Before the
Federal Communications Commission
Washington, D.C. 20554

In the Matter of	)	
	)	
Use of Spectrum Bands Above 24 GHz for Mobile Radio Services	)	GN Docket No. 14-177
	)	
Amendment of Parts 1, 22, 24, 27, 74, 80, 90, 95, and 101 To Establish Uniform License Renewal, Discontinuance of Operation, and Geographic Partitioning and Spectrum Disaggregation Rules and Policies for Certain Wireless Radio Services	)	WT Docket No. 10-112

COMMENTS OF SES AMERICOM, INC. AND O3B LIMITED ON THIRD FURTHER NOTICE OF PROPOSED RULEMAKING

I. Introduction and Summary

SES Americom, Inc. and its affiliate O3b Limited (collectively, "SES") respectfully submit these comments regarding the Federal Communication Commission's Third Further Notice of Proposed Rulemaking ("3rd FNPRM") in the above-captioned proceeding.[1] SES is one of the world's largest commercial satellite operators with a fleet of nearly 70 geostationary ("GSO") and non-geostationary ("NGSO") satellites in orbit. SES currently holds a number of authorizations in the millimeter wave ("mmW") frequencies, including a recent market access grant to operate a second generation NGSO constellation in portions of the V-band.[2]

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[1] *Use of Spectrum Bands Above 24 GHz For Mobile Radio Service*, Third Report and Order, Memorandum Opinion and Order, and Third Further Order of Proposed Rulemaking, FCC 18-73 (rel. June 8, 2018) ("3rd FNPRM").
[2] *See* O3b Limited, Call Sign S2935, File No. SAT-AMD-20171109-00154 (granted June 4, 2018) ("Market Access Grant"). In addition to the frequencies covered by the Market Access Grant, SES sought access to the 50 GHz band, but the Commission deferred action on that portion of the application until service rules are established in the instant proceeding.

SES and a number of other Fixed Satellite Service ("FSS") operators have already demonstrated substantial interest in the 50.4-51.4 GHz ("50 GHz") band by applying for access to the band to deploy innovative GSO and NGSO services.[3] The Commission should promote deployment of these next-generation satellite systems, which can enable expanded FSS access to the 50 GHz band without impairing realistic terrestrial deployment in the band.

The Commission proposes to apply its recently developed sharing rules for the 24.75-25.25 GHz band (the "24 GHz band") to the 50 GHz band.[4] These rules would combine the permitted aggregate population limits within the specified earth station power flux density ("PFD") contour on a per-county basis from the 28 GHz band with additional limitations derived from the 47 GHz band rules on the number of earth stations that can be sited as well as restrictions on covering interstate highways, cruise ports, and major event venues. SES believes the Commission should instead adopt a proposal that creates a more permissive regulatory structure for earth station siting in the 50 GHz band. Specifically, SES recommends that the Commission eliminate the population coverage limits in areas with lower population density and remove the restriction on covering interstate highways and passenger railroads, which will permit deployment of services consistent with the propagation characteristics of this higher band.

The changes that SES is advocating are neither radical nor likely to undermine the Commission's goal of facilitating the deployment of mobile services throughout the mmW bands, including the 50 GHz band. Instead, they will ensure that large swaths of spectrum in the

[3] *See* Hughes Network Systems, LLC, Call Sign S3017, File No. SAT-LOA-20170621-00092; WorldVu Satellites Limited, Call Sign S2994; Audacy Corporation, Call Sign S2982, File No. SAT-LOA-20161115-00117; Space Exploration Holdings, LLC, Call Sign S2992, SAT-LOA-20170301-00027; Telesat Canada, Call Sign S2991, File No. SAT-PDR-20170301-00023; ViaSat, Inc., Call Sign S2985, File No. SAT-PDR-20161115-00120.
[4] 3rd FNPRM at ¶ 94.

50 GHz band that would otherwise lie fallow are put to valuable use, all while protecting future terrestrial deployments in the band.

II. SES's Proposed Rule Changes Better Reflect the Physical Characteristics of the 50 GHz Band

SES applauds the Commission's continued efforts to facilitate spectrum access for FSS in the mmW spectrum. However, the Commission should be wary of adopting a one-size-fits-all approach for all mmW bands given the variation in propagation characteristics as operations move up to higher-frequency portions of the spectrum. The Commission's proposal to maintain population limits from the 24 and 28 GHz bands while further restricting the number of earth stations that can be cited in a Partial Economic Area ("PEA") does not reflect the properties of the 50 GHz band. As demonstrated below, radio waves in 50 GHz frequencies travel shorter distances than they do in lower mmW bands such as the 24 GHz band, whose sharing rules the Commission proposes to apply in 50 GHz.

The diminished propagation distances in the 50 GHz band have a two-fold effect on spectrum sharing between FSS and terrestrial operators. First, they shrink the size of earth station PFD contours, greatly minimizing the potential for individually-licensed earth stations to limit terrestrial deployment. Second, they make it even more difficult for terrestrial operators to deploy countywide networks in low-density or sparsely populated areas of the country. SES acknowledges that even in the 50 GHz band, urban areas may present a viable opportunity for terrestrial operators to provide enhanced fixed and mobile services. However, widespread deployment in suburban and rural areas is unlikely due to the decreased propagation distances of radio waves in the 50 GHz band. The Commission's rules should reflect this reality.

Within this context, SES proposes that the Commission maintain its current proposal for Tier 1 counties and PEAs,[5] which will generally be urban areas or other areas with a high population density. However, SES believes that it is in the public interest to greatly expand the ability of FSS operators to site earth stations in Tier 2 and Tier 3 counties in PEAs in the 50 GHz band, so that spectrum that is unlikely to be used by terrestrial operators is not left undeveloped.

SES proposes that in Tier 2 and 3 counties the Commission: (1) remove the limit on the number of individually-licensed earth stations per county; (2) remove the limit on population coverage; and (3) remove highways and passenger railroads from the specific locations that cannot be encumbered by an earth station PFD contour that otherwise meets the requirements for protected status under the proposed Section 25.136(g)(4) of the Commission's rules. Attached in Annex B is a draft revision to the Section 25.136(g)(4) rule that the Commission should apply to earth stations in the 50 GHz band instead of merely importing the 24 GHz band sharing rules.

The SES approach would maintain the Commission's proposed limits for earth station siting in urban areas and would also preserve terrestrial primacy in Tiers 2 and 3 by maintaining the Section 101.103(d) coordination requirement, meaning that no FSS operator could deploy an earth station without notifying and coordinating with local terrestrial licensees.[6] This coordination would ensure the protection of existing and operational terrestrial facilities as well as provide notice to terrestrial licensees of proposed new FSS earth stations. It would also preserve flexibility for terrestrial deployment, even in suburban and rural areas, in high traffic areas that are likely to create the demand necessary to support deployment in the 50 GHz bands,

[5] Section 25.156(g)(4)(ii) of the rules specifies the maximum permitted aggregate population within the -77.6 dBm/m^2/MHz PFD contour of earth stations based on three separate levels of county population – greater than 450,000, between 6,000 and 450,000, and fewer than 6,000 – referred to herein as Tier 1, Tier 2, and Tier 3 counties, respectively.
[6] 47 C.F.R. §101.103(d).

such as event venues and cruise ship ports. However, those earth stations that are able to comply with the remaining constraints must be able to operate without providing interference protection to future stations in the Upper Microwave Flexible Use Service ("UMFUS").

The SES approach removes the proposed numerical limits on earth station siting, which make much less sense in the 50 GHz band than they do in the 24 GHz band. The limit of three earth stations per county is particularly out of place in the 50 GHz band given the physical characteristics of the band. As discussed in more detail below, the different propagation characteristics as well as the economic realities of deploying in the 50 GHz band will facilitate sharing between FSS and terrestrial operators without this added regulatory burden. The SES proposal reflects this different sharing environment and will enable FSS earth stations to deploy more readily where there is no plausible case for terrestrial deployment. The obligation to coordinate and individually license FSS earth stations should be sufficient to protect realistic terrestrial deployments in suburban and rural license areas.

Similarly, SES proposes to remove the population coverage criteria for Tier 2 and Tier 3 counties. Terrestrial operators are expecting to build out networks in the 24, 28, 37/39, 42 and 47 GHz bands.[7] The Commission is evaluating whether to allocate portions of C-band[8] as well as the 26 GHz band[9] for additional mobile use. This is a staggering amount of spectrum that will be made available to mobile operators within a relatively short period of time, and it seems

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[7] *See generally Use of Spectrum Bands Above 24 GHz for Mobile Service Radio,* Second Report and Order, Second Further Notice of Proposed Rulemaking, Order on Reconsideration, and Memorandum Opinion and Order, 32 FCC Rcd 10988 (2017); *Use of Spectrum Bands Above 24 GHz for Mobile Service Radio,* Report and Order and Further Notice of Proposed Rulemaking, 31 FCC Rcd 8014 (2016).

[8] *Expanding Flexible Use of the 3.7 to 4.2 GHz Band,* Order and Notice of Proposed Rulemaking, FCC 18-91 (rel. July 13, 2018).

[9] 3rd FNPRM at ¶¶ 79-91.

unlikely that the terrestrial industry is prepared to build out nationwide networks in each one of these bands. Additionally, of all the bands listed above, the 50 GHz band is the least suited for widespread deployment. This is a perfect opportunity for the Commission to heed the calls by EchoStar and ViaSat[10] and to serve the public interest by developing a more balanced sharing scheme between FSS and terrestrial interests that reflects the realities of the band and ensures that 50 GHz spectrum will be put to efficient use.

The same logic underlies the proposal to remove the highway and railway transit systems from the exempted locations in the Commission's proposed rule. The terrestrial industry claims a potential need for unfettered UMFUS access to these locations in some of the lower mmW bands and as a result, the Commission has specified that FSS deployments in those bands would be unprotected from terrestrial facilities designed to serve highway and railway systems. These lower-frequency mmW bands are better suited to the massive infrastructure buildouts that will be required to line the nation's highways and railways with UMFUS base stations and transmitters. Without support on the record that the terrestrial industry intends to use the 50 GHz band for this specific purpose, the Commission should not simply default to preventing FSS operators from siting in the vicinity of nearly ubiquitous transit infrastructure.

III. The Propagation Characteristics of the 50 GHz Band Differ Significantly from Those of the 28 and 24 GHz Bands and Warrant a More Flexible Approach

Early on in the Spectrum Frontiers proceeding, the Commission wisely recognized that the propagation characteristics of the mmW bands would enable different services to effectively share spectrum in unprecedented ways.[11] As the Commission develops service rules for higher

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[10] 3rd FNPRM at ¶ 93.

