ERC REPORT 67

European Radiocommunications Committee (ERC) within the
European Conference of Postal and Telecommunications Administrations (CEPT)

Study of the Frequency sharing between HIPERLANs and MSS feeder links in the 5 GHz band

Marbella, February 1999

STUDY OF THE FREQUENCY SHARING BETWEEN HIPERLANS AND MSS FEEDER LINKS IN THE 5 GHZ BAND

STUDY OF THE FREQUENCY SHARING BETWEEN HIPERLANS AND MSS FEEDER LINKS IN THE 5 GHZ BAND

1 INTRODUCTION

WG SE has studied the issue of compatibility between HIPERLANs and NGSO MSS feeder links within the 5150-5250 band MHz for almost two years. This report has been issued after considerable debate and active participation from ETSI and MSS operators.

Two particular MSS networks are taken into account in this report, Globalstar and ICO, which are those operating in this band and have started to comply with the CEPT MRC milestones.

The HIPERLAN characteristics that are taken into account are those specified by ETSI (in as HIPERLAN Type 1: ETS 300 652). Characteristics of HIPERLAN type 2 (under the process of standardisation within ETSI) have not been precisely taken into account due to the lack of reliable and stable information, but the compatibility issue is expected to be very similar.

MSS and HIPERLAN communities have been in disagreement on several parameters and this report is based on values which are assumed to reflect conservative worst case assumptions and which have been agreed in WG SE and some also in the special ERM «Expert's» meeting held in February 1998, endorsed by ERM. Administrations also found it difficult to agree on the methodology and criteria, taking into account the relative regulatory status of HIPERLAN and MSS, for the evaluation of the protection requirements for MSS networks, reflecting diverging views on what should be considered as "harmful interference".

This report describes the methodologies and the parameters, which are taken into account in the studies. It will also explain where the areas of disagreement lie. It also provides recommendations, which should enable sharing as practicable.

It is also noted that the content of this ERC report has been the basis for European input to ITU-R and is therefore expected to be reflected, with modifications, in some ITU-R output documents (Recommendation or Report).

2 REGULATORY STATUS OF HIPERLANs

One of the difficulties continuously faced by WG SE on the compatibility between MSS feeder links and HIPERLANs was the regulatory status of HIPERLANs in regards to MSS feeder links. This potentially impacts the choice of the methodology and the criteria used for the compatibility calculation.

MSS Feeder links are allocated with a primary world-wide status in 5150-5250 MHz. In the Radio Regulations. S5.447 allocates Mobile Service in the band 5150-5250 MHz on a primary basis in several CEPT countries, but subject to agreement obtained under No. S9.21 (Article 14). In absence of such agreement, as it is the case, HIPERLANs can only be operated under article S4.4, i.e. not in accordance with the table of international allocations and, as such, HIPERLANs shall not cause harmful interference to MSS Feeder links nor claim protection.

On the other hand, WG FM, in answer to a liaison statement from WG SE, clearly answered that HIPERLAN and MSS Feeder link should be regarded as co-primary in Europe, in countries in S5.447.

However, given the global nature of MSS feeder links, such a position was not easy to apply and WG SE tried to concentrate on the RR situation.

3 METHODOLOGY

It is very difficult to estimate the possible number of HIPERLANs that could be deployed in the long term over a whole continent. For this reason, it has been decided to adopt a methodology that starts by estimating the maximum tolerable interference from all the HIPERLANs within the satellite footprint. Once this figure is decided, taking into account the characteristics of HIPERLANs and their conditions of deployment, one can evaluate the maximum tolerable number of HIPERLANs within the satellite footprint.

3.1 Maximum tolerable interference for MSS feeder links from HIPERLANs

In order to assess the maximum tolerable interference from HIPERLANs to the MSS feeder link, two methodologies have been proposed so far, both based inter alia on the contents of Appendix S8 of the RR.

3.1.1 Noise temperature increase at satellite receiver

The first one is based on the apparent increase in noise temperature at the satellite receiver, the increase in system noise temperature at the satellite receiver **ΔTsat** is shown as:

$$\Delta \mathbf{Tsat} = \mathbf{Cr} \times \mathbf{Tsat} \quad (1)$$

where,
Tsat: the receiver system noise temperature of the space station, referred to the input of the satellite receiver (NOTE, in Appendix S8 it is referred to the output of the receiving antenna: in the tables in the Annex 1, this parameter has been used in the case of ICO network - see note 2 in Annex 1)
Cr: criterion for the tolerable noise increase.

