineteen other European countries.[23] The current ComReg framework allocates seventeen frequency ranges to SES as the primary or co-primary use. Nine of the comparison countries allocate all of these frequencies to SES as the main use, while others have spectrum allocations more restricted in this range for satellite services. In all countries in this review, at least some frequencies in the Ka- and Ku- bands are available to satellite as the primary use.

Entries in national frequency plans can have varying implications in different jurisdictions. Many of the countries in the review list all possible uses in a band, even if operators in that country are not currently utilising the band. Further, countries allocate primary (or main) uses as well as secondary (or other) uses. As we are concerned with all opportunities provided to satellite operators, the information below includes both primary and secondary services. The primary/secondary distinctions are noted when specified in the national frequency plans.

The table below provides a high-level summary of the allocation of frequencies in certain bands to satellite services in the countries reviewed.

Table 7: Summary of frequency allocations to satellite services across reviewed countries

Band	FSS	EESS and/or SOS
VHF	0	9 (+3 secondary only)
Sub- 1GHz UHF	0	14
L	0	9 (+1 secondary only)
S	17 (+1 secondary only)	13

[23] Countries included: Belgium, Croatia, the Czech Republic, Finland, France, Germany, Iceland, Liechtenstein, Lithuania, Malta, the Netherlands, Norway, Portugal, Romania, Slovakia, Slovenia, Switzerland, and the UK.

C	18	12
Ku	18	6
Ka	18	10 (+ 1 secondary only)

B.2.1 Frequencies below 3 GHz

Sub-3 GHz spectrum is important to the operation of Earth exploration and Internet of Things (IoT) satellite services, which are both rapidly expanding use cases. Stakeholders in these sectors noted that satellite systems are already operating in the VHF and UHF bands in other countries. Such projects fall outside the current framework for licensing in Ireland, which only licenses SES services above 3 GHz.

Earth exploration and IoT stakeholders were particularly interested in frequencies around 400 MHz and 1-2 GHz. The range of 401 MHz- 403 MHz has been allocated to Earth exploration in many other jurisdictions and the ECA. Of the nineteen European countries in this review, half have designated this range to EESS as the primary use. The UK allocates the same frequencies to EESS as a secondary use. Frequencies in the ranges 1427-1429MHz, 2025-2110 MHz and 2200-2290 MHz are also often allocated to Earth exploration and/or space operation, with fifteen countries (as well as the ITU and European Common Allocation) allocating frequencies in at least one of these ranges to EESS and SOS primary use.

Table 8: Number of countries with EESS allocations in the given ranges

Frequency range	ITU/ECA allocation mode	Countries in review allowing SOS and/or EESS
401-403 MHz	Uplink	13
1427-1429 MHz	Uplink	7
2025-2110 MHz	Uplink	12

2200-2290 MHz	Downlink	13

B.2.2 The Ka-band

The Ka-band is used for a wide variety of SES use cases and projects. These users primarily utilise frequencies spanning from 27.5 to 30 GHz. Ireland's current spectrum allocation plan has 500 MHz available for licensing satellite services in this range, specifically 29.5-30 GHz. Stakeholders voiced frustration with this limited spectrum in Ireland, saying that the country is out of step with its peers when it comes to the Ka-band, complicating expansion and investment decisions.

Other countries (with few exceptions) follow the ITU allocation of these frequencies and designate 2.5 GHz of spectrum (27.5 GHz-30 GHz) in the Ka-band to licensed use by satellite operators. Of the listed countries, all allocate at least some frequencies between 27.5 GHz and 30 GHz to satellite services. Twelve allocate the entire 2.5 GHz to satellite services on a primary or co-primary basis. A further five open the entire range to satellite use with secondary (or a combination or primary and secondary) allocations, and two further countries allocate a majority of the band, but not the full 2.5 GHz, to satellite services.

B.2.3 Upper Frequency Bands

The use of higher frequency bands (Q, V and E bands) by satellite communications is a newer development and therefore the allocations of such frequencies are less standardised. ComReg has not identified any frequencies above 30 GHz for satellite use in Ireland under the current framework.

ECC Decision (21)01, passed in November 2021, formalised the European allocation of two higher-frequency ranges (47.2-50.2 GHz and 50.4-52.4 GHz) for use by the Fixed Satellite Service, Earth-to-space. There are pre-existing European allocations to FSS at 37.5-40.5 GHz (space-to-Earth) and 42.5-43.5 GHz (Earth-to-space) arising from ECC Decisions (00)02 and (02)04. In alignment with these decisions, several countries (including the UK, France, and Germany) allocate these ranges to FSS in their national frequency plans.

Satellite operators anticipate using even higher frequencies (the E band, or 70-80 GHz) in the future. The timeline of these technological developments is unclear, with some operators claiming they will be ready to make use of E-band spectrum in the immediate future and others expecting development to take many years. Much of this band is currently ECA allocated to defence systems using satellite, and there has not yet been harmonised allocation to civilian FSS use.

B.3 Licence types

Of the 22 countries surveyed that have defined SES licensing schemes, all make a distinction between gateways and user terminals. Certain user terminals are widely exempt from the licensing procedure, following the recommendations in ECC Decisions (05)01, (06)02, (06)03, and 17(04).

There are licensing regimes that offer just one general licensing procedure for all gateway projects, but often countries make distinctions between projects and offer multiple SES licence categories. Through the review, the following categories have been identified as distinctions in national licensing regimes:

- Fixed and mobile satellite earth stations;
- Receive-only, transmit-only and transmit-receive earth stations;
- Individual station licensing and network licensing;
- Coordinated and uncoordinated earth stations;
- A separate license category for satellite news gathering (SNG) operations;
- Long term and temporary licences.

A frequent point of concern was that Ireland's licensing regime does not accommodate sites with multiple antennas, often called dish farms or antenna farms, and that other countries' licensing regimes are more accommodating of these projects. ComReg's licensing conditions consider each antenna a separate earth station, even those that are co-located. This is in contrast to licensing conditions in the UK and France that allow an unlimited number of antennas within a defined earth station site.