[11] *Use of Spectrum Bands Above 24 GHz For Mobile Radio Services,* Notice of Proposed Rulemaking, 30 FCC Rcd 11878 (2015) at 11881, ¶ 2.

frequency bands, it should continue to reevaluate its regulatory schemes to reflect the respective physical properties of higher segments of the mmW bands.

SES has attached two international studies that demonstrate the distinction between the propagation values in the 50 GHz band and those of the 26 GHz band, which serves as a useful analog for the propagation values of the 24 GHz band. The studies, included in Annex A, demonstrate that radio waves in the 50 GHz band travel far shorter distances than radio waves in the 26 GHz band.[12] In some cases, the distances are reduced by 50 percent or more.

The physical properties of the 50 GHz band will have an impact on both earth station and terrestrial base station siting that should be reflected in the Commission's rules and are accounted for in the changes SES proposes. For earth station siting, the PFD contours for individually-licensed earth stations will be greatly reduced, decreasing the likelihood of an overlap with areas attractive for terrestrial deployment. Meanwhile, the costs of licensing and constructing earth station facilities combined with the smaller area covered by earth station PFD contours in the 50 GHz band make it unlikely that earth stations would be deployed in sufficient numbers to materially constrain terrestrial deployment. However, the additional flexibility SES proposes would better allow FSS operators to provide innovative broadband services in the U.S. and abroad as well as enable operators to test and develop their next generation services domestically.

[12] The SES Annex contains excerpts from two Task Group 5/1 Chairman's Reports: *Sharing and Compatibility Studies of IMT Systems in the 50.4-52.6 GHz Frequency Range.* Annex 10 to Task Group 5/1 Chairman's Report, and *Sharing and Compatibility of FSS and IMT Operating in the 24.25-27.5 GHz Frequency Range,* Attachment 3 to Annex 3 to Task Group 5/1 Chairman's Report.

Similarly, terrestrial base stations will face greater constraints in terms of the propagation distances of their signals in the 50 GHz band, requiring a more intensive and costly infrastructure build-out than would be needed in the 24 GHz and 28 GHz bands to reach the same coverage area. Given the logistical and economic challenges terrestrial operators are facing in, for example, the 28 GHz band,[13] where the radio waves travel much further, it seems unlikely that terrestrial operators will deploy countywide, let alone nationwide, networks in the 50 GHz band.

The 50 GHz band may well be useful for handling the demand for additional bandwidth in densely populated areas or high-traffic locations, which is why SES's proposal does not include changes to the population coverage limit in Tier 1 counties. Therefore, terrestrial operators will remain relatively unencumbered in locations where the demand for data will support the cost of the infrastructure necessary to deploy a terrestrial network in the 50 GHz band, particularly in urban areas.

Outside those areas, the Commission should adopt the modifications set forth by SES, which will increase flexibility for FSS operators, while still permitting terrestrial deployment if a business case for a 50 GHz terrestrial network can be made. By revising the rules to provide additional latitude for FSS earth station siting, the Commission can encourage satellite operators to deploy in areas where the 50 GHz spectrum is likely to remain unused by terrestrial operators.

IV. Conclusion

Given the physical properties of the band and a realistic assessment of how terrestrial operators are likely to deploy, SES offers a reasonable approach to balancing realistic and

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[13] *See* Sue Marek, *AT&T, Shaw, and China Mobile Outline 5G Trial Successes and Failures*, SDxCentral, May 17, 2018, available at: https://www.sdxcentral.com/articles/news/aatt-shaw-and-china-mobile-outline-5g-trial-successes-and-failures/2018/05/. *See also* Sue Marek, *AT&T's Mixed Messages on 5G Fixed Wireless*, SDxCentral, May 30, 2018, available at: https://www.sdxcentral.com/articles/editorial/atts-mixed-messages-on-5g-fixed-wireless/2018/05/.

economically feasible terrestrial deployments with the spectrum needs of satellite networks that plan to use the 50 GHz band. Commission adoption of the SES changes to the proposed sharing framework for the 50 GHz band will promote the public interest and the efficient use of this valuable spectrum.

Respectfully submitted,

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September 10, 2018

Annex A

Attachment 3 to Annex 3 to Document 5-1/406-E Task Group 5/1 Chairman's Report, Sharing and compatibility of FSS and IM operating in the 24.25-27.5 GHz frequency range, Study O

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Annex 10 to Document 5-1/406-E Task Group 5/1 Chairman's Report, Sharing and compatibility studies of IMT systems in the 50.4-52.6 GHz frequency range, Study D

Attachment 3 to Annex 3 to Document 5-1/406-E Task Group 5/1 Chairman's Report, Sharing and compatibility of FSS and IM operating in the 24.25-27.5 GHz frequency range, Study O

Radiocommunication Study Groups

1.15 Study O

[Source: Document 5-1/353]

Note: This study addresses the interference from GSO FSS into IMT systems. A complementary study addressing interference from IMT into GSO FSS can be found in study H.

1.15.1 Technical characteristics

1.15.1.1 Technical and operational characteristics of IMT systems operating in the 24.25-27.5 GHz frequency range

1.15.1.1.1 Technical characteristics of IMT systems

Table O-1 provides the line-of-sight (LOS) BS parameters (e.i.r.p. density 48 dBm/200 MHz).

TABLE O-1

BS parameters (e.i.r.p. density 48 dBm/200 MHz)

Parameter	Unit	BS	UE
Antenna array configuration $N_H \times N_V$	N/A	8×8	4×4
Single element output power	dBm/200 MHz	10	10
Maximum element gain	dBi	5	5
Conducted power (without ohmic losses)	dBm/200 MHz	28	22
Maximum composite antenna gain	dBi	23	17
Array Ohmic losses	dB	3	3
Maximum e.i.r.p.	dBm/200 MHz	48	36
H/V radiating element spacing	N/A	λ/2	λ/2
Antenna height (above ground level)	m	6 (suburban hotspot , urban) 15 (suburban **open space** hotspot)	1.5m (outdoor)
H/V 3 dB beamwidth	°	65 for both	90 for both
Am & SLA	dB	30 for both	25 for both
Mechanical downtilt	°	10 (suburban hotspot , urban) (Suburban **open space** hotspot)	-90..90°

Note: BS antenna model have been normalized to keep the total emitted radiation (TRP) from the antenna to a fixed value (0 dB, i.e. antenna model does not provide any additional gain or loss). The normalization correction was between ~+0.5 dBi and ~+5 dBi for the UE antenna and between ~+0.5 dBi and ~+10 dB for the BS antenna depending on antenna steering direction. The correction factor applied is the following:

$$\text{Correction factor} = \frac{1}{4\pi}\int_0^{2\pi}\int_0^{\pi} A_A(\theta,\varphi,\theta_{etilt},\varphi_{escan})\sin(\theta)\ d\theta d\varphi$$

1.15.1.1.2 Protection criterion of IMT systems

The acceptable interference to noise ratio at the IMT BS receiver is assumed to be -6 dB.

1.15.1.2 Technical and operational characteristics of the fixed-satellite service (Earth-to-space) operating in the 24.65-25.25 GHz and 27-27.5 GHz frequency range

The typical parameters of FSS uplink operating in the 24.65-25.25 GHz and 27-27.5 GHz frequency band are shown in Table O-2 (Documents 5-1/89 and 5-1/183) from Working Party 4A.

TABLE O-2

Typical parameters in FSS uplink

Parameter	Value	
Satellite	Carrier #13, #14	
Receive frequency	24.65-25.25, 27-27.5 GHz	
Earth station	Carrier #13	Carrier #14
Antenna diameter	0.45 m	13.2 m
Peak transmit antenna gain	40.4 dBi	69.7 dBi
Peak transmit power spectral density (clear sky)	-56 dB(W/Hz)	-60 dB(W/Hz)
Antenna gain pattern	Rec. ITU-R S.465-6	Rec. ITU-R S.465-6
Elevation angle	5 and 20 degrees	10 and 20 degrees

1.15.1.3 Propagation models for sharing and compatibility studies in the 24.65-25.25 GHz and 27-27.5 GHz frequency ranges

The signal propagating from the GSO earth station to the IMT-2020 BS is subject to the following attenuations:

– free space loss (Recommendation ITU-R P.525), additional propagation losses such as diffraction (Recommendation ITU-R P.452)

– clutter loss due to man-made objects between the FSS satellite and the IMT-2020 system (Recommendation ITU-R P.2108, Section 3.2 Statistical clutter loss model for terrestrial paths)

1.15.2 Interference from FSS (Earth-to-space) into IMT systems

1.15.2.1 Methodology for the single entry interference analysis

Two different methodologies were used:

– **Method 1:**

Five FSS earth stations were placed at different distances (0.1, 0.25, 0.5, 1, 5 and 10 km) from an IMT BS, pointing towards the BS with 2 different elevation angles. The IMT BS was randomly placed with 4 different antenna directions (pointing towards the earth station, pointing with ±90 deg. and 180 deg. azimuth offset).

The performed analysis uses a fixed number for the satellite earth station antenna gain (one value per elevation angle) towards the IMT BS, the propagation loss between the earth station and the BS, the polarisation loss (1.6 dB) and the IMT antenna ohmic loss (3 dB) and also distributions for the IMT BS antenna gain towards the earth station and for clutter losses between IMT and earth station. The clutter is assumed only at one end of the link and is set to zero for distances shorter than 250 m.

Satellite earth station antenna gain:

- FSS Carrier # 13 gain: 15 dBi towards IMT BS for 5 deg. elevation angle and -0.5 dBi for 20 deg. elevation angle.
- FSS Carrier # 14 gain: 7 dBi towards IMT BS for 10 deg. elevation angle and -0.5 dBi for 20 deg. elevation angle.

The distribution of propagation loss, clutter loss (no curve for 0.1 km where clutter is set to zero) and IMT antenna gain are shown in Section 1.15.2.2 (intermediate results for Method 1).