The tolerable aggregate HIPERLAN interference in one MSS channel, **I**, is given by:

$$\mathbf{I} = \mathbf{Cr} \times \mathbf{k} \times \mathbf{Tsat} \times \mathbf{Bs} \times \mathbf{Lf} \times \mathbf{Lfl} / \mathbf{Gs} \quad (2)$$

where,
- **k**: Bolzmann constant
- **Bs**: bandwidth of a MSS channel,
- **Lf**: free space loss of the uplink,
- **Gs**: satellite receiving antenna gain,
- **Lfl**: feeder loss of the satellite receiver.

Therefore, tolerable aggregate HIPERLAN interference per HIPERLAN channel **Ih** can be represented by:

$$\mathbf{Ih} = \mathbf{I} \times \mathbf{Bh} / \mathbf{Bs} = \mathbf{Cr} \times \mathbf{k} \times \mathbf{Bh} \times \mathbf{Tsat} \times \mathbf{Lf} \times \mathbf{Lfl} / (\mathbf{Gs}) \quad (3)$$

where,
Bh: HIPERLAN channel bandwidth.

3.1.2 Noise temperature increase on overall MSS link
The second methodology is based on the increment in the noise temperature on the overall MSS link.
The overall link system noise temperature **Tlink** is represented as:

$$\mathbf{Tlink} = \gamma \times \mathbf{Tsat} + \mathbf{Tearth} \quad (4)$$

where,
- **Tearth**: system noise temperature at the mobile receiver;
- γ: satellite system gain, calculated as follows:

$$\gamma = \mathbf{Pb} / \mathbf{Pa} \tag{5}$$

with **Pa** is the power of the uplink at the satellite receiver input,
and **Pb** is the power of the downlink at the mobile receiver input.

The increase in the system noise temperature Δ**Tsat** at the input of the LNA can be represented as:

$$\Delta \mathbf{Tsat} = \mathbf{Cr} \times (\gamma \times \mathbf{Tsat} + \mathbf{Tearth})/\gamma \tag{6}$$

The tolerable aggregate HIPERLAN interference on the earth surface just under the satellite (**I**) is given by:

$$\mathbf{I} = \mathbf{Cr} \times \mathbf{k} \times \mathbf{Bs} \times \mathbf{Lf} \times \mathbf{Lfl} \times (\gamma \times \mathbf{Tsat} + \mathbf{Tearth}) / (\gamma \times \mathbf{Gs}) \tag{7}$$

Therefore, the tolerable aggregate HIPERLAN interference per HIPERLAN channel (**Ih**) can be represented by:

$$\mathbf{Ih} = \mathbf{I} \times \mathbf{Bh} / \mathbf{Bs} = \mathbf{Cr} \times \mathbf{k} \times \mathbf{Bh} \times \mathbf{Lf} \times \mathbf{Lfl} \times (\gamma \times \mathbf{Tsat} + \mathbf{Tearth}) / (\gamma \times \mathbf{Gs}) \tag{8}$$

3.2 Maximum tolerable number of HIPERLANs

Given that the proportion **Ro** is assigned to HIPERLAN outdoor usage, the weighted loss in excess of free space loss for HIPERLANs **Ls** can be calculated by:

$$1/\mathbf{Ls} = \mathbf{Ro} + \mathbf{Ri}/\mathbf{Lsi} \tag{9}$$

where,
Ri: ratio assigned to HIPERLAN indoor usage (= 1- **Ro**),
Lsi: average loss in excess of free space loss for HIPERLAN indoor use.

Taking account of the characteristics of HIPERLAN propagation conditions and MSS receivers, the maximum tolerable interference on earth per HIPERLAN channel **It** can be expressed as:

$$\mathbf{It} = \mathbf{Ih} \times \mathbf{Ls} \times \mathbf{Fd} \tag{10}$$

where,
Fd: polarisation discrimination factor between MSS and HIPERLANs (since HIPERLAN interference is not polarised).