B.4 Fee structures

B.4.1 Variables considered

A small number of NRA's in this review[24] set a fixed price per earth station without other considerations, but the majority set licensing fees using one or more variables such as the frequency band and/or bandwidth.

In countries with these variable license schemes, nearly all considered the bandwidth requested by the earth station. The schemes demand higher fees for projects requiring more bandwidth, but the level of these per-MHz bandwidth-based fees vary significantly.

Many licensing schemes also consider the frequency band which the earth station will be using. This is not uniform, but these schemes typically charge less as the frequency increases (although some also charge less for the very low frequency bands).

Bandwidth and frequency band are the most common features used to calculate fees, but various countries include other measures in their fees structures. Some of these variables are listed below:

- Whether the project requires coordination of frequencies (also referred to as exclusive/non-exclusive use;
- the location of the site and/or the area covered by the communications, with some countries setting this variable based on population density;
- the type of satellite orbit with which the station will connect (GSO vs NGSO, or LEO vs non-LEO);
- use case; and
- the project's turnover.

For a summary of the variables used in the licensing schemes considered, see the following table.

[24] Fees review includes the following countries: all the countries listed in Footnote 2, plus Hungary, Spain, and Turkey.

Table 9: Fees schemes summary table

Country	Fixed price	Freq.	Bandwidth	Power	Area	Other
Belgium	–	–	Yes	–	–	–
Croatia	–	Yes	Yes	–	–	–
Czech Republic	–	–	Yes	–	–	Channel access (exclusive vs nonexclusive)
Finland	–	Yes	Yes	–	Yes	Use case, type of transmitter
France		Yes	Yes	–	–	–
Germany	Yes	–		–	–	–
Hungary	–	Yes	Yes	–	–	–
Iceland	Yes	–		–	–	–
Liechtenstein	–	Yes	Yes	–	–	Orbit (LEO vs non-LEO)
Lithuania	–	Yes	Yes	–	–	–
Malta	–	–	Yes	–	–	–
Netherlands	–	–	Yes	–	–	–
Norway	–	–		–	–	Falls under general authorisation
Portugal	–	–	Yes	–	–	–
Romania	Yes	–		–	–	–
Slovakia	–	Yes		–	–	–
Slovenia	–	Yes	Yes	–	–	Earth exploration exempt
Spain	–	Yes	Yes	–	Yes	–

Switzerland	–	Yes	Yes	–	–	Orbit (GSO vs NGSO)
Turkey	Yes	–		–	–	–
UK	–	Yes	Yes	Yes	–	Earth station to satellite paths

B.4.2 Multiple earth stations/antennas

Some regimes have provisions for applicants requesting more than one satellite earth station or more than one antenna at an earth station site. Again, these schemes are varied.

Croatia employs a scheme in which additional stations (up to ten) from the same licensee are charged a discounted fee. Fees on the tenth through twentieth stations are further discounted, and any subsequent earth stations beyond the twentieth do not require additional fees. Additional co-located earth stations in Australia are charged at a discounted rate. The current Irish scheme allows for discounts on more than ten earth stations only if the stations operate in the exclusive bands.

The UK allows multiple antennas within a 500m radius of the designated site and French regulations are similar. Ireland (among others) considers these additional antennas as separate earth stations and charges additional fees accordingly.

B.4.3 Level of fees

The following exercise considers three hypothetical projects applying for an SES license under different regulatory regimes in Europe and their resulting fees.[25] All examples are calculated for a project covering the entire territory and assumed to require coordination.

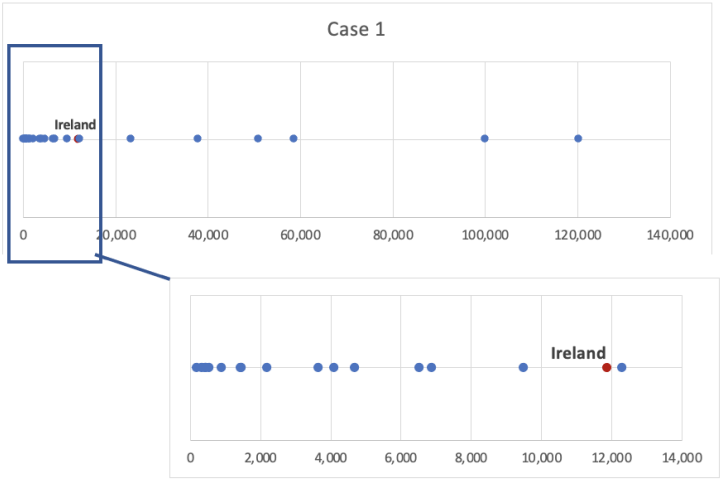
As evidenced in the findings and figures below, there is not an internationally agreed upon level of fees for SES licensing.

[25] SES fees in Finland are significantly higher than in the other countries in this review and so the observation has been removed from the graphs and ranges as an outlier.