– **Method 2:**

The interference level into an IMT BS station is calculated assuming that the FSS earth station and IMT BS antennas are pointed in azimuth directly toward each other, at offsets of 5, 10 and 48 degrees, and pointed away from each other. The interference topology from the FSS earth station to IMT system is illustrated the figure below:

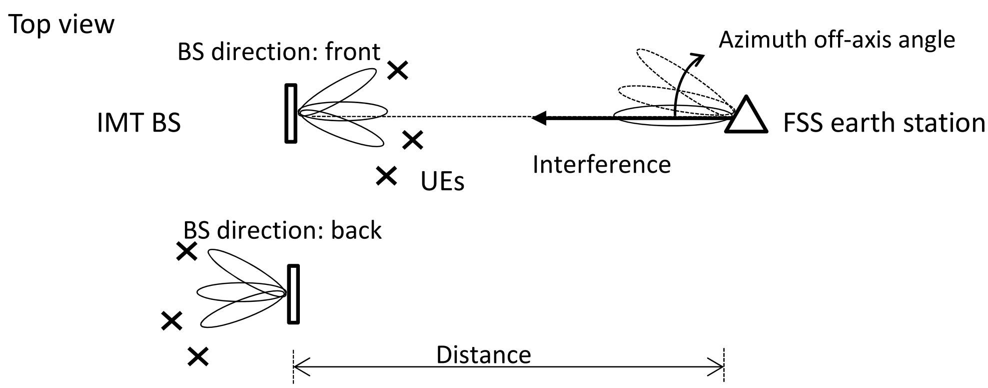


FIGURE O-1

Interference topology of FSS earth station to IMT BS

The interference-to-noise (I/N) ratio into an IMT receive station from an FSS transmit earth station is calculated below:

$$I/N = e.i.r.p._{FSS}(\theta_{FSS}) - Losses + G_{IMT}(\theta_{IMT}) - \mathrm{N} - \mathrm{PL} \qquad \text{(O-1)}$$

where:

I/N : Interference-to-noise ratio in dB;

$e.i.r.p._{FSS}(\theta_{FSS})$: FSS transmit earth station signal off-axis e.i.r.p. density in the direction of the IMT receive BS in dB(W/Hz);

$Losses$: Propagation loss in dB;

$G_{IMT}(\theta_{IMT})$: IMT receive station antenna gain in direction of the FSS transmit earth station in dBi;

N : IMT receive station noise power density in dBW;

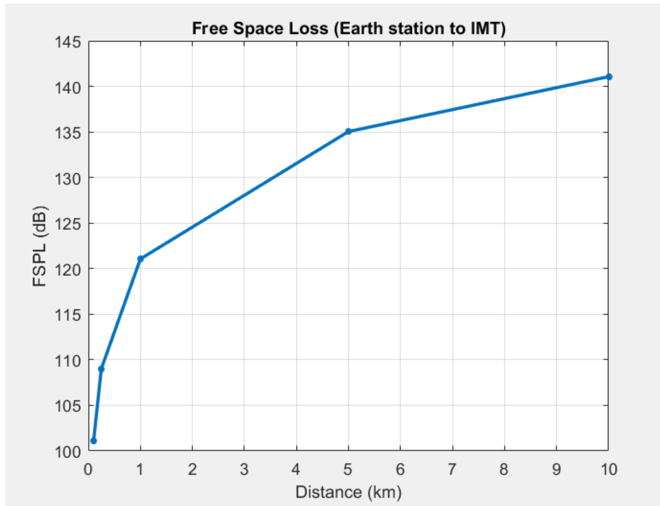
PL : Polarization losses in dB.

1.15.2.2 Method 1

The interference was calculated by combining the variable parameters (IMT antenna gain and clutter loss, e.g. 100 antenna gain values combined with 1 000 clutter loss values gives 100*1 000= 100 000 values) and adding the fixed values (free space loss, earth station antenna gains and other losses)

1.15.2.2.1 Free space losses

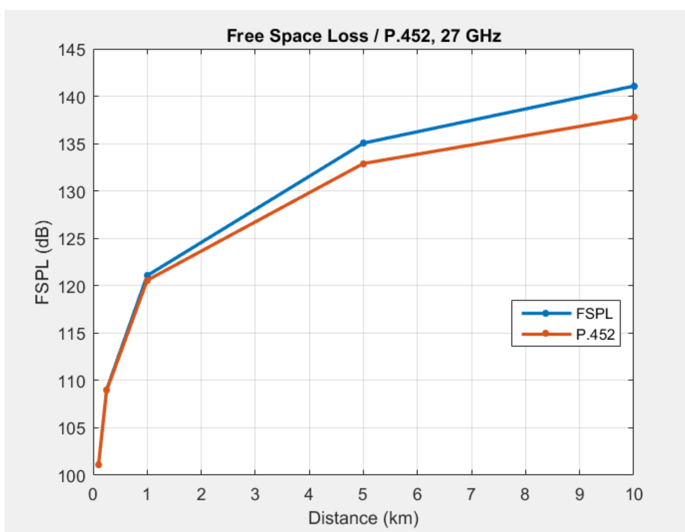
FIGURE O-2



1.15.2.2.2 Recommendation ITU-R P.452

FIGURE O-3

Comparison of FSPL and Recommendation ITU-R P.452



Parameters used to evaluate the losses as per Recommendation ITU-R P.452:

– Time percentage for which the calculated loss is not exceeded: 10%

– Zone inland

– Transmitter station latitude: 0°

– Receiver station latitude: 0°

– Transmitter antenna gain in direction of the horizon: FSS carrier #13 and 14 gain (section 3.1)

– Receiver antenna gain in direction of the horizon: 23 dBi

– Polarization direction: horizontal
– Distance from transmitter to coast: 0 km
– Distance from receiver to coast: 0 km
– Average radio refractive index lapse rate through lowest 1 km (N units per km): 53
– Sea-level surface refractivity (N units): 328
– Dry air pressure: 1013 hPa
– Temperature: 15°C

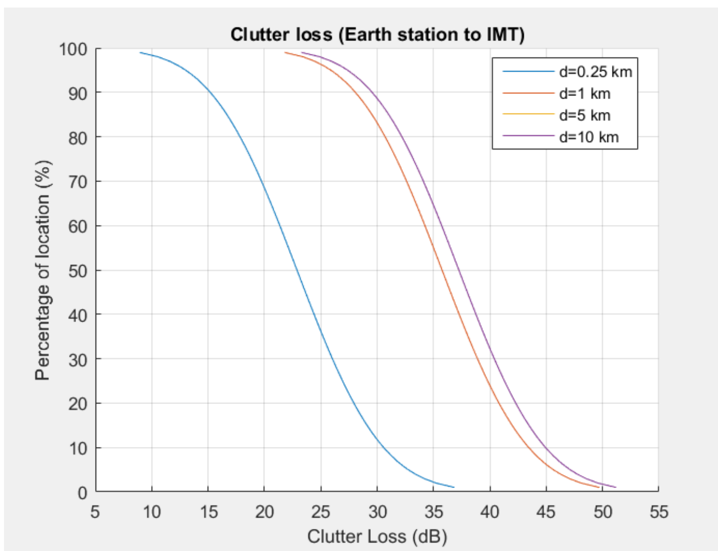
1.15.2.2.3 Clutter losses

Section 3.2 of Recommendation ITU-R P.2108 is applied to calculate the statistical distribution of clutter loss where the interference scenario is from a satellite earth station to an IMT station.

The cumulative distribution function (CDF) for different distances between the FSS earth station and the IMT BS at 27 GHz is shown in Figure O-4.

FIGURE O-4

Clutter losses



1.15.2.2.4 BS antenna gain distribution to FSS earth station

The BS antenna gain distribution has been simulated with an azimuth variation of ± 60° and two elevation ranges, referred to the antenna boresight direction.

FIGURE O-5

IMT BS elevation variation of -15° to 80°

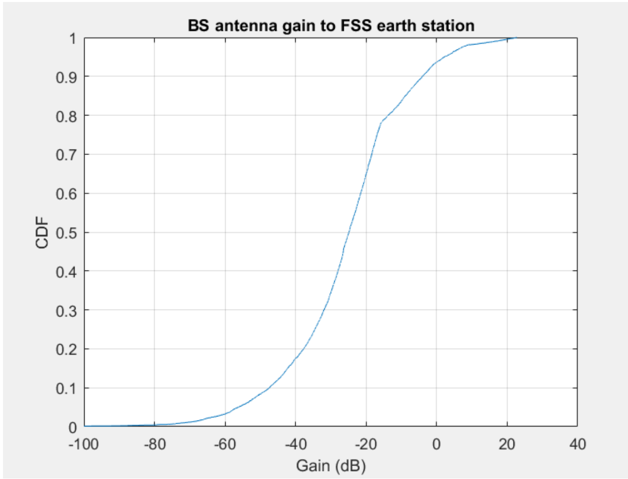
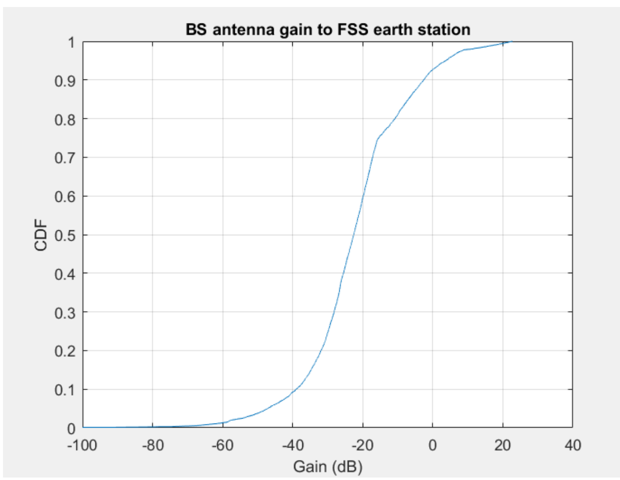


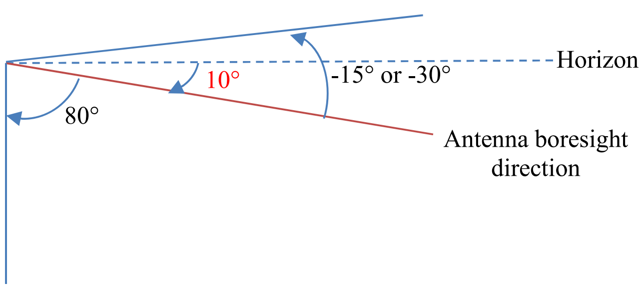
FIGURE O-6

IMT BS elevation variation of -30° to 80°



BS antenna orientation in elevation

(black : electrical tilt, red : mechanital tilt)



The maximum interference level has be evaluated as follows:

IMT receiver noise floor – 6 dB = thermal noise + noise figure – 6 dB= -204 dB(W/Hz) + 10 dB -6 dB= -200 dB(W/Hz).

