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GSO FSS deployment characteristics in the 14-14.5 GHz band

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REPORT ITU-R S.2364-0

GSO FSS deployment characteristics in the 14-14.5 GHz band

(2015)

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1 General FSS characteristics

This Report provides an estimate of the current GSO FSS deployment characteristics in the 14-14.5 GHz band. The FSS earth station deployment models below can be used to estimate how earth stations may be deployed in sharing studies between FSS and other radiocommunication services in the 10-17 GHz band. Future GSO FSS deployment characteristics may differ from characteristics provided in this Report.

Non-GSO FSS deployment characteristics were not considered in this Report.

The following tables contain characteristics for the FSS in the 10-17 GHz band. They include a sampling of transmitting earth station antenna patterns and characteristics for use in FSS networks. Recommendations ITU-R S.1855 and ITU-R S.728 are used for the off-axis antenna pattern or off-axis e.i.r.p. density mask, as appropriate. Recommendation ITU-R BO.1213 is considered primarily for modelling the main lobe characteristics of an FSS earth station antenna.

The FSS GSO satellite downlink characteristics in the 10-17 GHz band are considered to have the maximum allowable pfd at the Earth's surface for the frequency band under consideration as specified by ITU Radio Regulations (RR) No. **21.16**.

This pfd level was designed to protect terrestrial systems that share existing FSS frequencies on a co-primary basis. Typically, FSS GSO satellite downlink transmissions have e.i.r.p. density levels usually between –35 and –20 dBW/Hz depending on the transmission requirements, which are significantly lower than the –13 dBW/Hz level that would be derived from RR No. **21.16**.

The model contained herein defines three main types of transmissions (VSAT, Wideband, and Point-to-Point) currently active on fixed satellite systems and the relative frequency of use of these transmission types. For each of the transmission types, typical earth station characteristics are outlined. The characteristics in the tables below are taken from a statistical analysis of all the transmissions from 73 active satellites in the 14.0-14.5 GHz band (horizontal and vertical polarization). There was an overall total of 25 937 transmissions which gives an average of 355 transmissions per satellite. The 73 satellites occupy less than 73 orbital locations and therefore the average number of transmissions per orbital location will be greater than the average number of transmissions per satellite. The use of transmission types serves to provide an accurate description of FSS earth station operations and their transmissions.

1.1 Very small aperture terminals transmission type

Very small aperture terminals (VSATs) are earth stations with small diameter antennas that commonly transmit carriers with lower e.i.r.p. densities and smaller bandwidths. Transmissions by VSATs are typically return links carrying data from remote sites back to a hub station or links between VSAT terminals. VSAT transmissions constitute about 69.3% of uplink FSS transmissions, which represents 15.28% of the total bandwidth.

Transmissions were considered to be of the VSAT transmission type if the transmitting earth station was less than 3 m in diameter and the bandwidth was less than 3 MHz. A total of 17 982 transmissions met the criteria of the VSAT transmission type and the statistical analysis of their characteristics is provided in later sections.

1.2 Wideband transmission type

Wideband transmissions are typically data or video carriers from hub stations. These stations transmit wideband carriers, have large diameters and the ability to transmit higher e.i.r.p. densities. In addition to the hub station transmissions, earth stations used for SNG can also transmit wideband carriers. Although the SNGs have small diameters, some have high gains and can transmit higher e.i.r.p.

densities. The Wideband transmission type constitutes about 4.9% of uplink FSS transmissions, which represents 56.8% of the total bandwidth.

Any transmission in the sample with a bandwidth of 18 MHz or larger was classified as belonging to the Wideband transmission type. The 18 MHz limit was used because it is half of a typical transponder bandwidth. In order for the satellite to receive transmissions with large bandwidths, higher e.i.r.p. must be transmitted. Earth stations with higher gains, including the high-gain SNG terminals, are required to achieve this higher e.i.r.p.. A total of 1 258 transmissions met the criteria of the wideband transmission type and the statistical analysis of their characteristics is provided in later sections.

1.3 Point-to-Point transmission type

Point-to-Point transmissions include all other transmissions that are not classified as belonging to the VSAT or Wideband transmission types. The earth stations transmitting Point-to-Point links typically have diameters and e.i.r.p. densities larger than VSATs but smaller than hub stations transmitting wideband carriers. The Point-to-Point transmission type constitutes about 25.8% of uplink FSS transmissions, which represents 27.92% of the total bandwidth.

In the analysis, all transmissions that did not meet the criteria of the VSAT or Wideband transmission types were classified as Point-to-Point links. Transmissions from earth stations in this transmission type have bandwidths less than 18 MHz and varying antenna diameters. A total of 6 697 transmissions met the criteria of the Point-to-Point transmission type and the statistical analysis of their characteristics is provided in later sections.

2 FSS characteristics for single-entry analysis

The FSS characteristics, as provided in Table 1, can be used to generate results based on the potential interference from one FSS earth station. The impact of each transmission type should be evaluated individually.