Case 1: LEO Broadband

The first case is a large LEO constellation providing broadband internet to a large area. This applicant requires 500 MHz of bandwidth in the Ka-band, with max power 67 dBW. The estimated annual fees for this project ranged from €167 to €120,060, with the current Irish framework falling at €11,850. The bandwidth requirements of this project make it especially sensitive to fees structures with high per-MHz bandwidth coefficients

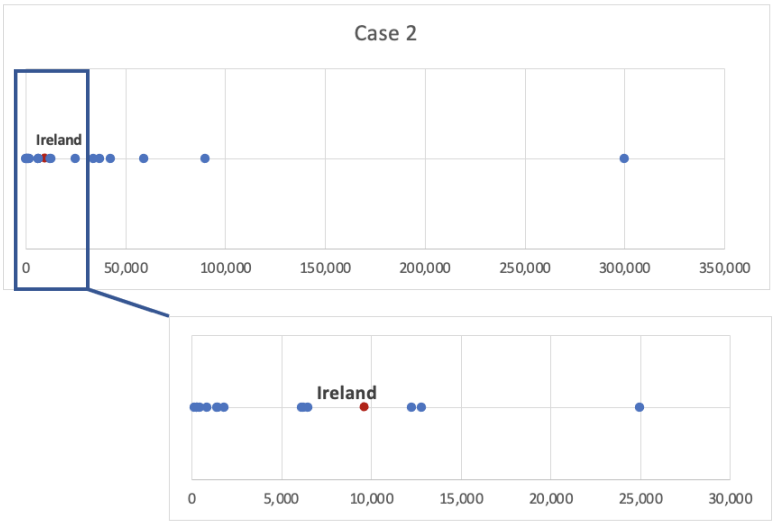
Figure 1: Range of international fees (€), LEO Broadband



Case 2: Earth Exploration

The second case is an Earth exploration project in the C-band. This example requires 375 MHz of bandwidth and uses 67 dBW of power. This type of licence currently accrues annual fees of €9,625 in Ireland. Annual fee calculations under other regimes for this example were €167 on the low end and €300,000 on the high end. Like the first case, this project is sensitive to fee structures reliant on the bandwidth. Additionally, it is sensitive to the frequency band-based fees that make the S band one of the most expensive frequencies at which to operate. Note that at least one jurisdiction exempts Earth exploration satellites from licensing fees.

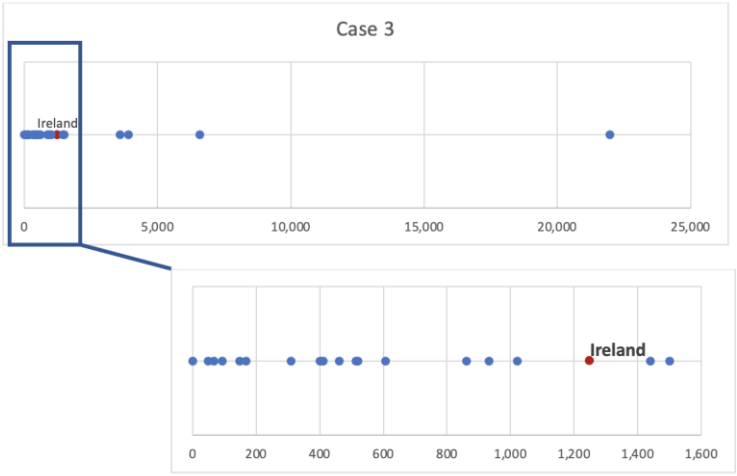
Figure 2: Range of international fees (€), Earth Exploration



Case 3: Satellite News Gathering

The third case is one of Satellite News Gathering (SNG) using a small bandwidth (6 MHz) in the Ku-band, which are the frequencies traditionally used for SNG. Irish fees for this project stand at €1,250. The power used in this example is 56 dBW. Fees for such a project ranged from €0.48 to €21,978.

Figure 3: Range of international fees (€), Satellite News Gathering



Annex C Technical review

This section provides a review of the mandatory technical conditions laid out in the ComReg's Satellite Earth Station (SES) Guidelines[26], (hereinafter, the "Guidelines"), and assesses the applicability of these technical conditions to the Irish frequency spectrum ecosystem in the light of the relevant ITU, CEPT and ETSI recommendations and the international best practices. Specifically, this section discusses the following technical aspects:

- Telecommunications Equipment Directive
- Reference standards
- Operation mode
- Maximum transmit power
- Site clearance
- Airport exclusion and notification zones
- Other technical parameters

C.1 Telecommunications equipment directive

According to ComReg's Guidelines, all radio and telecommunications equipment in use in Ireland since 5 June 2001 must comply with the essential requirements and other provisions laid out in the European Commission's (EC) Radio and Telecommunications Terminal Equipment (R&TTE) Directive 1999/5/EC[27].

This Directive established a regulatory framework for the placing on the market, free movement and putting into service in the Community of radio equipment and telecommunications terminal equipment; and defined the essential requirements that all apparatus should follow.

On 16 April 2014, the EC enacted the updated R&TTE Directive 2014/53/EU[28] "*on the harmonisation of the laws of the Member States relating to the making available on the market of radio equipment and repealing Directive 1999/5/EC*", replacing Directive 1999/5/EC.

[26] ComReg Document 00/64 R3

[27] EC Directive 1999/5/EC

[28] EC Directive 2014/53/EU

While Directive 2014/53/EU does not notably differ from Directive 1999/5/EC, the EC claimed that the latter had suffered from substantial amendments in the past and, since further amendments were to be made, it had to be replaced in the interest of clarity. Moreover, Directive 2014/53/EU introduced new modifications, mainly:

- The conformity assessment procedures were further expanded to ensure a uniformly high level of performance of notified bodies throughout the European Union.
- The safeguard procedure was improved for the sake of transparency and to reduce processing times.

Therefore, acknowledging that Directive 1995/5/EC is no longer in force and has been repealed by Directive 2014/53/EU, we suggest including the latter in the Guidelines as the Directive of reference in Ireland.

C.2 Reference standards

While the R&TTE Directive provides the essential requirements to operate equipment in the EU/EEA, the reference standards (e.g., ETSI, ITU, CEPT) go a step further in providing their detailed technical specifications (e.g., conformance requirements, testing methodologies).

To gather a broader perspective of the different technical requirements usually set for the operation of satellite links, we have carried out a benchmark of the practices adopted by other European national regulatory authorities ("NRA"), namely:

- Ofcom (UK)
- ANFR (France)
- BNetzA (Germany)
- Ofcom (Switzerland)
- ANACOM (Portugal)
- NKOM (Norway)

This set of countries is preserved throughout the assessment of the different technical requirements (sections 1.2 to 1.7), even if some of these NRAs do not set specific obligations in some of these fields. The table below illustrates the requirements laid out in ComReg's Guidelines as well as in other European jurisdictions for SES.