1.15.2.2.5 Distribution functions for IMT BS receiver gain and clutter loss

1.15.2.2.5.1 Interference from FSS Carrier #13, earth station 5° elevation towards satellite

On each graph, the dotted line indicates the maximum interference level of -200 dB(W/Hz)

IMT BS antenna gain simulated with azimuth: - 60° to 60°, elevation: -15° to 80°

FIGURE O-7

Free Space Losses

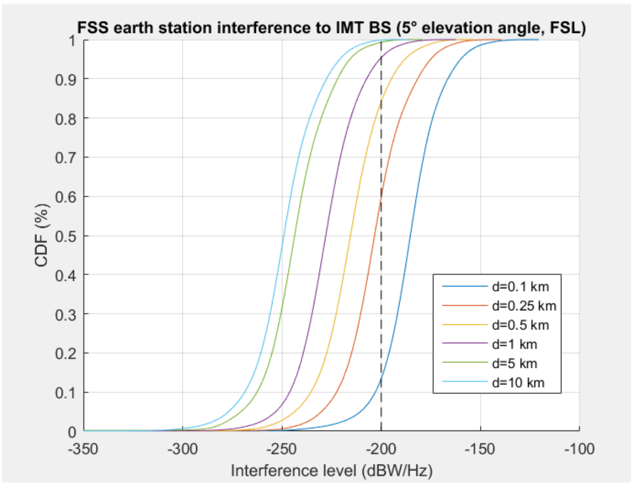
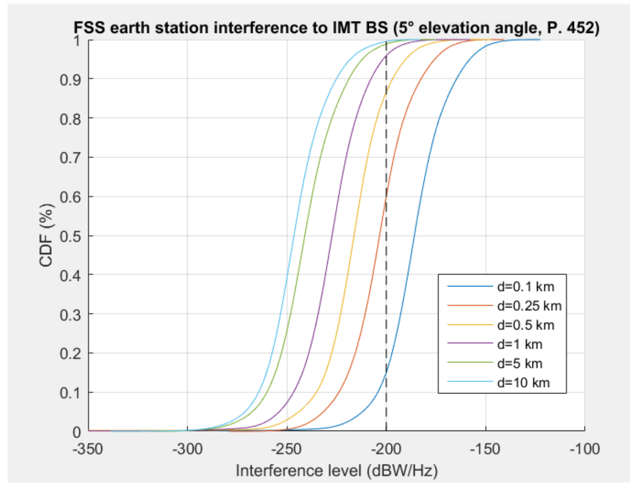


FIGURE O-8

Rec. ITU-R P.452



IMT BS antenna gain simulated with azimuth: - 60° to 60°, elevation: -30° to 80°

FIGURE O-9

Free Space Losses

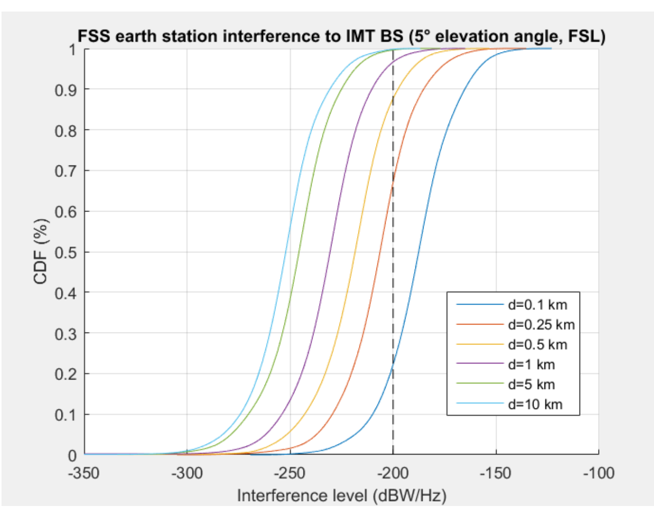
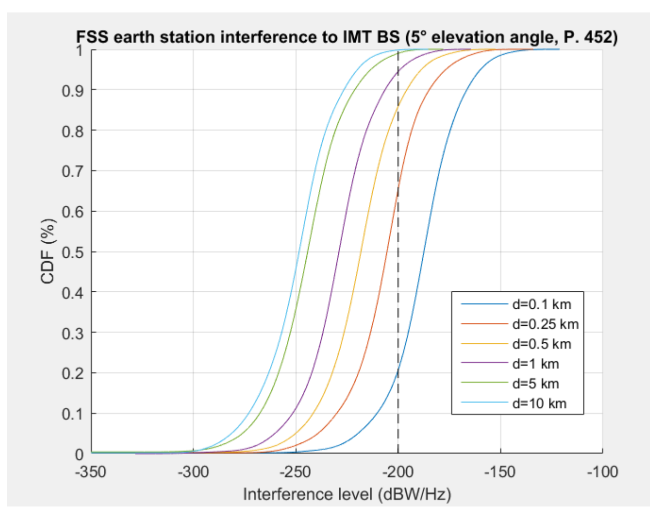


FIGURE O-10

Rec. ITU-R P.452

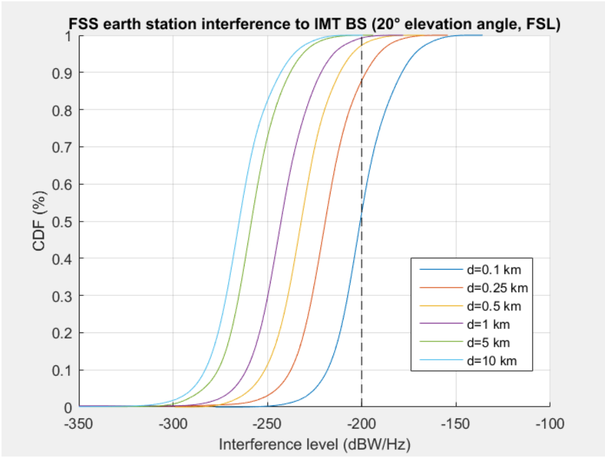


When the simulations are done with a BS elevation angle of -15° to 80° or -30° to 80°, using free space losses or taking into account the diffraction losses, the result is very similar. Therefore, the following simulations will present only the free space loss case and the BS elevation variation of -15° to 80°.

1.15.2.2.5.2 Interference from FSS Carrier #13, earth station 20° elevation towards satellite

IMT BS antenna gain simulated with azimuth: - 60° to 60°, elevation: -15° to 80°

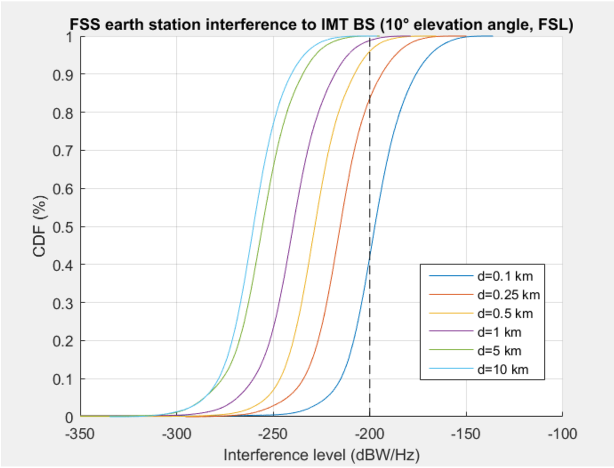
FIGURE O-11



1.15.2.2.5.3 Interference from FSS Carrier #14, earth station 10° elevation towards satellite

IMT BS antenna gain simulated with azimuth: - 60° to 60°, elevation: -15° to 80°

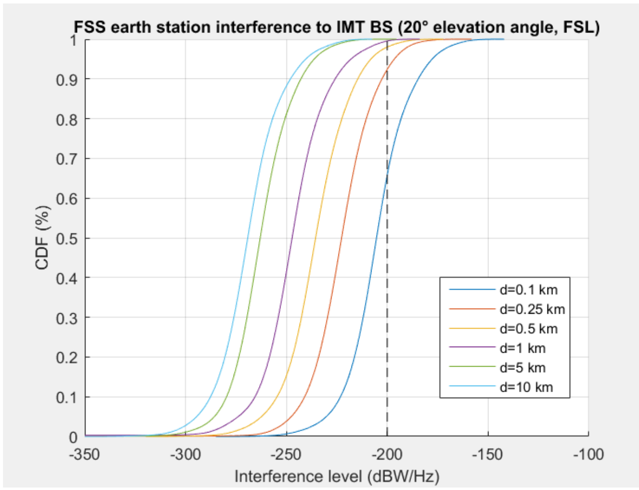
FIGURE O-12



1.15.2.2.5.4 Interference from FSS Carrier #14, earth station 20° elevation towards satellite

IMT BS antenna gain simulated with azimuth: - 60° to 60°, elevation: -15° to 80°

FIGURE O-13



1.15.2.3 Method 2: Maximum IMT receiver gain and clutter loss associated with 1% and 50 % of locations

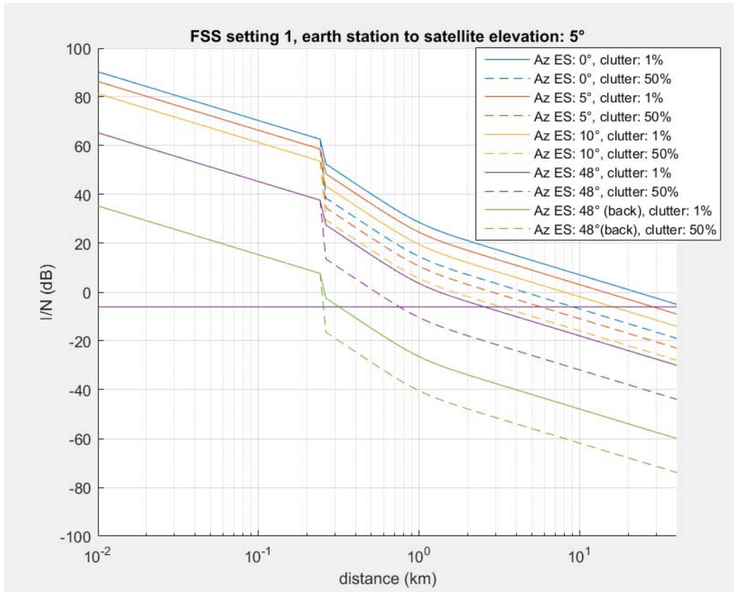
Two scenarios have been studied:

– The maximum antenna gain was assumed for IMT BS, when the BS is directed to FSS transmit earth station.

– An IMT antenna discrimination of 30 dB was assumed when the back-lobe of the IMT BS is directed to the FSS transmit earth station.