Therefore, the maximum tolerable number of instantaneous transmitting HIPERLANs per HIPERLAN channel **Nact** can be calculated by:

$$\mathbf{Nact} = \mathbf{It} / \mathbf{Ph} \tag{11}$$

where,
Ph: average HIPERLAN EIRP.

Taking into account the activity ratio per device **Ra**, the maximum tolerable number of indoor and outdoor deployed HIPERLANs **Nt** per HIPERLAN channel within the satellite footprint is given by:

$$\mathbf{Nt} = \mathbf{Nact} / \mathbf{Ra} \tag{12}$$

3.3 Discussion on the validity of each methodology

The two calculation methods, as shown in Eqs. (3) and (8), give some very different results, due to the fact that γ is generally well below 1. Thus equation (8) leads to a maximum number of HIPERLAN terminals much higher than equation (3).

Appendix S8 explains that :

- Eq (8) is valid for non regenerative satellites
- Eq (3) is valid for regenerative satellites

The first generation of Globalstar and ICO satellites are non regenerative satellites. However, both operators have indicated that future generations might use regenerative satellites, particularly to compensate for the expected reduction in MSS feeder link 5GHz spectrum in 2010 from 160 MHz to 100 MHz.

The disagreement on the interpretation of whether ΔTsat or ΔTlink should be used is summarised by the two following statements :

- The ΔTsat proponents believe that ΔTsat is the correct method to be used for both first and second generation satellites to ensure the protection of MSS satellites in the long term. ΔTsat proponents point out that that the licence exempt nature of HIPERLANs would make it impossible to clear the band for second generation satellites, which may be more susceptible to interference than first generation. They also emphasise that the ITU-R regulatory status of HIPERLANs means that the primary MSS is also protected for future systems.
- The ΔTlink proponents believe that is more appropriate for first generation, non-regenerative satellites and that ΔTsat is more appropriate for second generation, regenerative satellites. ΔTlink proponents stress that despite the ITU-R regulatory status of HIPERLANs, MSS operators should take into account the existence of HIPERLANs and not make their second generation systems more susceptible to interference than the first generation. .

In order to have an idea of the impact of the choice between the $\Delta T_{sat}/T_{sat}$ and the $\Delta T_{link}/T_{link}$ methodologies, the following exercise has been done.
In both cases (also in the second one, ΔT_{link} being related to ΔT_{sat}), it is possible to evaluate the corresponding estimated tolerable ΔT_{sat}. The figures presented in the following table 3.3.1 represent the ΔT_{sat} corresponding to each method, in the two cases of an acceptable criteria of 1% or 6% in the case of Globalstar network (Tsat = 549.5 K, γ = -22.8 dB):

		Method	
		$\Delta T_{link}/T_{link}$	$\Delta T_{sat}/T_{sat}$
Criteria	0,01	565 K	5 K
	0,06	3391 K	33 K

TABLE 3.3.1 : Tolerable ΔT_{sat} (K) due to interference, depending on the chosen methodology and criteria

The difference is noticeable. The difference between the ΔTlink and ΔTsat methodologies is of the order of magnitude of 20 dB, the same magnitude as the multiplying factor γ. The difference is therefore dependent on γ.

The Table 3.3.2 gives the same results in terms of tolerable interference power per channel obtained with both methods combined with both criteria:

		Method	
		$\Delta T_{link}/T_{link}$	$\Delta T_{sat}/T_{sat}$
Criteria	0,01	-110 dBm/1.23 MHz	-131 dBm/1.23 MHz
	0,06	-102 dBm/1.23 MHz	-123 dBm/1.23 MHz

TABLE 3.3.2: Tolerable I (dBm) due to interference, depending on the chosen methodology and criteria

It has been noted that, in the case of methodology $\Delta T_{link}/T_{link}$ and criteria of 6%, the total received power for CDMA systems would be significantly higher, possibly leading to non-linear effects which have not been discussed in this report.

4 TECHNICAL PARAMETERS

4.1 Maximum tolerable interference for the MSS feeder link from HIPERLANs

4.1.1 Criterion for the tolerable noise increase Cr.

Similarly to the methodology case, there are discussions on the appropriate criteria for the tolerable noise. It was noted that there is no existing criteria defined in ITU-R which are addressing exactly the sharing under consideration.