Table 10: Benchmark of reference standards[29]

Band (GHz)	Ireland[30]	UK	France	Germany	Switzerland	Portugal	Norway
Sub 3 GHz	NA	–	–	N.C.	**ETSI** EN 301 441 EN 301 442 EN 301 444	**ETSI** EN 301 444	–
3.400 – 3.600	–	N.C.	–	N.C.	N.C.	–	–
3.600 – 4.200	**CEPT** ECC/DEC/(05)09	–	–	N.C.	N.C.	**ETSI** EN 301 443	–
4.500 – 4.800	–	N.C.	–	N.C.	N.C.	–	–
5.150 – 5.250	–	–	–	N.C.	N.C.	–	–
5.250 – 5.350	–	N.C.	–	N.C.	N.C.	–	–
5.350 – 5.470	–	N.C.	–	N.C.	N.C.	–	–
5.470 – 5.570	–	N.C.	–	N.C.	N.C.	–	–
5.725 – 5.850	–	–	–	N.C.	N.C.	–	–
5.850 – 5.925	–	–	–	**ETSI** TS101 136	**ETSI** EN 301 443	–	–
5.925 – 6.700	**CEPT** ECC/DEC/(05)09	–	–	**ETSI** TS101 136	**ETSI** EN 301 443	**ETSI** EN 301 443	–
6.700 – 7.075	–	–	–	**ETSI** TS101 136	N.C.	–	–

[29] N.C.: band not considered.

[30] Reference standards are extracted from the ComReg's Radio Frequency Plan f–or Ireland. No standards are provided in the Guidelines.

7.250 – 7.300	–	N.C.	–	N.C.	N.C.	–	–
7.300 – 7.450	–	N.C.	–	N.C.	N.C.	–	–
7.450 – 7.550	–	N.C.	–	N.C.	N.C.	–	–
7.550 – 7.750	–	N.C.	–	N.C.	N.C.	–	–
7.900 – 8.400	–	N.C.	–	N.C.	N.C.	–	–
10.700 – 11.700	**CEPT** ECC/DEC/(03)04 ECC/DEC/(05)10 ECC/DEC/(05)11 ECC/DEC/(06)02 ECC/DEC/(06)03 ECC/DEC/(12)01 ECC/DEC/(18)04 ECC/DEC/(18)05 ERC/DEC/(00)08	–	–	N.C.	N.C.	**ETSI** EN 301 427 EN 301 428 EN 301 430	–
11.700 – 12.500	**CEPT** ECC/DEC/(06)02 ECC/DEC/(06)03 ECC/DEC/(12)01 ECC/DEC/(18)04 ECC/DEC/(18)05 ERC/DEC/(00)08	–	–	N.C.	N.C.	–	–
12.500 – 12.750	**CEPT** ECC/DEC/(05)10 ECC/DEC/(05)11 ECC/DEC/(06)02 ECC/DEC/(06)03 ECC/DEC/(12)01 ECC/DEC/(18)04 ECC/DEC/(18)05	–	–	N.C.	N.C.	**ETSI** EN 301 427 EN 301 428 EN 301 430	–

12.750 – 13.250	–	–	–	N.C.	**ETSI** EN 301 430	–	–
13.750 – 14.000	–	–	–	N.C.	**ETSI** EN 301 428	–	–
14.000 – 14.250	**CEPT** ECC/DEC/(05)10 ECC/DEC/(05)11 ECC/DEC/(06)02 ECC/DEC/(06)03 ECC/DEC/(18)04 ECC/DEC/(18)05 ERC/REC 13-03	**ETSI** EN 303 979 EN 303 980	–	**ETSI** EN 301 427	**ETSI** EN 303 980 EN 302 977 EN 302 448 EN 301 428 **CEPT** ECC/DEC/(18)04 ECC/DEC/(18)05 ECC/DEC/(17)04	**ETSI** EN 301 427 EN 301 428 EN 301 430	–
14.250 – 14.500	**CEPT** ECC/DEC/(05)10 ECC/DEC/(05)11 ECC/DEC/(06)02 ECC/DEC/(06)03 ECC/DEC/(18)04 ECC/DEC/(18)05 ERC/REC 13-03	–	–	**ETSI** TS101 136	**ETSI** EN 303 980 EN 302 977 EN 302 448 EN 301 428 **CEPT** ECC/DEC/(18)04 ECC/DEC/(18)05 ECC/DEC/(17)04	–	–
17.300 – 18.100	**CEPT** ECC/DEC/(13)01 ECC/DEC/(15)04	–	–	**ETSI** TS101 136	N.C	**ETSI** EN 301 459	–
19.700 – 20.200	**CEPT** ECC/DEC/(06)02 ECC/DEC/(06)03 ECC/DEC/(13)01 ECC/DEC/(15)04	–	–	N.C	N.C	–	–

27.500 – 30.000[31]		**ETSI** EN 303 979 EN 303 980	–	**ETSI** TS101 136	**ETSI** EN 301 459 **CEPT** CC/DEC/(06)03	**ETSI** EN 301 459	–
Q band **33.000 – 50.000**	NA	–	–	N.C	N.C	–	–
V band **50.000 – 75.000**	NA	–	–	N.C	N.C	–	–
W band **75.000 – 110.000**	NA	–	–	N.C	N.C	–	–

[31] Currently only 500 MHz included in ComReg's guidelines (29.5-30 GHz).

As the table above shows, for the six countries benchmarked:

- Four specify, at least, one reference standard for SES bands.
- Two do not specify any reference standard specific to satellite licenses.
- All existing references are based on either the CEPT or the ETSI standards.
- There is a large preference for the adoption of the ETSI standards, which ensure compliance with the R&TTE Directives 2014/53/EU and 1995/5/EC.