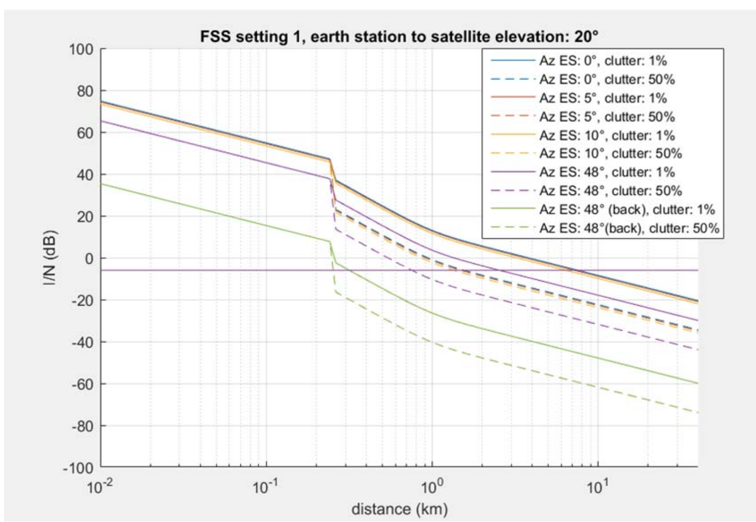
1.15.2.3.1 Interference from FSS Carrier #13, earth station 5° elevation towards satellite to IMT

FIGURE O-14



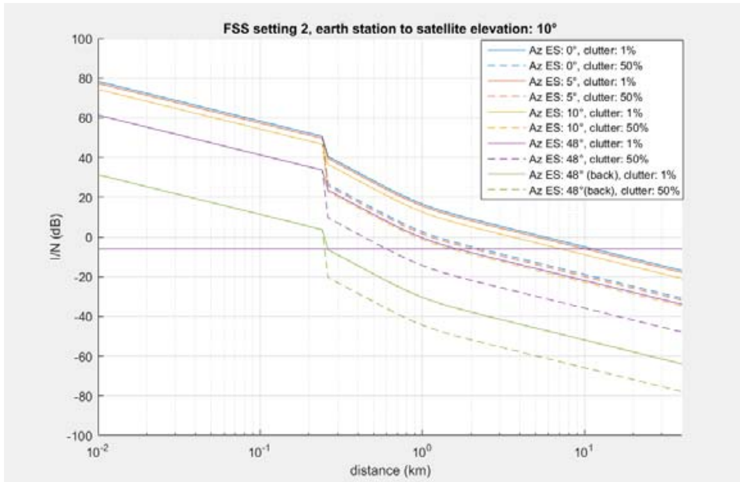
1.15.2.3.2 Interference from FSS Carrier #13, earth station 20° elevation towards satellite to IMT

FIGURE O-15



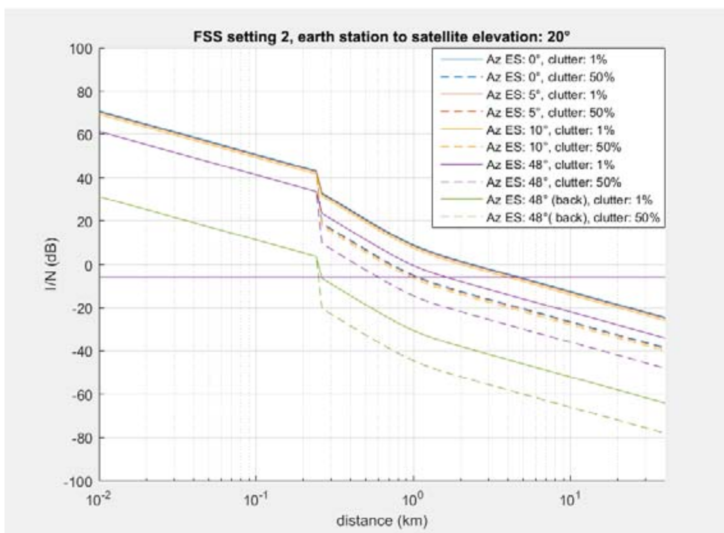
1.15.2.3.3 Interference from FSS Carrier #14, earth station 10° elevation towards satellite to IMT

FIGURE O-16



1.15.2.3.4 Interference from FSS Carrier #14, earth station 20° elevation towards satellite to IMT

FIGURE O-17



1.15.3 Summary and analysis of the results of study O

Method 1

Separation distance between FSS earth station and IMT BS to meet an I/N protection criterion of -6 dB.

TABLE O-3

FSS scenario	Elevation angle towards satellite	Required FSS-IMT separation distance
Carrier #13 (ES antenna:0.45 m)	5°	10 km
	20°	2 km
Carrier #14 (ES antenna:13.2 m)	10°	3 km
	20°	2 km

Method 2

Table O-4 summarises the simulated necessary separation distance to satisfy the protection criterion of IMT (*I/N* of -6 dB) in different environments and deployments of IMT stations and FSS earth station for clutter losses of 1% and 50% and maximum IMT BS gain.

TABLE O-4

Carrier	BS direction	FSS azimuth off-axis	BS separation distance	
			Clutter 1%	Clutter 50%
#13 (5 degree elevation)	Front	0°	40 km	10 km
		5°	30 km	6 km
		10°	15 km	3.5 km
		48°	3 km	0.7 km
	Back	48°	0.3 km	0.25 km
#13 (20 degree elevation)	Front	0°	7.5 km	1.5 km
		5°	7.5 km	1.5 km
		10°	7.5 km	1.5 km
		48°	2.5 km	0.7 km
	Back	48°	0.3 km	0.25 km
#14 (10 degree elevation)	Front	0°	11.5 km	2.5 km
		5°	11.5 km	2.5 km
		10°	7 km	1.5 km
		48°	2 km	0.5 km
	Back	48°	0.25 km	0.25 km
#14 (20 degree elevation)	Front	0°	4 km	1 km
		5°	4 km	1 km
		10°	4 km	1 km
		48°	1.6 km	0.5 km
	Back	48°	0.25 km	0.25 km

Method 1 (distribution function for IMT BS antenna gain and clutter losses) suggests that for FSS Carrier # 13 and with a 0.45 m antenna, the required separation distance is approximately 10 km (worst case) for a low elevation angle of earth station towards the satellite. For 20° FSS elevation angle towards the satellite, which is in the 26 GHz band a more realistic case, the separation distance is around 2 km. The separation distance is similar for FSS Carrier #14 with a 13.2 m antenna.

Method 2 (maximum IMT BS gain and clutter loss set to 1%) shows that for FSS Carrier #13, the required separation distance is 40 km when the FSS earth station and the IMT earth station are facing each other for a low elevation angle of the earth station towards the satellite. With an elevation angle of 20°, the required separation distance is 7.5 km.
For FSS Carrier#14, the separation distance is 11.5 km for a FSS earth station elevation angle of 5°. If the FSS earth station and the IMT BS are not pointing directly at each other, the separation distance can be reduced as shown in Table O-4.

Conclusion of Study O

For an earth station elevation angle to satellite of 20°, which is used in operation in the frequency band under study, the required distance between FSS and IMT varies between 2 km and 7.5 km, depending on the propagation conditions such as clutter loss, IMT BS orientation, FSS earth station orientation. Therefore, it is not possible to determine a fixed distance where IMT networks will not be affected; this will have to be handled on a case by case basis.

For the case of large FSS earth stations at known locations such as gateways, coordination zones around FSS earth stations can be determined to avoid interference towards IMT base stations. In this case, compatibility between both systems can be achieved by coordination, allowing for the effective co-existence of IMT and FSS earth stations.

For the case of ubiquitous deployment of small FSS earth stations, sharing between IMT and FSS is not practicable within the same geographical areas, particularly as it is not feasible to individually coordinate large numbers of ubiquitous earth stations, nor is it even possible to determine a coordination contour around ubiquitous earth stations.

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Annex 10 to Document 5-1/406-E Task Group 5/1 Chairman's Report, Sharing and compatibility studies of IMT systems in the 50.4-52.6 GHz frequency range, Study D

Radiocommunication Study Groups

2/1.4 Study D: Sharing study of the fixed-satellite service (Earth-to-space) and IMT systems in the 47.2-50.2 GHz and 50.4-51.4 GHz frequency ranges (For information only see Doc. 5-1/355 (France))

2/1.4.1 Introduction

This study provides some outputs of the sharing studies of IMT systems into the FSS in the 47.2-50.2 GHz and 50.4-51.4 GHz frequency range and is intended to be responsive to *resolves to invite ITU-R* 2 of Resolution **238 (WRC-15)** under WRC-19 agenda item 1.13.

To complement the French study on interference of IMT system into a FSS satellite receiver presented during TG 5/1 in January 2018, this study provides an interference simulation of a single FSS earth station into a single IMT base station.

It is proposed to include the results of the interference of IMT systems into FSS (earth-to-space) in the 47.2-50.2 GHz and 50.4-51.4 GHz frequency range in Study D of Annex 9 to the TG 5/1 Chairman's Report.

2/1.4.2 Technical characteristics

2/1.4.2.1 Technical and operational characteristics of IMT systems operating in the 47.2-50.2 GHz and 50.4-51.4 GHz frequency ranges

2/1.4.2.1.1 Technical characteristics of IMT systems

Table D-1 provides the line of sight (LOS) BS parameters (e.i.r.p. density 52 dBm/200 MHz)

TABLE D-1

BS parameters (e.i.r.p. density 52 dB(m/200 MHz))

Parameter	Unit	BS
Antenna array configuration N_H x N_V	N/A	8×16
Single element output power	dB(m/200 MHz)	8
Maximum element gain	dBi	5
Conducted power (without ohmic losses)	dB(m/200 MHz)	29
Maximum composite antenna gain	dBi	26
Array Ohmic losses	dB	3
Maximum e.i.r.p.	dB(m/200 MHz)	52
H/V radiating element spacing	N/A	λ/2
Antenna height (above ground level)	m	6 (suburban hotspot , urban) 15 (suburban open space hotspot)
H/V 3 dB beamwidth	°	65 for both
Am & SLA	dB	30 for both
Mechanical downtilt	°	10 (suburban hotspot , urban)

Note: BS antenna model have been normalized to keep the total emitted radiation (TRP) from the antenna to a fixed

Parameter	Unit	BS

value (0 dB, i.e. antenna model does not provide any additional gain or loss). The normalization correction was between ~+0.5 dBi and ~+5 dBi for the UE antenna and between ~+0.5 dBi and ~+10 dB for the BS antenna depending on antenna steering direction. The correction factor applied is the following:

$$\text{Correction factor} = \frac{1}{4\pi}\int_0^{2\pi}\int_0^{\pi} A_A(\theta,\varphi,\theta_{etilt},\varphi_{escan})\sin(\theta)\ d\theta d\varphi$$

2/1.4.2.1.2 Protection criterion of IMT systems

The acceptable interference to noise ratio at the IMT BS receiver is assumed to be -6 dB.