The values of 1% and 6% have been considered in this report.
6% increase of noise is generally used as a coordination threshold between two satellite networks (Appendix S5 of the RR), so that it guarantees that if one does not exceed this level one is not expected to create harmful interference.[1]

1% increase of noise was proposed to reflect the unequal ITU-R status of MSS and HIPERLANs.[1]

It is stressed here that, technically, it is extremely difficult to assess the level of interference, which would correspond to any harmful interference. Any MSS operator will need to coordinate with a number of other users of their frequency band (Mobile Satellite Service or other services) and only the aggregate interference is meaningful. Therefore, the discussion on the increase of noise criteria can be seen as a discussion on which constrain on the MSS satellite are reasonable, or not, considering their respective regulatory status.

4.1.2 Remaining Parameters

- Equivalent noise temperature at the satellite receiver **Tsat**:
  400 K, ICO (at the antenna port)
  549.5 K, Globalstar
- Equivalent noise temperature at the mobile receiver **Tearth**:
  288 K, ICO
  293.7 K, Globalstar
- Power of the uplink at the satellite receiver input **Pa**:
  -140 dBW, ICO
  -141.2 dBW, Globalstar
- Power of the downlink at the mobile receiver input **Pb**:
  -148 dBW, ICO
  -164 dBW, Globalstar
- Satellite receiving antenna gain **Gs**:
  10 dB, ICO

[1] The 6% criteria corresponds to a 0.25 dB degradation in C/N
The 1% criteria corresponds to a 0.04 dB degradation in C/N

6 dB, Globalstar

- Feeder loss of the satellite receiver **Lfl**:

1 dB, ICO
2.9 dB, Globalstar

- HIPERLAN channel bandwidth **Bh** = 24 MHz

4.2 Maximum tolerable number of HIPERLANs

4.2.1 Average loss in excess of free space loss for HIPERLAN indoor use Lsi:

Several fora have already investigated the issue of estimating the average loss on the path between HIPERLANs and MSS feeder link satellites at 5 GHz. Three effects need to be examined: the building shielding loss (indoor to outdoor additional loss referring to one building), the additional loss due to obstacles around a specified building ; and the increase due to multipath effect.
One aim of this section is to show two models produced during the discussion on the indoor to outdoor loss, some considerations on the additional loss due to obstacles around a building and some simplistic considerations on the multipath effect.

4.2.1.1 Shielding loss due to indoor to outdoor (one building)

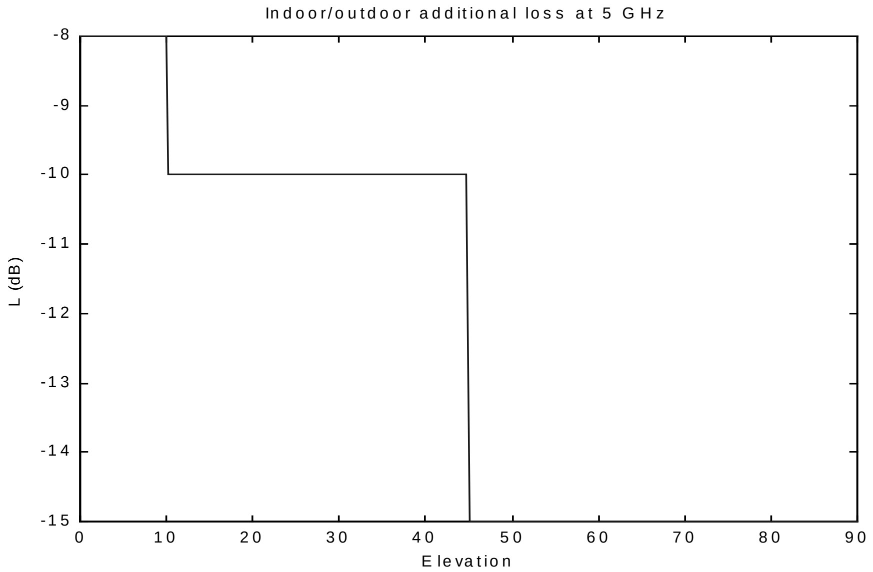
Several papers have considered the properties of materials and the topology of a typical building. It is very hard to say what a typical building is over an entire continent and this has been the main issue of a long discussion. A difficult compromise for the overall figure to be considered for the study relative to Globalstar and ICO systems was reached in ERM expert group is as follows:

- 9 dB for Globalstar and
- 10 dB for ICO.