Both ETSI and CEPT standards are defined for each satellite service (e.g. earth stations on mobile platforms (ESOMP) transmitting towards satellites in non-geostationary orbits) and frequency band (e.g. 27.5 GHz – 29.1 GHz and 29.5 GHz – 30.0 GHz), allowing full flexibility when specifying the appropriate technical requirements for each configuration. The CEPT and ETSI standards are broadly equivalent in their basic characteristics (operation modes, restrictions, parameters to report) as both institutions work in partnership to ensure harmonisation of spectrum requirements; nevertheless, ETSI's standards tend to provide more detail with regards to technical requirements and testing compliance methods.

Moreover, only ETSI is officially recognised by the EC as a European Standards Organization (ESO) – only the standards developed by the ESOs are recognised as European Standards (ENs). For this reason, most of the NRAs consulted have selected the ETSI's standards as a reference.

Currently, ComReg follows the CEPT standards in the Radio Frequency Plan for Ireland for each band. However, despite not critical in our view, ComReg may consider migrating to ETSI's EN reference to align with the standards followed by most NRAs. In particular, if ETSI's EN is followed, the directives outlined below shall be applied to each group of bands:

- 3.400 - 7.075 GHz:
    1. ETSI EN 301 441 V2.1.1 for Mobile Earth Stations (MES) licenses.
    2. ETSI EN 301 442 V2.1.1 for NGSO Mobile Earth Stations (MES) licenses.
    3. ETSI EN 301 444 V2.1.1 for Land Mobile Earth Stations (LMES) licenses.
- 3.400 - 7.075 GHz:
    1. ETSI EN 301 443 V2.1.1 for Very Small Aperture Terminal (VSAT) licenses.

2. ETSI EN 301 447 V2.1.1 for Earth Stations on board Vessels (ESVs) licenses.

- 10.7 - 14.5 GHz:
    1. ETSI EN 301 427 V2.1.1 for Mobile satellite Earth Stations (MES) licenses.
    2. ETSI EN 301 428 V2.1.2 for Very Small Aperture Terminal (VSAT) licenses.
    3. ETSI EN 301 430 V2.1.1 for Satellite News Gathering Transportable Earth Stations (SNG TES) licenses.
    4. ETSI EN 302 340 V2.1.1 for satellite Earth Stations on board Vessels (ESVs) licenses.
    5. ETSI EN 302 977 V2.1.1 for Vehicle-Mounted Earth Stations (VMES) licenses.
    6. ETSI EN 302 448 V2.1.1 for tracking Earth Stations on Trains (ESTs) licenses.
- 17.3 - 30.0 GHz:
    1. ETSI EN 301 360 V2.1.1 and ETSI EN 301 459 V2.1.1 for fixed terminals.
    2. ETSI EN 303 978 V2.1.2 and ETSI EN 303 979 V2.1.2 for terminals on mobile platforms.

For the higher frequencies (Q, V, W bands), as it can be inferred from the previous table, technical guidelines are still undeveloped. We are not aware of recommended technical conditions being available for these frequencies, therefore, our recommendation is to wait for technical conditions to be developed and/or for any relevant ECC Decision before opening up the frequencies for SES. This approach is applicable for all technical aspects discussed in the document

C.3 Operation mode

SES frequencies can be operated under two configurations or modes, namely:

- Earth-to-Space or transmitting SES.
- Space-to-Earth or receiving SES.

Moreover, a single frequency band may not be limited to a single mode of operation, and it may be indistinctly used in both operation modes if required.

Although the operation mode of each band is defined in, for instance, the ETSI standards[32], NRAs may have adopted alternative approaches. The table below illustrates the requirements laid out in ComReg's Guidelines as well as in other European jurisdictions as regards the operation mode of the different SES bands.

[32] E.g. The 2016 SES Harmonised Standard for VSATs (https://www.etsi.org/deliver/etsi_en/301400_301499/301443/02.01.01_60/en_301443v020101p.pdf)

Table 11: Benchmark on operation modes for Satellite Earth Stations[33]

Band (GHz)	Ireland	UK	France	Germany	Switzerland	Portugal	Norway	ETSI Standard
Updated in:	*2017*	*2017*	*2020*	*2006*	*2021*	*2010*	*2000*	*2016 - 2017*
Sub 3 GHz	NA	N.C.	Both	N.C.	Earth-To-Space	Both	Both	Both
3.400 – 3.600	Space-to-Earth	N.C.	Space-to-Earth	N.C.	N.C.	Space-To-Earth	Space-To-Earth	Space-To-Earth
3.600 – 4.200	Space-to-Earth	Space-to-Earth	Space-to-Earth	N.C.	N.C.	Space-To-Earth	Space-To-Earth	Space-To-Earth
4.500 – 4.800	Space-to-Earth	N.C.	Space-to-Earth	N.C.	N.C.	Space-To-Earth	Space-To-Earth	Space-To-Earth
5.150 – 5.250	Earth-to-Space	Earth-to-Space	Earth-to-Space	N.C.	N.C.	Earth-To-Space	Earth-To-Space	-
5.250 – 5.350	Earth-to-Space	N.C.	Earth-to-Space	N.C.	N.C.	N/A	Both	-
5.350 – 5.470	Earth-to-Space	N.C.	Earth-to-Space	N.C.	N.C.	N/A	Both	-
5.470 – 5.570	Earth-to-Space	N.C.	Earth-to-Space	N.C.	N.C.	N/A	Both	-
5.725 – 5.850	Earth-to-Space	Earth-to-Space	Both	N.C.	N.C.	Earth-To-Space	Earth-To-Space	-
5.850 – 5.925	Earth-to-Space	Earth-to-Space	Earth-to-Space	Earth-to-Space	Earth-to-Space	Earth-To-Space	Earth-To-Space	Earth-To-Space
5.925 – 6.700	Earth-to-Space	Earth-to-Space	Earth-to-Space	Earth-to-Space	Earth-to-Space	Earth-To-Space	Earth-To-Space	Earth-To-Space
6.700 – 7.075	Both	Earth-to-Space	Both	Earth-to-Space	N.C.	Earth-To-Space	Both	Earth-To-Space
7.250 – 7.300	Space-to-Earth	N.C.	Space-to-Earth	N.C.	N.C.	Space-To-Earth	Space-To-Earth	-
7.300 – 7.450	Space-to-Earth	N.C.	Space-to-Earth	N.C.	N.C.	Space-To-Earth	Space-To-Earth	-
7.450 – 7.550	Space-to-Earth	N.C.	Space-to-Earth	N.C.	N.C.	Space-To-Earth	Space-To-Earth	-
7.550 – 7.750	Space-to-Earth	N.C.	Space-to-Earth	N.C.	N.C.	Space-To-Earth	Space-To-Earth	-
7.900 – 8.400	Both	N.C.	Both	N.C.	N.C.	Both	Both	-
10.700 – 11.700	Both	Space-to-Earth	Both	N.C.	Both	Both	Both	Space-To-Earth