2/1.4.2.2 Technical and operational characteristics of the fixed-satellite service (Earth-to-space) operating in the 47.2-50.2 GHz and 50.4-51.4 GHz frequency range

The typical parameters of FSS uplink operating in the 47.2-50.2 GHz and 50.4-51.4 GHz frequency bands are shown in Table D-2 (Documents 5-1/89 and 5-1/183) from Working Party 4A.

TABLE D-2

Typical parameters in FSS uplink

Parameter	Value	
Satellite	Carrier #38, #16	
Receive frequency	47.2-50.2 GHz and 50.4-51.4 GHz	
Earth station	Carrier #38	Carrier #16
Antenna diameter	9 m	6.8 m
Peak transmit antenna gain	71.1 dBi	68.6 dBi
Peak transmit power spectral density (clear sky)	-55 dB(W/Hz)	-54 dB(W/Hz)
Antenna gain pattern	Rec. ITU-R S.465-6	Rec. ITU-R S.465-6
Elevation angle	10 and 20 degrees	10 and 20 degrees

2/1.4.3 Propagation models for sharing and compatibility studies in the 47.2-50.2 GHz and 50.4-51.4 GHz frequency range

The signal propagating from the GSO earth station to the IMT-2020 BS is subject to the following attenuations:

– free space loss (Recommendation ITU-R P.525), additional propagation losses such as diffraction (Recommendation ITU-R P.452)

– clutter loss due to man-made objects between the FSS satellite and the IMT-2020 system (Recommendation ITU-R P.2108, Section 3.2 Statistical clutter loss model for terrestrial paths)

2/1.4.4 Interference from FSS (Earth-to-space) into IMT systems

2/1.4.4.1 Methodology for the single entry interference analysis

Two different methodologies were used:

Method 1

Five FSS earth stations were placed at different distances (0.1, 0.25, 0.5, 1, 5 and 10 km) from an IMT BS, pointing towards the BS with 2 different elevation angles. The IMT BS was randomly placed with 4 different antenna directions (pointing towards the earth station, pointing with ±90° and 180° azimuth offset).

The performed analysis uses a fixed number for the satellite earth station antenna gains (one value per elevation angle) towards the IMT BS, the propagation loss between the earth station and the BS, the polarisation loss (1.6 dB) and the IMT antenna ohmic loss (3 dB) and also distributions for the IMT BS antenna gain towards the earth station and for clutter losses between IMT and earth station. The clutter is assumed only at one end of the link and is set to zero for distances shorter than 250 m.

Satellite earth station antenna gain:

– FSS Carrier # 38 gain: 7 dBi towards IMT BS for 10° elevation angle and -0.5 dBi for 20° elevation angle

– FSS Carrier # 16 gain: 7 dBi towards IMT BS for 10° elevation angle and -0.5 dBi for 20° elevation angle

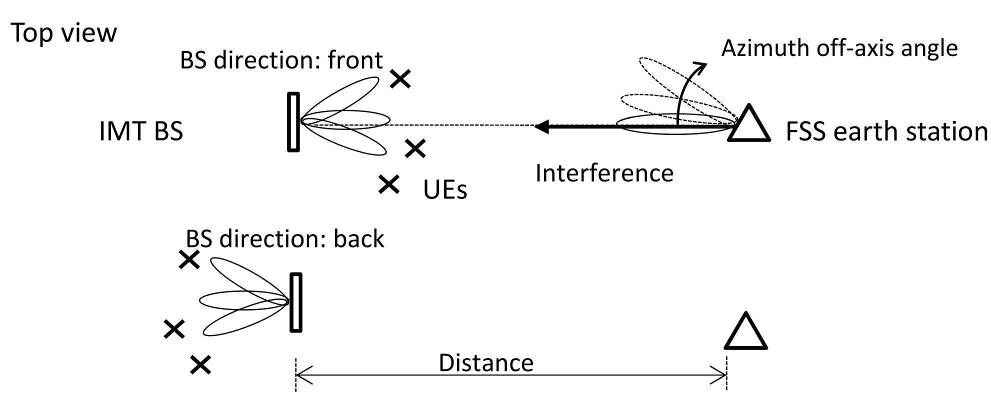
The distribution of propagation loss, clutter loss (no curve for 0.1 km where clutter is set to zero) and IMT antenna gain are shown in section 3.2 (intermediate results for Method 1).

Method 2

The interference level into an IMT BS station is calculated assuming that the FSS earth station and IMT BS antennas are pointed in azimuth directly toward each other, at offsets of 5, 10 and 48°, and pointed away from each other. The interference topology from the FSS earth station to IMT system is illustrated the figure below:

FIGURE D-1

Interference topology of FSS earth station to IMT BS



The interference-to-noise (*I/N*) ratio into an IMT receive station from an FSS transmit earth station is calculated below:

$$I/N = e.i.r.p._{FSS}(\theta_{FSS}) - Losses + G_{IMT}(\theta_{IMT}) - \mathrm{N} - \mathrm{PL} \quad \text{(D-1)}$$

where:

I/N: Interference-to-noise ratio in dB;

$e.i.r.p._{FSS}(\theta_{FSS})$: FSS transmit earth station signal off-axis e.i.r.p. density in the direction of the IMT receive BS in dB(W/Hz);

Losses: Propagation loss in dB;

$G_{IMT}(\theta_{IMT})$: IMT receive station antenna gain in direction of the FSS transmit earth station in dBi;

N: IMT receive station noise power density in dBW;

PL: Polarization losses in dB.

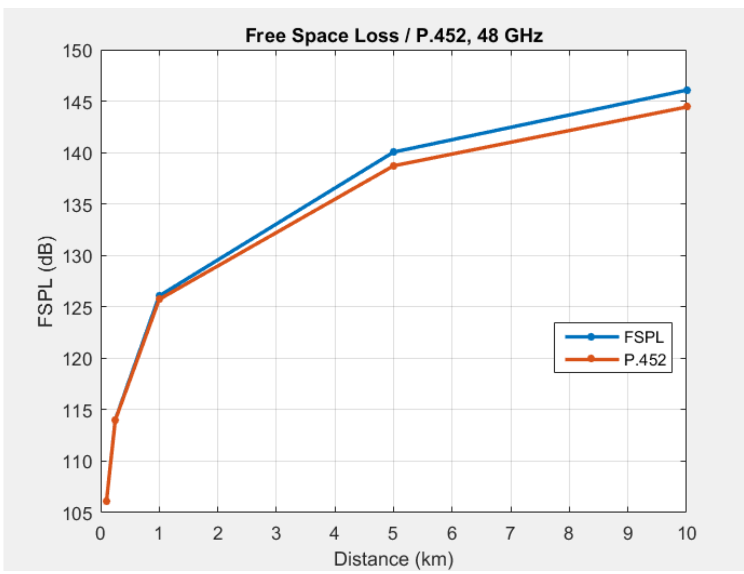
2/1.4.4.2 Method 1

The interference was calculated by combining the variable parameters (IMT antenna gain and clutter loss, e.g. 100 antenna gain values combined with 1 000 clutter loss values gives 100×1000= 100 000 values) and adding the fixed values (free space loss, earth station antenna gains and other losses)

2/1.4.4.2.1 Free space losses and losses calculated with Recommendation ITU-R P.452

FIGURE D-2

Comparison of FSPL and Recommendation ITU-R P.452



Parameters used to evaluate the losses as per Recommendation ITU-R P.452:

– Time percentage for which the calculated loss is not exceeded: 10%
– Zone inland
– Transmitter station latitude: 0°
– Receiver station latitude: 0°
– Transmitter antenna gain in direction of the horizon: FSS Carriers #38 and #16 gain (Section 2/1.4.4.1)
– Receiver antenna gain in direction of the horizon: 26 dBi
– Polarization direction: horizontal

– Distance from transmitter to coast: 0 km
– Distance from receiver to coast: 0 km
– Average radio refractive index lapse rate through lowest 1 km (N units per km): 53
– Sea-level surface refractivity (N units): 328
– Dry air pressure: 1 013 hPa
– Temperature: 15°C.

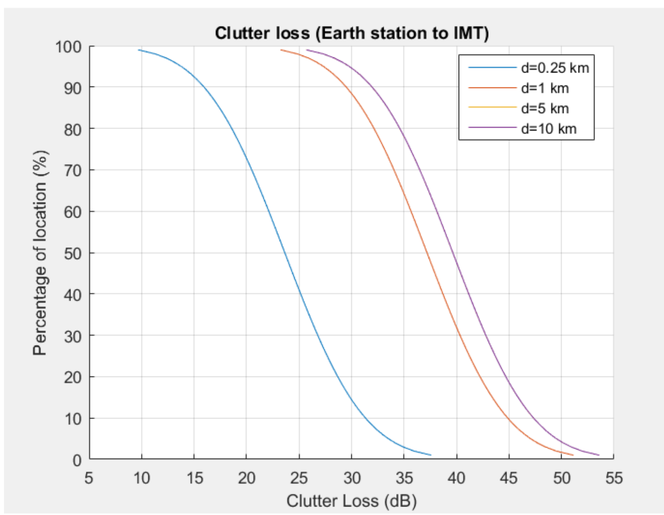
2/1.4.4.2.2 Clutter losses

Section 3.2 of Recommendation ITU-R P.2108 is applied to calculate the statistical distribution of clutter loss where the interference scenario is from a satellite earth station to an IMT station.

The cumulative CDF for different distances between the FSS earth station and the IMT BS at 27 GHz is shown in Figure D-3.

FIGURE D-3

Clutter losses



1/1.4.4.2.3 BS antenna gain distribution to FSS earth station

The BS antenna gain distribution has been simulated with an azimuth variation of ±60° and two elevation ranges, referred to the antenna boresight direction.