This compromise was based on the two following models.
In both models, the loss depends on the elevation of the satellite and both already include the additional loss due to propagation inside the building.
The models are as follows:

Model 1)

$$L_{sh} = 8\ dB \qquad \theta < 10\ deg.$$
$$L_{sh} = 10\ dB \qquad 10\ deg. < \theta < 45\ deg. \qquad Model\ 1$$
$$L_{sh} = 15\ dB \qquad 45\ deg. < \theta < 90\ deg.$$



Model 2)

$$L_{sh} = -8.4-(0.038*\theta)\wedge 2 \qquad\qquad Model\ 2$$

4.2.1.2 Additional loss due to obstacles around the buildings

In order to take into account the additional shielding due to obstacles around the building, the same models can be modified saying that, for example, p% ([50%]) of the paths for low elevation angles up to el deg. ([10 deg.]) are completely blocked or, equivalently, there is an additional *x* dB ([50 dB]) loss on those paths.
What is important is the difference in dB from the figures derived from the models for each satellite network considered, so that we propose to observe the difference using the two models and an assumed increase of 50 dB in the attenuation on half of the paths for the two MSS satellite networks planned to operate in the band.
For the Globalstar network (altitude of 1414 km) we obtain:

Model and parameters	**Shielding (Δ from same model without additional shielding)**
Model 1, x=0	L = 9.2 dB
Model 1, x=50, p=50, el=10	L = 10.6 dB (Δ = 1.4 dB)
Model 1, x=50, p=70, el=10	L = 11.4 dB (Δ = 2.2 dB)
Model 2, x=0	L = 9.0 dB
Model 2, x=50, p=50, el=10	L = 10.2 dB (Δ = 1.2 dB)
Model 2, x=50, p=50, el=20	L = 10.9 dB (Δ = 1.9 dB)
Model 2, x=50, p=70, el=10	L = 10.8 dB (Δ = 1.8 dB)

The table shows that the additional effect due to obstacles around the building is not enormous and can be estimated as follows:

- around 1.5 dB.

For the ICO network (altitude of 10355 km), we obtain:

Model and parameters	**Shielding (Δ from same model without additional shielding)**
Model 1, x=0	L = 10 dB
Model 1, x=50, p=50, el=10	L = 11 dB (Δ = 1 dB)
Model 1, x=50, p=70, el=10	L = 11.3 dB (Δ = 1.3 dB)
Model 2, x=0	L = 9.7 dB
Model 2, x=50, p=50, el=10	L = 10.4 dB (Δ = 0.7 dB)
Model 2, x=50, p=50, el=20	L = 11 dB (Δ = 1.3 dB)
Model 2, x=50, p=70, el=10	L = 10.8 dB (Δ = 1.1 dB)

The table shows that the average additional loss can be presented by:

- 1 dB.

It was noted that there is a lot of uncertainty on the validity of these assumptions due to the wide range of diverging values, which have been found in the literature. The values selected here are considered as conservative worst case assumption.

4.2.1.3 Multipath effect

Few papers have been produced on this issue. One indicates that the potential increase in noise due to multipath that can be perceived at the satellite receiver is not negligible and can be estimated as several dBs. Nevertheless it is recognised that it is not unlikely that, for the purpose of avoiding interference, the loss additional to free space, as described in the two models above, could be considered as slightly conservative (overestimation of the loss).
It is considered that multipath effects do not have a major impact on the overall issue.

Consequently, the average loss in excess of free space loss for HIPERLAN indoor use for MSS networks at 1414 km and 10355 km can be set as follows:

- **Lsi**: 10.5 dB for Globalstar at 1414 km
- **Lsi**: 11 dB for ICO at 10355 km.

4.2.2 Activity ratio per device Ra:

This parameter refers to the average transmission time per device over the total time.
It has been recognised that the risk of interference is likely to be more important during the busy hours of the day, and that the busy hours for MSS networks and for HIPERLANs are assumed to coincide. In this sense, the figure that is proposed here is a worst case.
Taking into account only the busy hours, a compromise can be reached at the following figure:

- **Ra**: 5%.