The maximum PSD values for the future FSS allocation can be expected to range between –60 and –47 dBW/Hz depending on the application envisaged. For VSAT transmissions, the application generally requires a PSD of around –50 dBW/Hz. In some cases, this could be exceeded (e.g. –42 dBW/Hz). For the Wideband and Point-to-Point transmission types, the PSD values are typically lower but could go as high as –50 dBW/Hz.

TABLE 1

Single-entry characteristics for the FSS in the 10-17 GHz band

Earth station									
Transmission type	VSAT			Wideband			Point-to-Point		
Percentage of total satellite transmissions	69.3			4.9			25.8		
Range of peak antenna gains[1] (dBi)	37.2-50.5			51.7-60.8			43.9-57.2		
Range of antenna sizes (m)	0.6-2.8			3.2-9.1			1.3-6.0		
3 dB beamwidth at 14 GHz[2] (°)	1.15			0.85			0.74		
Maximum power spectral density at antenna port (dBW/Hz)	–42[3]			–49			–50[4]		
Alternative maximum power spectral density at antenna port (dBW/Hz)	–59	–55	–50	–60	–57	–53	–60	–57	–53
Maximum e.i.r.p. density at the transmit antenna port (dBW/Hz)[5]	1.5			3.0			3.5		
Minimum elevation angle	10°								
Off-axis radiation pattern	Rec. ITU-R S.1855			Rec. ITU-R S.580			Rec. ITU-R S.580		
Off-axis power limits	Rec. ITU-R S.728[6]								
Main lobe characteristics	Rec. ITU-R BO.1213								

3 Characteristics for cumulative analysis

3.1 Spectrum usage by FSS transmissions

Table 2 provides FSS transmissions in terms of occupied spectrum, assuming that each network will aim at achieving a homogeneous power density at the GSO from all its Earth-to-space transmissions.

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[1] The peak antenna gain is estimated at the centre of the band (14.25 GHz) and 65% efficiency.

[2] The 3 dB beamwidth was calculated assuming non-uniform illumination using 70 as the coefficient relating the ratio λ/D to the beamwidth ($\theta_{3dB}=70\lambda/D$).

[3] This level is derived based on Recommendation ITU-R S.728 and is 8 dB higher than one known administration's domestic rules for routine licensing of VSAT earth stations. Currently, there are a small number of ESs operating at this power level.

[4] This level is equivalent to one known administration's domestic rules for routine licensing of FSS earth stations.

[5] The maximum e.i.r.p. density at the antenna port is the actual maximum e.i.r.p. seen in operation. It corresponds to gains values of 43.5 dBi (1.2 m), 52 dBi (3.3 m), and 53.5 dBi (3.9 m) for VSAT, Wideband, and Point-to-Point respectively, transmitting the maximum PSD quoted in the Table.

[6] Recommendation ITU-R S.728-1 – Maximum permissible level of off-axis e.i.r.p. density from very small aperture terminals (VSATs).

TABLE 2

FSS transmission spectrum usage (500 MHz)

Transmission type		**Number of transmissions in the FSS model**[7]	**Average bandwidth of transmission (MHz)**	**Total spectrum usage (MHz)**	**Percentage of spectrum usage (%)**
VSAT	FSS1	10 734	0.5	5 367	13.22
	FSS2	7 248	0.7	5 073	18.30
	combined	17 982	0.58	10 440	15.28
Wideband	FSS1	618	28.3	17 489	43.09
	FSS2	640	33.3	21 312	76.87
	combined	1 258	30.84	38 801	56.80
Point-to-Point	FSS1	6 114	2.9	17 731	43.67
	FSS2	583	2.3	1 341	4.83
	combined	6 697	2.94	19 072	27.92

This Table is used to derive the overall deployment of earth stations by transmission type based on the bandwidth of the victim receiver under consideration.

3.1.1 Current frequency reuse factor

The use of spot beams on FSS GSO satellites can increase the effective available amount of total global bandwidth at a geostationary orbital location in direct correlation to the number of spot beams employed. This effective increase of available spectrum is dependent upon sufficient isolation between the uplink beams. For instance, if there is a geographical overlap between two uplink spot beams of the same frequency of one or more satellites in an orbital slot then an earth station uplink to that orbital slot, at that same frequency, operating in the area of the geographical overlap would be seen by both uplink spot beams and thereby reduce the amount of overall available bandwidth (for uplink transmission) by the bandwidth carrier of this earth station operating in that geographical overlap.

With sufficient isolation between spot beams originating from a geostationary orbital location, two spot beams would double the available amount of total global bandwidth and three spot beams would triple the available amount of total global bandwidth. However, it should be recognized that, in practice, the use of multiple beams using the same frequencies in the 14.0-14.5 GHz band is currently not common and the current frequency reuse, of about 1.2 per satellite (this figure is derived based on a fleet of 46 satellites), introduced by the use of spot beams and dual polarization has been accounted for in the transmission data presented. Multiple beams originating from a GSO FSS orbital location, either on the same satellite or on multiple collocated satellites, may be employed to increase the amount of available bandwidth from that orbital location and thereby increase the number of FSS earth stations that can be deployed. Conducting studies using frequency reuse calculated on a GSO FSS orbital location basis may differ from studies using frequency reuse calculated on a per satellite basis.