FIGURE D-4

IMT BS elevation variation of -15° to 80°

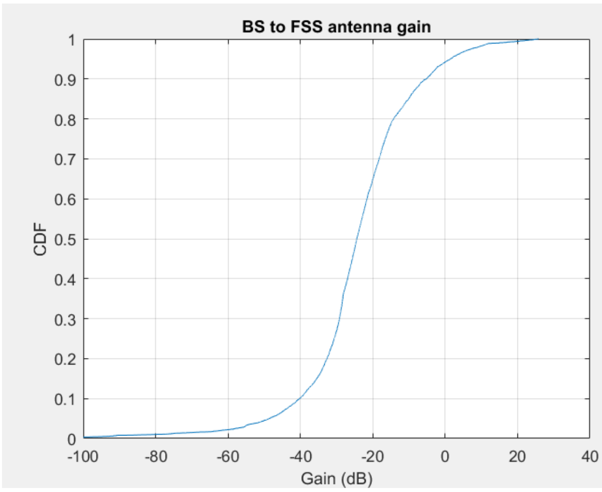
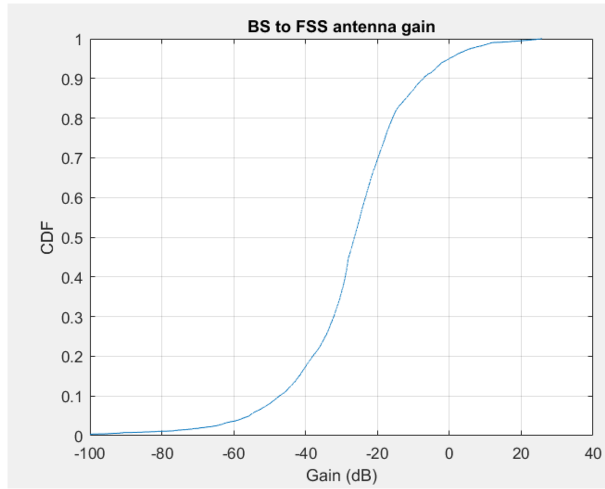
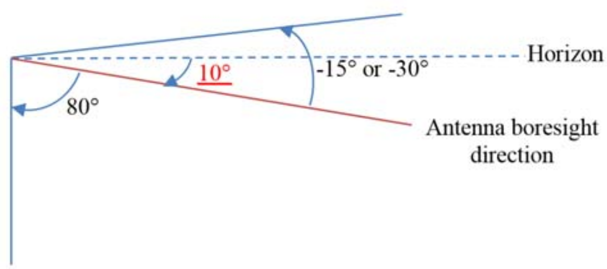


FIGURE D-5

IMT BS elevation variation of -30° to 80°



BS antenna orientation in elevation
(black : electrical tilt, red : mechanital tilt)



The maximum interference level has been evaluated as follows:

IMT receiver noise floor – 6 dB = thermal noise + noise figure – 6 dB= -204 dB(W/Hz) + 12 dB -6 dB= -198 dB(W/Hz).

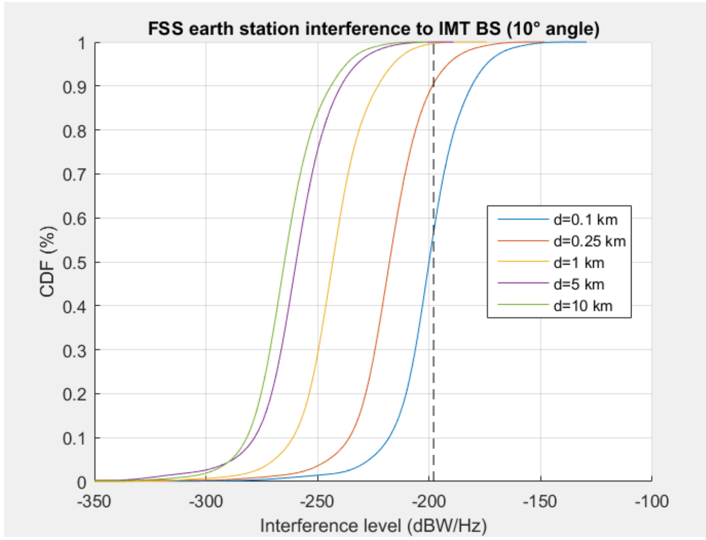
2/1.4.4.2.4 Results of interference from FSS into IMT

2/1.4.4.2.4.1 Interference from FSS Carrier #38, earth station 10° elevation towards satellite

On 1each graph, the dotted line indicates the maximum interference level of -198 dB(W/Hz).

IMT BS antenna gain simulated with azimuth: - 60° to 60°, elevation: -15° to 80°

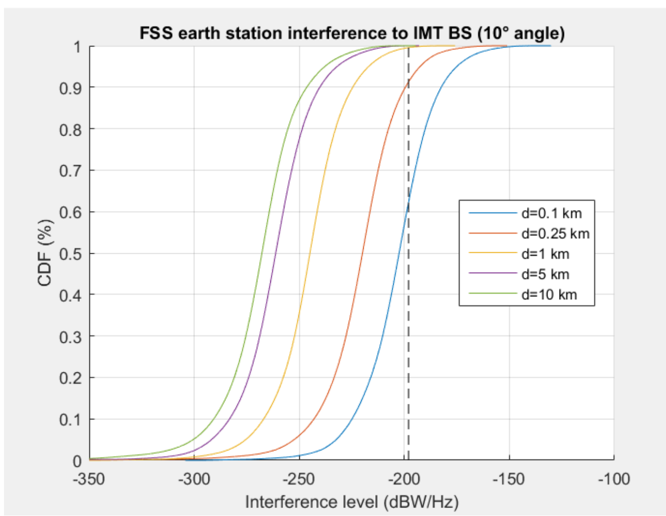
FIGURE D-6



IMT BS antenna gain simulated with azimuth: - 60° to 60°, elevation: -30° to 80°

FIGURE D-7

Free space losses

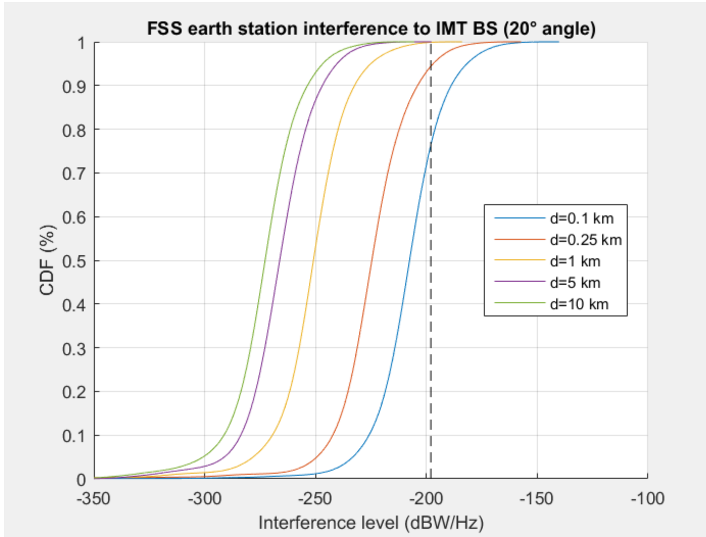


When the simulations are made with BS elevation angles varying from -15° to 80° or from -30° to 80°, using free space losses or taking into account the diffraction losses, the result is very similar. Therefore, the following simulations will present only the free space loss case for BS elevations of -15° to 80°.

2/1.4.4.2.4.2 Interference from FSS Carrier #38, earth station 20° elevation towards satellite

IMT BS antenna gain simulated with azimuth: -60° to 60°, elevation: -15° to 80°

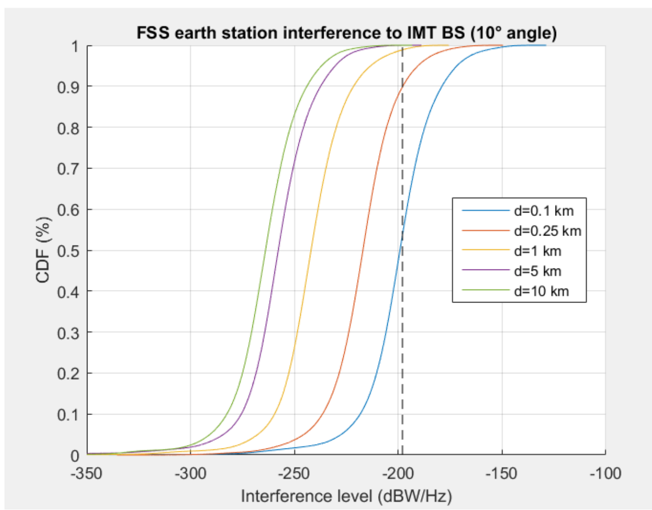
FIGURE D-8



2/1.4.4.2.4.3 Interference from FSS Carrier #16, earth station 10° elevation towards satellite

IMT BS antenna gain simulated with azimuth: - 60° to 60°, elevation: -15° to 80°

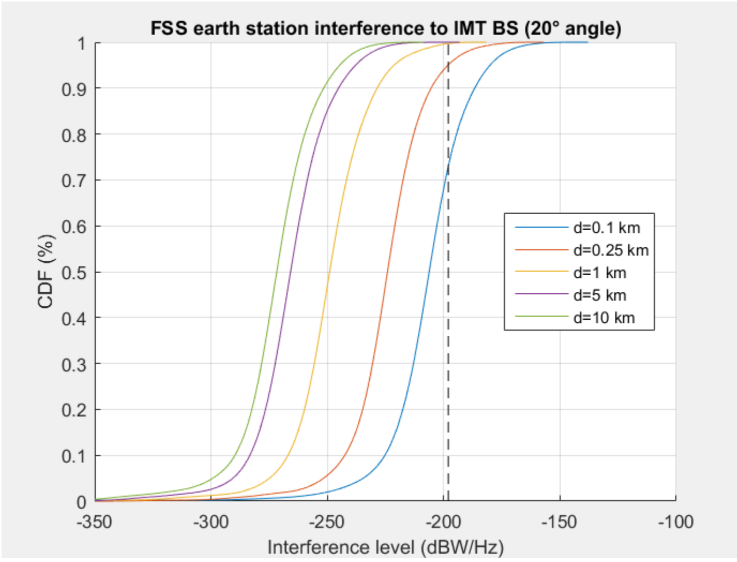
FIGURE D-9



2/1.4.4.2.4.4 Interference from FSS Carrier #16, earth station 20° elevation towards satellite

IMT BS antenna gain simulated with azimuth: - 60° to 60°, elevation: -15° to 80°

FIGURE D-10



2/1.4.4.3 Method 2: Maximum IMT receiver gain and clutter loss associated with 1% and 50% of locations

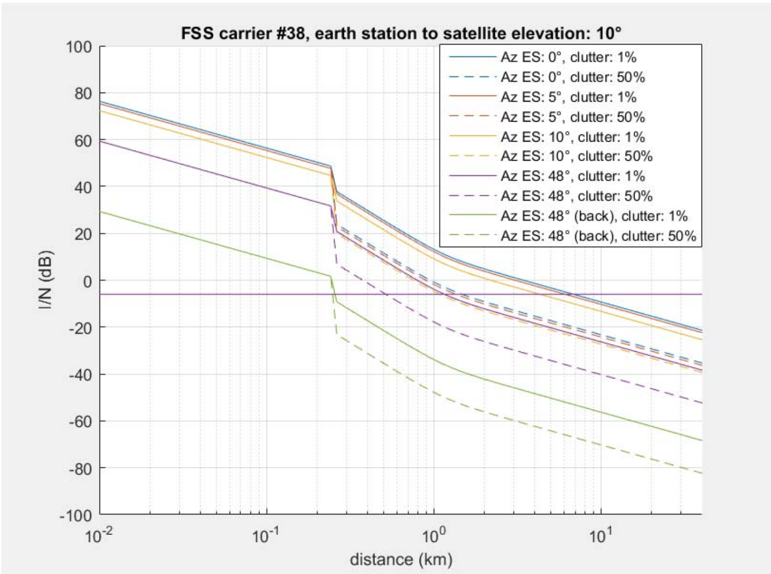
Two scenarios have been studied:

– The maximum antenna gain was assumed for IMT BS, when the BS is directed to FSS transmit earth station.