[33] N.C.: Band not considered.

11.700 – 12.500	Space-to-Earth	Space-to-Earth	Space-to-Earth	N.C.	Both	N/A	N/A	Space-To-Earth
12.500 – 12.750	Both	Both	Both	N.C.	Both	Both	Both	Space-To-Earth
12.750 – 13.250	Earth-to-Space	Earth-to-Space	Both	Earth-to-Space	Earth-to-Space	Earth-To-Space	Earth-To-Space	Earth-To-Space
13.750 – 14.000	Earth-to-Space	Earth-to-Space	Earth-to-Space	Earth-to-Space	Earth-to-Space	N/A	Earth-To-Space	Earth-To-Space
14.000 – 14.250	Earth-to-Space	Earth-to-Space	Earth-to-Space	Earth-to-Space	Both	Earth-To-Space	Earth-To-Space	Earth-To-Space
14.250 – 14.500	Earth-to-Space	Earth-to-Space	Earth-to-Space	Earth-to-Space	Both	Earth-To-Space	Earth-To-Space	Earth-To-Space
17.300 – 18.100	Both	Both	Both	Earth-to-Space	N.C.	Both	Both	Space-To-Earth
19.700 – 20.200	Space-to-Earth	Space-to-Earth	Space-to-Earth	N.C.	Both	Space-To-Earth	Space-To-Earth	Space-To-Earth
27.500 – 30.000[34]	Earth-to-Space	Earth-to-Space	Earth-to-Space	Earth-to-Space	Both	Earth-To-Space	Earth-To-Space	Earth-To-Space
Q band 33.000 – 50.000	NA	N.C.	Both	N.C.	N.C.	Both	Both	
V band 50.000 – 75.000	NA	N.C.	Both	N.C.	N.C.	Both	Both	
W band 75.000 – 110.000	NA	N.C.	Both	N.C.	N.C.	Earth-To-Space	Both	

[34] Currently only 500 MHz included in ComReg's guidelines (29.5-30 GHz).

As the table above shows, for the six countries benchmarked:

- They all set an operation mode for each accepted SES band within their guidelines.
- In general, there is a broad alignment among all the countries benchmarked, albeit with a few exceptions (e.g., "both" vs "earth-to-space" configurations in the 6.700-7.075 GHz band, or Germany specification in the 17.3-18.1 GHz band).

In line with these general observations, we conclude that the operation modes defined by ComReg in Ireland are also broadly aligned with the international best practices. For instance, we observe it is mostly equivalent to the configurations recently set up by ARCEP in France. While international evidence suggests some further bands may be opened to "both" channel configurations (e.g., all bands above 14 GHz), we do not anticipate any relevant upcoming need to undergo this modification.

Therefore, our recommendation is to preserve the currently defined operating modes for all the different bands.

C.4 Maximum transmit power

According to the Guidelines, "*licensees must ensure that non-ionising radiation ("n.i.r.") emissions […] are within the limits specified in the guidelines published by the International Commission for Non-Ionising Radiation Protection (ICNIRP)*[35]. *Emission levels must comply with any radiation emission standards adopted and published by ICNIRP, any radiation emission standards of CENELEC and any other radiation emission standards specified by law*".

In international practice, rather than defining NIR emission limits, NRAs define the maximum "transmit power" or "power density", commonly represented by the Effective Isotropic Radiated Power, "EIRP", which is defined by the ITU as "*the product of the power supplied to the antenna and the antenna gain in a given direction relative to an isotropic antenna (absolute or isotropic gain)*".[36]

[35] Source: ICNIRP GUIDELINES, 1998 (https://www.icnirp.org/cms/upload/publications/ICNIRPemfgdl.pdf)

[36] Source: ITU, Radio Regulations, 2020, paragraph 1.161 (https://www.itu.int/pub/R-REG-RR-2020)

While most of these parameters are already defined in the ETSI standards, the table below illustrates the requirements laid out in ComReg's Guidelines as well as in other European jurisdictions with regards to the maximum transmit power.