Although the beam patterns for one of the satellites in current operation in the 14-14.5 GHz band seem to indicate a frequency reuse factor of 5 for that particular satellite, the actual frequency reuse

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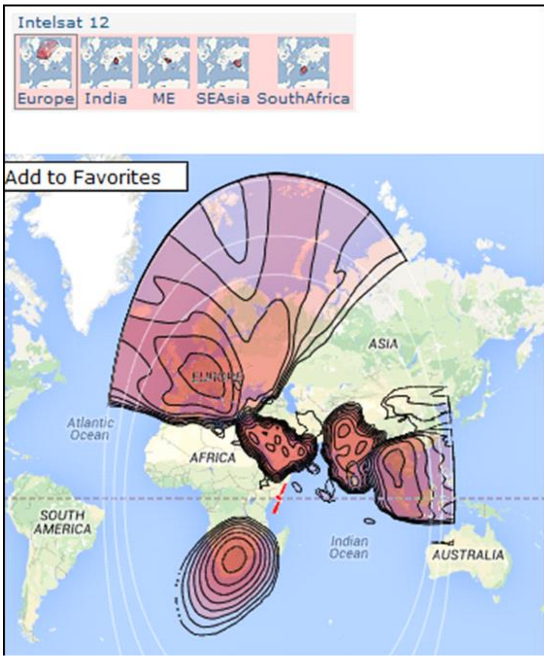
[7] Total number of transmissions reflect the current reported frequency reuse factor of 1.2 and use of both horizontal and vertical polarizations.

is 1.3 (see Fig. 1). There are five reported footprints covering the regions indicated at the top in miniature of Fig. 1. The five patterns have been combined into the one larger image shown in Fig. 1. The frequency reuse is much lower than expected due to each of the 5 beams being allocated a portion of the uplink frequency band in a single polarization. Note that there are areas with no coverage, notably Central and Western Africa. It is conceivable, although unlikely, that those areas could be covered through another satellite in the same GSO orbital slot and not overlap with the coverage areas provided by this current satellite at 45 degrees E longitude utilizing the 14.0-14.5 GHz band. Therefore, parametric studies using frequency reuse factors larger than the reported average values could be considered in sharing studies.

FIGURE 1

Beam patterns for one current Ku band satellite at 45 degrees E longitude in the GSO arc



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This frequency reuse factor may not be representative of some future satellite deployments. The frequency reuse factor should be re-evaluated as information on future satellite technologies and capacities becomes available.

3.1.2 Activity factor

The activity factor for the FSS ES uplink can vary according to the traffic and use of multiple access techniques, such as TDMA, that are employed by the satellite network. The use of multiple access techniques is most common for the VSAT transmission type. To simplify the analysis, transmissions from VSAT networks of earth stations using multiple access techniques may be represented as a single earth station transmitting 100% of the time. The activity factor for the Point-to-Point and Wideband transmission types may also be assumed to be 100% as these transmissions do not typically employ multiple access techniques at this time.

However, the use of this simplifying assumption in a simulation where a FSS TDMA network is represented by a single earth station transmitting 100% of the time should be examined on a case-by-case basis in regards to its over or under representing the degree of degradation imparted to the receiver of the victim service under study. As an example, a single FSS earth station TDMA burst exceeding the *I/N* protection criteria threshold can corrupt an EESS (active) sensor measurement of longer duration than that of the single TDMA burst.

An assessment of the simplifying assumption of using a single continuously transmitting earth station in place of a TDMA network was done, showing that this simplifying assumption underestimates the amount of interference seen by the EESS (active) JASON-3 altimeter by 3.4 dB considering a 100% VSAT TDMA deployment and a 0% wideband and PP deployment[8].

3.2 E.i.r.p. and PSD density per transmission type

In actual deployments, the e.i.r.p. density of FSS uplink earth stations was found to have very large variations for any given transmission type. The major contributors to the large variations in e.i.r.p. density levels are as follows:

- Location of the transmit (Tx) ES within the uplink beam and the location of the receive (Rx) ES within the downlink beam.
- The bit error ratio (BER) and per cent of the time performance objectives of the carrier will determine the required carrier to noise (*C/N*) and the rain margin.
- ES operating at lower elevation angles would suffer more rain attenuation and require a higher uplink e.i.r.p.

Table 3 provides provisional PSD and e.i.r.p values to be used in studies. The mean of the peak envelope power density for the PSD and e.i.r.p. density recorded in Table 3 is the arithmetic mean of the peak envelope power for the FSS transmissions. The values were provided by two FSS operators as being representative of those used in their global networks and are also included in Table 3. It should be noted that using maximum peak envelop power density values for all earth stations will produce an interference environment significantly worse than that which would be produced by representing the mean of the peak e.i.r.p. and PSD density distributions observed in practice.