– An IMT antenna discrimination of 30 dB was assumed when the back-lobe of the IMT BS is directed to the FSS transmit earth station.

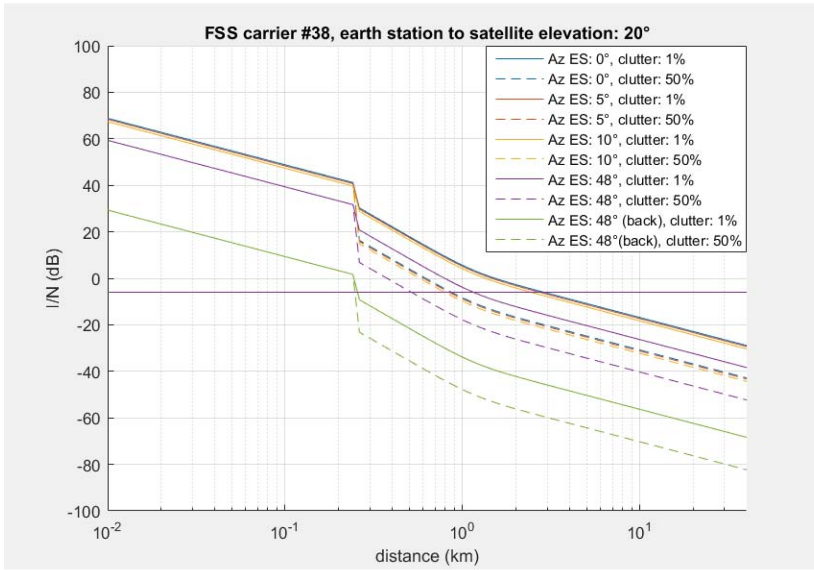
2/1.4.4.3.1 Interference from FSS Carrier #38, earth station 10° elevation towards satellite to IMT

FIGURE D-11



2/1.4.4.3.2 Interference from FSS Carrier #38, earth station 20° elevation towards satellite to IMT

FIGURE D-12



2/1.4.5 Summary and analysis of the results of Study D

Method 1

Separation distance between FSS earth station and IMT BS to meet an I/N protection criterion of -6 dB.

TABLE D-3

FSS scenario	Elevation angle towards satellite	Required FSS-IMT separation distance
Carrier #38 (ES antenna:0.45m)	10°	5 km
	20°	1 km
Carrier #16 (ES antenna:13.2m)	10°	5 km
	20°	1 km

Method 2

Table D-4 summarises the simulated necessary separation distance to satisfy the protection criterion of IMT (*I/N* of -6 dB) in different environments and deployments of IMT stations and FSS earth station for clutter losses of 1% and 50% and maximum IMT BS gain.

TABLE D-4

Carrier	BS direction	FSS azimuth off-axis	BS separation distance	
			Clutter 1%	Clutter 50%
#38 (10° elevation)	Front	0°	7 km	1.5 km
		5°	7 km	1.5 km
		10°	5 km	1.5 km
		48°	1.2 km	0.5 km
	Back	48°	0.3 km	0.25 km
#38 (20° elevation)	Front	0°	3 km	1 km
		5°	3 km	1 km
		10°	3 km	1 km
		48°	1.2 km	0.5 km
	Back	48°	0.25 km	0.25 km

Method 1 (distribution function for IMT BS antenna gain and clutter losses) suggests that for FSS Carrier # 38 and with a 9 m antenna, the required separation distance is 5 km (worst case) for a low elevation angle of earth station towards the satellite. For a 20° FSS elevation angle towards the satellite, which is, in the 50 GHz band a more realistic case, the separation distance is around 1 km. The separation distance is similar for FSS Carrier #16 with 6.8 m antenna.

Method 2 (maximum IMT BS gain and clutter loss set to 1% and 50%) shows that for FSS Carrier #38, the required separation distance is 7 km when the FSS earth station and the IMT earth station are facing each other for a low elevation angle of the earth station towards the satellite. With an elevation angle of 20°, the required separation distance is 3 km.

Conclusion

For an earth station elevation angle to satellite of 20°, which is used in operation in the frequency band under study, the required distance between the FSS and IMT varies between 1 and 3 km, depending on the propagation conditions such as clutter loss, IMT BS orientation and FSS earth station orientation. Therefore, it is not possible to determine a fixed distance where IMT networks will not be affected; this will have to be handled on a case by case basis.

For the case of large FSS earth stations at known locations such as gateways, coordination zones around FSS earth stations can be determined to avoid interference towards IMT base stations. In this case, compatibility between both systems can be achieved by coordination, allowing for the effective co-existence of IMT and FSS earth stations.

For the case of ubiquitous deployment of small FSS earth stations, sharing between IMT and FSS is not practicable, particularly as it is not feasible to individually coordinate large numbers of ubiquitous earth stations, nor is it even possible to determine a coordination contour around ubiquitous earth stations.

2/2 Summary and analysis of the results of studies

Several sharing and compatibility studies between IMT and FSS in the Earth-to-space direction have been conducted in the frequency band 50.4-52.6 GHz. These studies have employed deterministic and statistical analyses using the parameters provided by the responsible groups.

In the case of aggregate interference from IMT stations into a FSS space station, one study concluded that for the worst-case scenario, the mean I/N, is -34 dB for GSO. Another study

calculated a value of -30.4 dB mean I/N for a GSO satellite and -21.7 dB for a non-GSO satellite. One study calculated probability distributions of IMT gain towards the space station and presumed the worst-case value for each IMT transmitter (elevation and azimuth) in the satellite beam and found an I/N of -19 dB without clutter considerations.

[Sensitivity analysis carried out according to Annex 1 to the TG 5/1 Chairman's Report with a 5 dB increase in an IMT antenna element power or 16×16 antenna elements instead of 8×16 elements shows no interference issues. Some studies considered that if the IMT characteristics deviate even further (e.g. in terms of denser IMT deployments, higher IMT base station e.i.r.p., higher IMT base station elevation angle, different antenna element output power and/or antenna array), beyond what is defined in the sensitivity analysis of Annex 1, there might be interference issues.] Some administrations are of the view that, to address these potential cases, mitigation techniques would be required. Some other administrations are of the view these mitigation techniques are not necessary.

For the case of a FSS earth station interfering into IMT, the results concluded there is a need for a separation distance between few hundred meters to 5 km. [Because of the required separation distance, in case of ubiquitous deployment of small FSS earth stations, sharing between IMT and the FSS is not feasible within the same geographical area.]

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Annex B

SES' Proposal for 50 GHz Sharing Rules: 25.136(h)

Annex B

Proposed 25.136(h) Language for 50.4-51.4 GHz Band

§25.136 Earth Stations in the 27.5-28.35 GHz, 37.5-40 GHz, 47.2-48.2 and 50.4-51.4 GHz bands.

***

(h) Notwithstanding that FSS is co-primary with the Upper Microwave Flexible Use Service in the 50.4-51.4 GHz band, earth stations in that bands shall be limited to individually licensed earth stations. An applicant for a license for a transmitting earth station in the 50.4-51.4 GHz band must meet one of the following criteria to be authorized to operate without providing any additional interference protection to stations in the Upper Microwave Flexible Use Service:

(1) The FSS licensee also holds the relevant Upper Microwave Flexible Use Service license(s) for the area in which the earth station generates a power flux density (PFD), at 10 meters above ground level, of greater than or equal to −77.6 dBm/m2/MHz;

(2) The applicant demonstrates compliance with all of the following criteria in its application:

(i) **In counties with a population equal to or greater than 450,000 within the UMFUS license area, as referenced in Table 1 to this paragraph,** there are no more than two other authorized earth stations operating in the 50.4-51.4 GHz band within the county where the proposed earth station is located that meet the criteria contained in either paragraphs (e)(1) (e)(2), (e)(3) or (e)(4) of this section, and there are no more than 14 other authorized earth stations operating in the 50.4-51.4 GHz band within the Partial Economic Area where the proposed earth station is located that meet the criteria contained in paragraphs (e)(1) (e)(2), (e)(3) or (e)(4) of this section. For purposes of this requirement, multiple earth stations that are collocated with or at a location contiguous to each other shall be considered as one earth station;

(ii) **In counties with a population of less than 450,000 within the UMFUS license area, as referenced in Table 1 to this paragraph,** the area in which the earth station generates a power flux density (PFD), at 10 meters above ground level, of greater than or equal to −77.6 dBm/m2/MHz, together with the similar area of any other earth station operating in the 50.4-51.4 GHz band authorized pursuant to paragraph (e) of this section, does not cover, in the aggregate, more than the amount of population of the county within which the earth station is located as noted below:

TABLE 1 TO PARAGRAPH (h)(4)(ii)

Population within UMFUS license area	Maximum permitted aggregate population within −77.6 dBm/m^2/MHz PFD contour of earth stations
Greater than 450,000	0.1 percent of population in UMFUS license area.
Between 0 and 450,000	No restriction

(iii) The area in which the earth station generates a PFD, at 10 meters above ground level, of greater than or equal to −77.6 dBm/m^2/MHz does not contain any major event venue, urban mass transit route, or cruise ship port. For purposes of this rule, an urban area shall be an Adjusted Urban Area as defined in section 101(a)(37) of Title 21 of the United States Code.

(iv) The applicant has successfully completed frequency coordination with the UMFUS licensees within the area in which the earth station generates a PFD, at 10 meters above ground level, of greater than or equal to −77.6 dBm/m^2/MHz with respect to existing facilities constructed and in operation by the UMFUS licensee. In coordinating with UMFUS licensees, the applicant shall use the applicable processes contained in §101.103(d) of this chapter.