Table 12: Benchmark on maximum transmit power for Satellite Earth Stations[37]

Band (GHz)	Ireland	UK	France	Germany	Switzerland	Portugal	Norway	ETSI Standard
Updated in:	*2017*	*2016*	*2020*	*2010*	*2016*	*2010*	*2012*	*2016 - 2017*
Sub 3 GHz		N.C.	EIRP 10 dBW	N.C.	CEPT/ECC (04)09 EIRP 33 dBW	EIRP 16 – 34 dBW		EIRP 49 dBW
3.400 – 3.600	Only EIRP limit defined in the Guidelines is 70 dBW but only for Airport Notification Areas Otherwise, the only technical requirement related to transmission limits is the NIR, specified by ICNIRP CENELEC	N.C.	N.C.	N.C.	N.C.	Dependent on prior frequency coordination	–	EIRP 55 dBW
3.600 – 4.200		ITU-RR 21.8 EIRP 40 dBW	N.C.	N.C.	N.C.	–	–	EIRP 55 dBW
4.500 – 4.800			N.C.	N.C.	N.C.	–	–	EIRP 55 dBW
5.150 – 5.250		ITU-RR 21.8 EIRP 40 dBW	N.C.	N.C.	N.C.	–	–	EIRP 55 dBW
5.250 – 5.350		N.C.	N.C.	N.C.	N.C.	–	–	EIRP 55 dBW
5.350 – 5.470		N.C.	N.C.	N.C.	N.C.	–	–	EIRP 55 dBW
5.470 – 5.570		N.C.	N.C.	N.C.	N.C.	–	–	EIRP 55 dBW
5.725 – 5.850		ITU-RR 21.8 EIRP 40 dBW	N.C.	N.C.	N.C.	–	–	EIRP 55 dBW
5.850 – 5.925		ITU-RR 21.8 EIRP 40 dBW	N.C.	EIRP 50 dBW	–	–	–	EIRP 55 dBW

[37] N.C: Band not considered

5.925 – 6.700		ITU-RR 21.8 EIRP 40 dBW	N.C.	EIRP 50 dBW	–	Dependent on prior frequency coordination	–	EIRP 55 dBW
6.700 – 7.075		ITU-RR 21.8 EIRP 40 dBW	N.C.	EIRP 50 dBW	N.C.	–	–	EIRP 55 dBW
7.250 – 7.300		N.C.	N.C.	N.C.	N.C.	–	–	EIRP 55 dBW
7.300 – 7.450		N.C.	N.C.	N.C.	N.C.	–	–	EIRP 55 dBW
7.450 – 7.550		N.C.	N.C.	N.C.	N.C.	–	–	EIRP 55 dBW
7.550 – 7.750		N.C.	N.C.	N.C.	N.C.	–	–	EIRP 55 dBW
7.900 – 8.400		N.C.	N.C.	N.C.	N.C.	–	N.C.	EIRP 55 dBW
10.700 – 11.700		ITU-RR 21.8 EIRP 40 dBW	N.C.	N.C.	N.C.	EIRP 34 – 60 dBW	–	EIRP 55 dBW
11.700 – 12.500		ITU-RR 21.8 EIRP 40 dBW	EIRP 53 dBW	N.C.	N.C.	EIRP 34 – 60 dBW	–	EIRP 61-78 dBW
12.500 – 12.750		ITU-RR 21.8 EIRP 40 dBW	N.C.	N.C.	N.C.	EIRP 34 – 60 dBW	–	EIRP 61-78 dBW
12.750 – 13.250		ITU-RR 21.8 EIRP 40 dBW	N.C.	EIRP 50 dBW	ITU-RR 5.502-03 EIRP 45 dBW	–	–	EIRP 61-78 dBW
13.750 – 14.000		ITU-RR 21.8 EIRP 40 dBW	EIRP 59 dBW	EIRP 50 dBW	ITU-RR 5.502-03 EIRP 45 dBW	–	–	EIRP 61-95 dBW
14.000 – 14.250		OFCOM - IR2077 EIRP 55 dBW	N.C.	EIRP 50 dBW	CEPT/ECC (18)05 EIRP 50-60 dBW	EIRP 34 – 60 dBW	EIRP 60 dBW	EIRP 61-95 dBW
14.250 – 14.500		ITU-RR 21.8 EIRP 40 dBW	N.C.	EIRP 50 dBW	CEPT/ECC (18)05 EIRP 54.5-60 dBW	–	EIRP 60 dBW	EIRP 61-95 dBW

17.300 – 18.100		ITU-RR 21.8 EIRP 64 dBW	N.C.	EIRP 50 dBW	N.C.	–	EIRP 60 dBW	EIRP 61-78 dBW
19.700 – 20.200		ITU-RR 21.8 EIRP 64 dBW	N.C.	N.C.	N.C.	EIRP 34 – 60 dBW	–	EIRP 61-78 dBW
27.500 – 30.000[38]		OFCOM - IR2077 EIRP 55 dBW	N.C.	EIRP 50 dBW	CEPT/ECC Rep. 22 EIRP 50 – 60 dBW	EIRP 34 – 60 dBW	EIRP 60 dBW	EIRP 61-85 dBW
Q band 33.000 – 50.000		N.C.	N.C.	N.C.	N.C.	–	–	-
V band 50.000 – 75.000		N.C.	N.C.	N.C.	N.C.	–	–	-
W band 75.000 – 110.000		N.C.	N.C.	N.C.	N.C.	–	–	-

[38] Currently only 500 MHz included in ComReg's guidelines (29.5-30 GHz).

As the table above shows, for the six countries benchmarked, four define specific / customised EIRP limits for some of the bands under consideration, while the other two resort to international standards for the definition of the EIRP limits.

On the other hand, ComReg requires licensees to comply with the limits specified by the ICNIRP and CENELEC, which provides a different alternative to the approaches followed by the consulted NRAs.

Despite the differences observed among the consulted NRAs, the definition of EIRP limits appears to be a standard practice in Europe. Moreover, these limits are broadly aligned with the ETSI's recommendations, ranging from 40-50 dBW in low bands and rising to ~60 dBW in high bands.

In our view, depending on the current effectiveness of the NIR limits to meet ComReg's objectives, it may consider:

- Keeping the current technical requirements, without any modifications.
- Replacing the existing requirements by the ETSI's EIRP recommendations.

C.5 Site clearance

Site clearance refers to the mechanism and conditions licensees must comply with to ensure the safe operation of SES. The table below illustrates the requirements laid out in ComReg's Guidelines as well as in other European jurisdictions on this regard.

This requirement is defined for SES as a whole and, thus, a breakdown by frequency band is not applicable.