The standard deviations of the e.i.r.p. and PSD density distributions can be derived from Figs 2 through 7. Cumulative distributions for the densities are shown following Table 3 for context. The statistics incorporate the current DVB-S2 use.

When information becomes available, the statistics should be updated for evaluation of increased use of DVB-S2 and other standards in the future. However, the use of the appropriate value provided in Table 3 is dependent on the characteristics of the victim receiver.

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[8] CPM Report on technical, operational and regulatory/procedural matters to be considered by the World Radiocommunication Conference 2015.

TABLE 3

Provisional PSD and e.i.r.p. values

ES peak power spectral and e.i.r.p. density transmission type		**PSD@ antenna port**	**e.i.r.p. density**
		Mean of peak envelope power density (dBW/Hz)	**Mean of peak envelope power density (dBW/Hz)**
VSAT	FSS1	–54.04	–9.89
	FSS2	–54.42	–8.42
	Combined	–54.19	–9.23
Wideband	FSS1	–56.48	–4.45
	FSS2	–56.40	–2.64
	Combined	–56.43	–3.40
Point-to-Point	FSS1	–57.19	–5.68
	FSS2	–60.01	–4.82
	Combined	–57.52	–5.62

FIGURE 2

VSAT e.i.r.p. density cumulative distribution

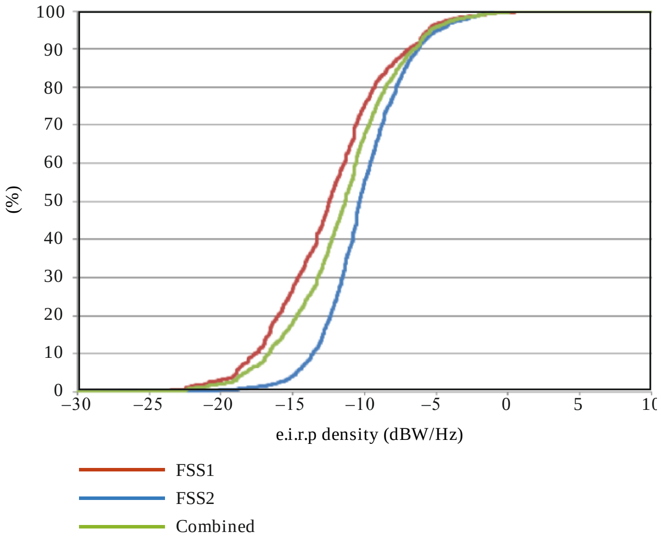

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FIGURE 3

VSAT power spectral density cumulative distribution

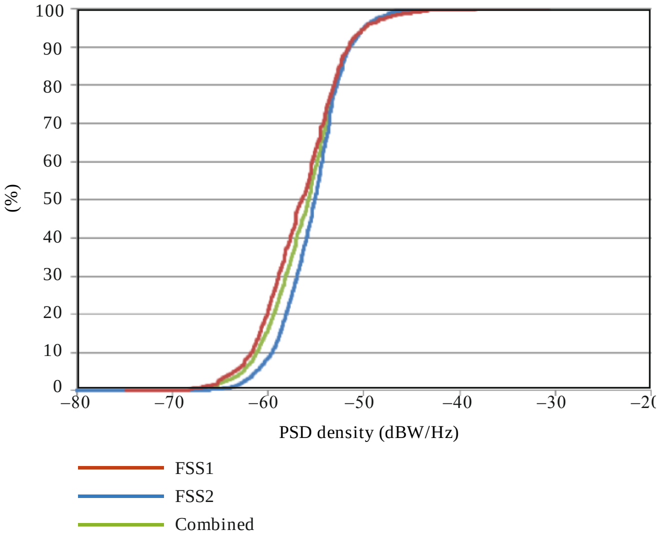

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FIGURE 4

Wideband e.i.r.p. density cumulative distribution

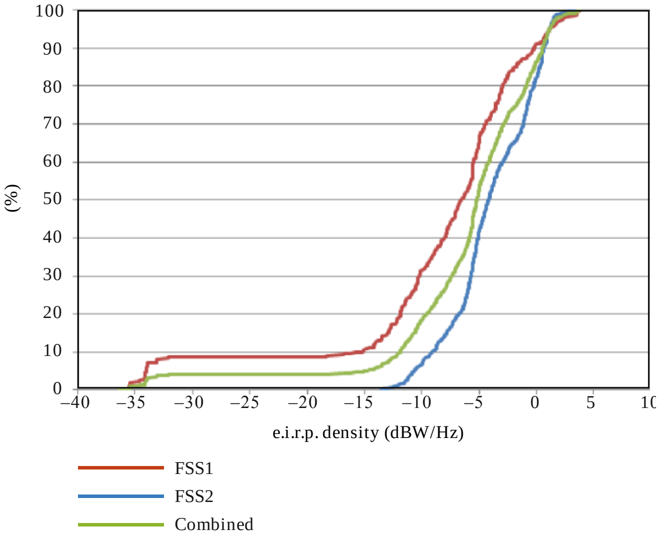

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FIGURE 5

Wideband power spectral density cumulative distribution

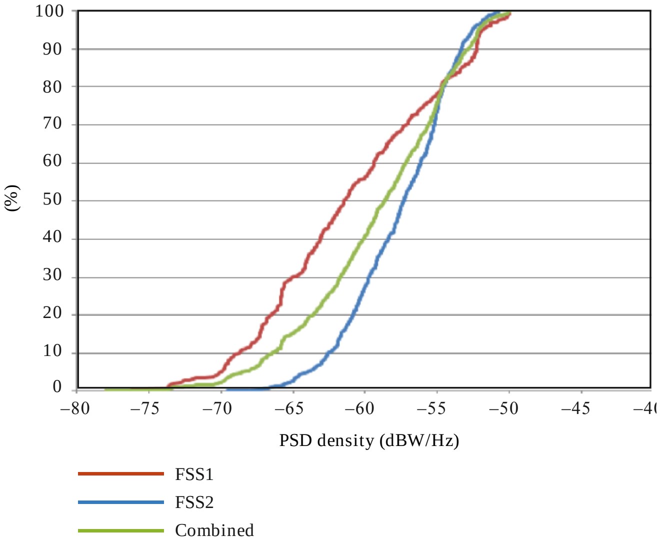

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FIGURE 6

Point-to-Point e.i.r.p. density cumulative distribution

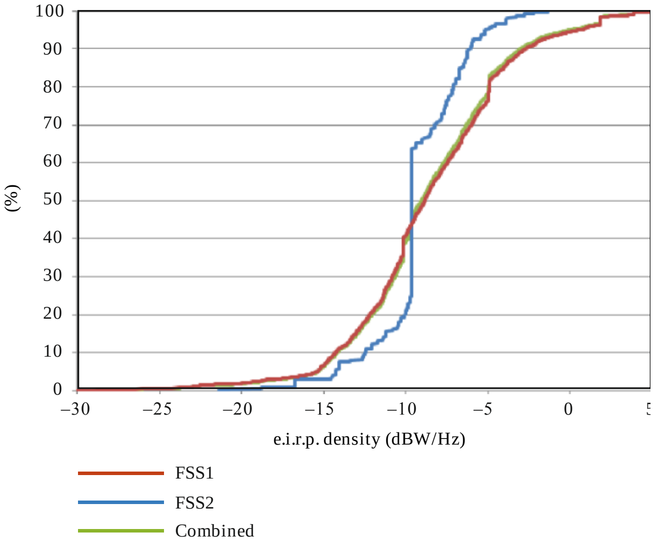

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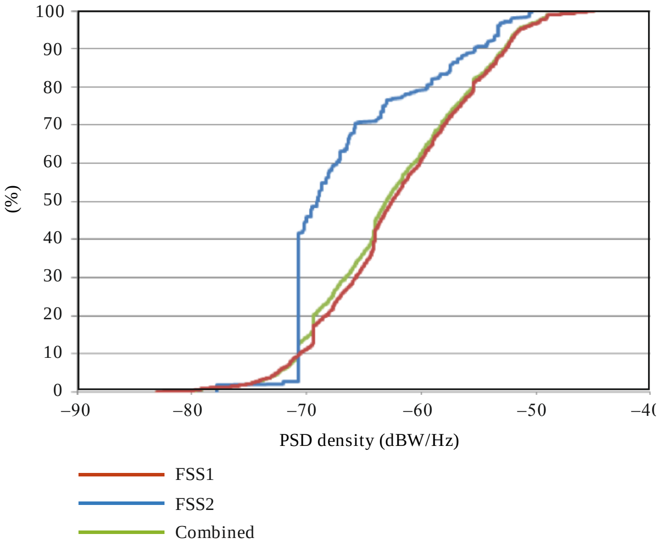
FIGURE 7

Point-to-Point power spectral density cumulative distribution



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3.3 Transmission bandwidth distribution

The transmission bandwidths to be assumed for the studies are an important consideration. The transmission allocated bandwidth characteristics are given below in Table 4. A channel is assigned an allocated bandwidth and this limits the number of carriers that can be used within a transponder. For example, depending on the application, a VSAT transmission type antenna could transmit a 64 or a 128 kbit/s information rate carrier with a total channel bandwidth of 112.5 kHz and 240 kHz, respectively. The numbers provided in Table 4 were provided by two FSS operators as being representative of the transmission allocated bandwidth by transmission type for their global networks. For dynamic simulations the following carrier bandwidth per transmission type can be used.