Table 13: Benchmark on site clearance for Satellite Earth Stations

Country	Recommendations currently followed
Ireland	Site clearance must be ensured by means of the following actions: • *"the antenna must be directed away from public vantage points by at least 5 degrees;* • *the antenna must be directed away from any radio masts in the near vicinity by 10 degrees;* • *a mechanism must be incorporated which inhibits operation at elevation angles of less then 10 degrees;*

	• *the Earth Station must not be situated within 100 metres of a radio installation operating within ± 250 MHz of the Earth Station carrier frequency. This distance is increased if the installation is within ± 45 degrees of the TES main beam. When issuing a TES licence, ComReg will advise the licensee of any such radio installations in operation at that time; and* • *the TES must not be parked under electricity power lines.*"
UK	"*Licensees must ensure that their apparatus (i.e., equipment with antennas) meet current planning requirements, and where the antennas may constitute a hazard, particularly to aircraft, then it is the applicant's responsibility to obtain appropriate approvals.*"
France	–
Germany	–
Switzerland	–
Portugal	–
Norway	–

As the table above shows, the majority of benchmarked countries do not provide indications regarding site clearance mechanisms. In fact, although UK acknowledges the importance of a good planning and protection of the SES, details are not provided in their guidelines or licensing procedures manuals.

Given that no explicit site clearance requirements are imposed in the other (benchmarked) European jurisdictions, and operators are bound by the General Authorisation conditions on avoiding harmful interference to other systems, there does not seem to be any obvious need or justification for setting such specific requirements in the SES Guidelines. We are therefore of the view that ComReg can consider removing these.

C.6 Airport exclusion and notification zones

The table below illustrates the requirements laid out in ComReg's Guidelines, in other European jurisdictions and in the EEC (CEPT) standards with regards to the airport exclusion and notification zones. This requirement is defined typically for SES

as a whole and, thus, a breakdown by frequency band is not provided.

Table 14: Benchmark on airport exclusion and notification zones for Satellite Earth Stations

Country	Recommendations currently followed
Ireland	Airport notification zone: 7 km Airport restriction zone: 1 km wide (centred on the runway centre line)
UK	Fenced limits of an airport or aerodrome (all perimeters defined).
France	–
Germany	The frequency used in the vicinity of airports must ensure that no impairment of the electronics on board aircraft will take place. In transmit mode, a minimum distance of 500 metres must be kept from the enclosure of the airport compound.
Switzerland	–
Portugal	Distance to limit area of airports depend on the frequency band: • 19.7 – 20.2 GHz: At least 500 m • 14.0 – 14.5 GHz: At least 1,800-2,300 m depending on the EIRP • 29.5 – 30.0 GHz: At least 3,500 m
Norway	–
ECC (CEPT) standard[39]	Minimum separation distance with an aircraft for earth stations in a fixed location or mobile earth stations: • Within a wedge-shaped area of airspace of 3 nautical miles (5.556 km) from the runway: **At least 500 ft (150.24 metres)** • Outside the wedge-shaped area of airspace of 3 nautical miles (5.556 km) from the runway: **At least 1000 ft (304.8 metres)**

[39] ECC Report 272 (2018): Earth Stations operating in the frequency bands 4-8 GHz, 12-18 GHz and 18-40 GHz in the vicinity of aircraft

Minimum separation distance with an aircraft for earth stations operated on vessels: **At least 1000 ft (304.8 metres)**

As the table above shows, the approaches adopted by NRAs towards the definition of airport exclusion and notification zones varies greatly. However, we observe that:

I. it is common to define rules to protect airport zones from harmful interference;
II. when minimum distances are set, these fall in the same range of those defined by ComReg; and
III. rules currently established by ComReg's Guidelines are more restrictive than the ECC (CEPT) standard but within the same order of magnitude regarding minimum distance from the aircraft (1 km wide vs 610 m wide).

Therefore, we do not recommend modifying the requirements currently in place in Ireland unless complaints are received from operators regarding the exclusion zone requirements in place.

C.7 Other technical parameters

The sections above present the most common technical requirements found in Ireland and in the rest of benchmarked countries. In addition to these, we provide below our views on a set of additional parameters that, despite not being widespread, are also worth considering:

- **Coordination:** Refers to the process of modifying and balancing certain operation parameters when various spectrum users coexist to reduce the probability of interference between them to acceptable levels.

  National and international coordination processes are described in ComReg's Satellite Guidelines. These processes are only applicable when a SES frequency band is shared with another primary wireless service (e.g. 4G). Some other countries apply different criteria for determining when coordination is required (e.g. in Germany, all stations with an antenna diameter of more than 2 metres are subject to coordination; in France, all requests besides exclusive or priority assignments are subject to coordination).

  Recommendation: The criteria established by the Guidelines to determine subject-to-coordination requirements is

reasonable as it enforces only those cases when a potential interference issue might arise. Therefore, no modifications are recommended on this regard.

- **Antenna diameter:** A reference to the minimum antenna diameter is found in the ITU Radio Regulations[40] for the 13.75 – 14.00 GHz band (1.2 metres). SES operators are obliged to adhere to the ITU RR for the minimum antenna diameter in Ireland, UK, France and Switzerland.

  Recommendation: Including the 1.2-metre antenna diameter requirement for the 13.75 – 14.00 GHz band in the Guidelines (in addition to the Radio Frequency Plan where this requirement is already specified) since this is the only strict requirement on antenna diameter specified in international references and present in most of the benchmarked countries.

- **Polarisation:** References to polarisation modes are found in Germany's interface requirements. Further, ETSI also account for the effect of polarisation modes in its technical requirements.

  Recommendation: No explicit requirements on the polarisation mode were found outside Germany. We do not see any solid reasons/needs to include specific requirements with regards to this parameter in ComReg's Guidelines.

[40] Source: ITU, "Radio Regulations", 2020 (https://www.itu.int/pub/R-REG-RR-2020)