TABLE 4

Transmission type and bandwidth

Transmission type		**Bandwidth (MHz)**	
		Average	**Standard deviation**[9]
VSAT	FSS1	0.5	0.5
	FSS2	0.7	1.1
	Combined	0.6	0.8
Wideband	FSS1	28.3	8.8
	FSS2	33.3	1.5
	Combined	30.8	6.5
Point-to-Point	FSS1	2.9	3.6
	FSS2	2.3	3.0
	Combined	2.8	3.5

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[9] The standard deviation is calculated based on the 99% (equivalent to three sigma) of the cumulative distribution curves divided by 3.

Figures 8 to 10 provide the bandwidth cumulative distributions for the three transmission types.

FIGURE 8

VSAT bandwidth cumulative distribution

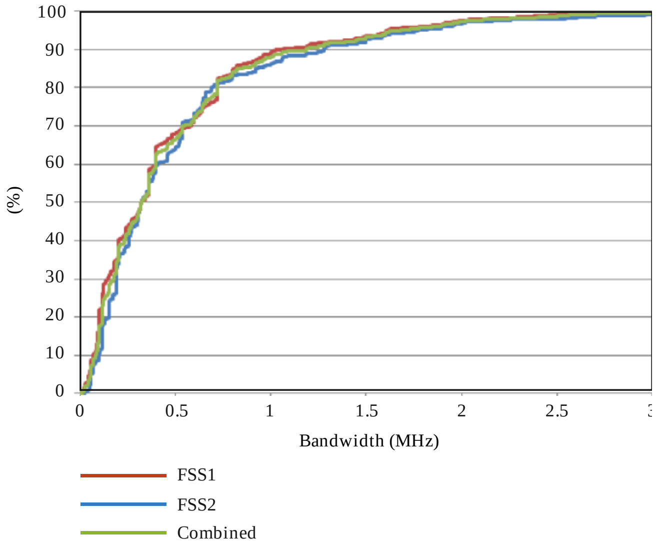

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FIGURE 9

Wideband bandwidth cumulative distribution

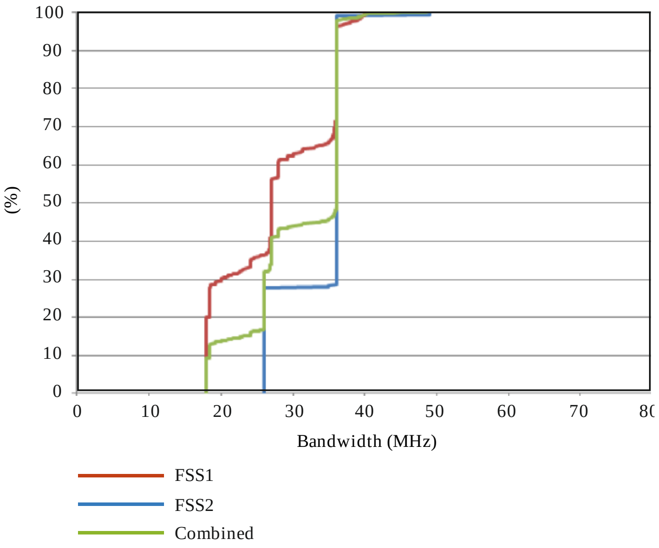

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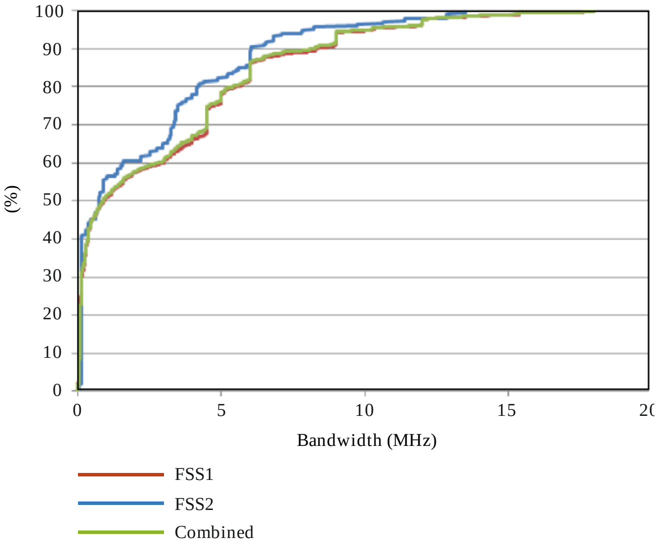
FIGURE 10

Point-to-Point bandwidth cumulative distribution



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3.4 Dual polarization operation

FSS satellite antennas normally use linear polarization in the 14-14.5 GHz band. Dual polarization (H,V) is normally used on the FSS satellite receive antenna. Regardless of the polarization employed by a low Earth orbiting space based victim receiver, space based victim receivers can potentially receive interference from FSS ES (E-s) operations regardless of the polarization of the ES or the polarization of the victim receiver due to the dynamic orientation of the space based victim receiver. The amount of interference from each of the ESs and the space based victim receiver will depend on the dynamic orientation of polarization angle between the ES and the space based victim receiver. The dynamic orientation of polarization angle between the ES and the space based victim receiver will vary particularly when the victim receiver is in low Earth orbit and the antenna is rotating; this may require that both polarizations of an FSS ES deployment be taken into account in sharing studies. The amount of interference seen by the space based victim receiver will also depend upon the type of polarization employed by the space based victim receiver; such as, linear or circular. The table in ITU RR Appendix **8** section 2.2.3 provides values of the factors of polarization isolation to be used in calculating interference between networks. These table values may be used in simulations to calculate interference contributions of an individual ES instead of calculating the specific loss due to polarization mismatch for every interaction between the ES and the space based victim receiver.

In the studies between a linearly polarized space based receiver and a dual polarized linear (H, V) FSS ES deployment, RR Appendix **8** section 2.2.3 indicates a value of 1 for polarization isolation between the two networks under study. Instead of this isolation factor of 1, a 3 dB reduction may be used in studies reducing the impact between linearly polarized space based receiver and a dual polarized linear (H, V) ES deployment. The 3 dB reduction corresponds to an average polarization misalignment between the victim receiver and the FSS ES of 45 degrees.

Individual FSS emissions transmit on one polarization. Therefore, the total population of ESs simulated should be half of one polarization and half of the other polarization. For the purpose of simplifying simulations, the polarization of each ES could be assumed to be co-polar with the victim receiver and apply the appropriate polarization isolation factor from the table in ITU RR Appendix **8** section 2.2.3. A 3 dB reduction could be used in studies reducing the impact between a linearly polarized space based receiver and a dual polarized linear (H,V) ES deployment.

FSS ESs >= 4.5 m typically employ dual polarization. Therefore, the population of ESs (equal to or greater than 4.5 m) simulated should employ both polarizations. For the purpose of simplifying simulations, both polarizations of the ES (>= 4.5 m antenna) could be assumed to be co-polar with the victim receiver and apply the appropriate polarization isolation factor from the table in ITU RR Appendix **8** section 2.2.3. A 3 dB reduction could be used in studies reducing the impact between a linearly polarized space based receiver and a dual polarized linear (H,V) ES deployment.

3.5 Satellite transponder loading

The satellite transponder loading factor is different from the average network activity factor. It is usually assumed that all transponders are fully loaded across the entire transponder bandwidth. All satellite operators try to optimize their transponders to be fully loaded; however, due to varying carrier and traffic demands quite often the transponders are power limited and the entire transponder bandwidth is not fully occupied for any single FSS satellite. In addition the traffic loading will vary depending on the region and the local traffic demands. The transponder loading associated with the data provided in this Report averages to around 80%.

The information in this Report is provided in the form of transmissions per satellite in the 500 MHz FSS allocation at 14.0-14.5 GHz. Using the number of transmissions per 500 MHz replaces the need to calculate transmissions based on transponder loading, dual polarization, and frequency reuse factor as those three parameters are incorporated in the number of transmissions per 500 MHz allocation provided.

3.6 Total number of transmissions in the simulation

The total number of earth stations to be considered in the simulation is derived on the basis of the above discussion. It is assumed that there is one satellite per orbital location. Therefore, the total number of transmissions at a single orbital location (500 MHz, dual polarization), based on a number of assumptions, to be used in the simulations are as follows:

TABLE 5

Number of FSS transmissions per satellite (500 MHz)[10]

Transmission type		Percentage of total satellite transmissions	Number of transmissions
VSAT	FSS1	61.5%	262
	FSS2	85.6%	226
	Combined	69.3%	246
Wideband	FSS1	3.5%	15
	FSS2	7.5%	20
	Combined	4.8%	17
Point-to-Point	FSS1	35.0%	149
	FSS2	6.9%	18
	Combined	25.9%	92
All	FSS1	100%	426
	FSS2	100%	264
	Combined	100%	355

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[10] Dual polarization.

3.7 GSO FSS satellite locations and distributions

For the purpose of study, a 3° spacing could be assumed, even if in some portions of the orbital arc less than or greater than 3° spacing is employed.

Using this 3° spacing will lead to considering 120 FSS satellites in uplink studies involving the three ITU Regions.

3.8 FSS earth station deployment methodology

The FSS earth station deployment methodology below can be used to estimate how earth stations may be deployed in the bands under consideration. The deployment model to be used will be different for the cases of space-based victim receivers and terrestrial/aeronautical receivers.

3.8.1 Deployment methodology for non-GSO receiver studies

In the interference simulations, the following methodology should be used to distribute earth stations over the Earth's surface. In an attempt to model a realistic scenario, earth stations are randomly distributed among cities taken from the U.N. city database with a normally distributed weighting factor based on city population. Within a given city, earth stations are randomly distributed within a circular area based on the city's equivalent area as a function of population.

The following provides an outline of the steps to distribute the earth station deployment for the studies to be performed:

1) Determine the global deployment characteristics (e.g. number of transmissions vs transmission type) of ES to be simulated according to the agreed upon ES characteristics and methodology set forth in § 3.1 through § 3.7.
2) The earth stations identified as VSAT[11] or Point-to-Point transmission types can be distributed varying between 100% uniformly on land masses and 100% within city populations as described in Steps 4 through 8. For the earth stations that are uniformly distributed, the distribution should be between 65 degrees North latitude and 50 degrees South latitude. It is recommended that parametric studies be conducted examining the impact of the distribution of the VSAT and Point-to-Point transmission type earth stations varying between 100% uniformly on land masses and 100% within city populations.
3) For the number of earth stations identified as Wideband distribute them according to Steps 4 through 8 below.
4) Load U.N. world city database consisting of world cities with population and lat/lon data.
5) Specify a population threshold and extract those cities from the U.N. database whose population exceed this threshold (e.g. 545 cities have population ≥ 500 000 people).
6) Compute the equivalent area urban radii of the cities in Step 5 using the empirical relationship $R_p = \alpha P^{\beta}$ (km) where P is the city population and α and β are constants (see Recommendation ITU-R F.1509). For example, for the US, $\alpha = 0.035$ and $\beta = 0.44$ are applicable. For other areas of the world, $\alpha = 0.0155$ and $\beta = 0.44$ were used.
7) Specify the number of FSS GSO satellites based on their orbital spacing and set their orbital locations (i.e. 120 FSS satellites, 3° spacing).
8) For each FSS GSO satellite perform the following steps:
    a) Determine which cities in Step 5 are visible from the GSO orbital location based on a specified minimum elevation angle (e.g. 20° used in this analysis).

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[11] The VSAT stations generated under this methodology actually represent the traffic generated from all VSAT stations assigned to that channel.

b) Take this subset of visible cities and sort them in descending order of population.

c) Let M be the number of earth stations computed in step 1 and let N be the number of cities (sorted in descending order of population) in Step 8b. Randomly distribute the M earth stations among the N cities according to a normal distribution as follows:

   i) Generate a large number K (e.g. K = 10 000) of normally distributed random samples with mean = 1 and standard deviation σ = (N-1)/3. This will cause about 99.75% of the samples to be between 1-3σ = 2-N and 1+3σ = N.

   ii) Extract those samples (~ K/2) that are ≥ 1 and select M samples out of this subset.

   iii) Round the M samples from Step ii) downward to the nearest integer to get M integers with values between 1 and N.

   iv) Assign the M earth stations to the N cities according to the integer values in Step iii) where the integer values correspond to the city indices of the N visible cities. This results in the more populated cities having on average more earth stations than less populated cities.

9) After performing Step 8 for each FSS GSO satellite, determine the number of earth stations in each of the cities found in Step 5.

10) For each city in Step 9, randomly distribute the earth stations located in that city within a circular area according to its equivalent radius as found in Step 6.

As a result of the assignment methodology, the earth stations are randomly assigned to the satellites that are visible.

3.8.1.1 Non-GSO space-based receiver bandwidth

For some of the FSS ES and space-based receiver compatibility studies, the space-based receiver bandwidth is much wider than 10 MHz and therefore may in some extreme cases see more than 30 times the number of interfering earth stations as a receiver having 10 MHz in bandwidth. This may render the ability to perform dynamic analyses impossible unless simplifying assumptions are adopted whenever practical. Simplifying assumptions should be evaluated as to the degree that they may misrepresent the interference presented to a victim receiver.

3.8.1.2 FSS ES simplifying assumptions

The faithful representation of the deployment of the FSS ESs would include all the ESs that are determined to be within the bandwidth of the victim receiver. The following assumptions may be used to reduce the number of FSS ESs represented in the simulations.

1) Activity factor

Rather than representing all the ESs in a deployment and including in the simulation the activity factor for each ES, an equivalent lesser number of ESs are represented where each ES is operating at 100% activity factor. If the number of ESs represented in the deployment is sufficiently large then this assumption is considered to have no significant impact on the validity of the results.

However, this assumption may misrepresent the impact of TDMA transmissions from earth stations on a victim receiver if the victim receiver data is susceptible to corruption from TDMA bursts.

2) Dual polarization operation

The 3 dB polarization isolation factor addressed in § 3.4 may also be addressed by reducing by 50% the number of earth stations with no polarization factor. However, the equivalence of these two approaches has not been confirmed.

3) Aggregation of FSS ESs deployed within each urban area

Using FSS off axis radiation patterns, develop three antenna patterns; one for each transmission type:

a) The aggregate power levels are verifiable by comparing it to the actual value of power level of having each antenna of each transmission type represented individually. An individual representation of ESs will show a greater amount of interference incidences than an aggregate value because the non-GSO space based victim receiver will pass through considerable more FSS transmissions although the aggregate may have a higher power for a particular city location.

b) It is therefore concluded that the aggregate power representation method under represents the interference caused by the actual FSS ES deployment.

c) If the aggregate antenna values have a simulated result that exceeds acceptable interference levels for sharing with FSS, then it is assumed that modelling each of the earth stations individually, will also exceed acceptable interference levels for sharing with FSS. If the results indicate that compatibility is marginally achieved then further detailed simulation is warranted.