This figure has been derived taking into consideration the protocol defined in ETS 300 652 for HIPERLAN type 1. The discussion has been carried out on considering the hard-to-predict future traffic of HIPERLANs, existing applications and those which might be developed, as well as the constraint on the bit rate (figures from 1% to 15% have been proposed from the different parties).
It is the view of WG SE that the same figure can be applied to all the HIPERLANs similar to HIPERLAN type 1.

4.2.3 Average HIPERLAN EIRP Ph:

The 1 W EIRP is the maximum admissible EIRP of HIPERLAN type 1 devices in the ETS 300 652. This ETS also allows for 10 mW and 100 mW EIRP levels for HIPERLAN type 1.

For the purpose of providing some examples, two figures have been chosen**:**

- **Ph**: 100 mW and 1 W.

As for HIPERLAN type 1 as specified in ETS 300 652, the contention factor is introduced.
In fact, HIPERLAN type 1 is characterised by a protocol in which all the devices that want to transmit enter together in a contention phase and the network progressively selects which will transmit. During this phase, first several devices transmit at the same time, then only one device per cell transmits some Low Bit Rate information packets. The Low Bit Rate transmission is made in a reduced band (around 1.4 MHz), which implies an increase in the power spectral density in 1.4 MHz at the centre of the 23.5 MHz HIPERLAN channel. The increase in power spectral density is of a factor of 16 (around 12 dB), but as the LBR mode of transmission appears only during a limited portion of the frame, the estimated impact is lower and has been obtained by a weighting of the different power spectral densities over the transmission phases of the frame. For the ergodic nature of the problem, the weighting over the frame has the same meaning as weighting over a high number of uncorrelated users.

The analysis carried out on the structure of the protocol, applying such weighting, resulted in the figure of 4 (**6 dB**). This means that, for any device for which the average output power is **Ph** in dB, a figure of **Ph** + 6 dB needs to be considered in calculating the interference as perceived at the satellite.

Less than 10% of ICO’s narrow band (25 kHz) channels in the band 5150-5250 MHz will be affected by the 1.4 MHz higher spectral density transmissions, with respect to co-channel interference.

4.2.4 Mean or peak power (meaning of the figures used in the calculation):

The compatibility studies between HIPERLANs and MSS Feeder Links in the 5150-5250 MHz band consist in evaluating the interference seen by satellite systems. This interference, because of the large view of the antenna apertures of satellites, is a large scale, statistical average over many thousands of devices operating independently of each other.

Advanced modulation schemes with high efficiency (e.g. more than 2 bit/s/Hz) which will be used for HIPERLAN type 2 typically have noise like characteristics with large peak to average ratios – in excess of 10 dB.

The probability of occurrence of the larger peaks is an inverse function of their amplitude. Seen on a large scale, these peaks do not cause more interference than classical single carrier modulation schemes like GMSK or QPSK.

Considering that it is equivalent to have geographical averaging or time averaging for large population of HIPERLANs with non synchronised operations, it is more appropriate to consider the average value of RF power. HIPERLANs transmit in bursts and therefore the average power must be defined and measured in terms of "burst average" both for, small scale interference assessment and large scale interference assessment. The method of measurements should ensure that the measured value is representative of the mean RF power emitted over a period that is sufficiently long to average out the effects of instantaneous data pattern variations.

In line with these considerations, the figures of the EIRP which are used in the calculations and which are presented in the table in Annex 1 are to be read as mean EIRP measured during transmission time.

4.2.5 Proportion assigned to HIPERLAN outdoor usage Ro:

For the purpose of providing some examples, two figures have been chosen for **Ro**: 1% and 15%.

The 1% of "incidental/accidental" outdoor use is based on the assumption that there is a regulatory restriction on HIPERLANs use to indoor in the band 5150-5250 MHz, assuming also that additional usable spectrum outside of 5150-5250 MHz band is made available to support outdoor HIPERLAN use.
The 15% of outdoor use are based on an upper bound assumption if there is no regulatory restriction on outdoor use of HIPERLANs in the band 5150-5250 MHz.

4.2.6 Remaining Parameters:

Polarisation discrimination factor between MSS and HIPERLANs, **Fd** = 2 dB, with respect to assessing co-channel interference.

5 CALCULATION RESULTS

Using the above-mentioned methodologies and parameters, the calculation results are shown in Annex 1.

The value for gamma used in the calculations for both ICO and Globalstar was derived from the available information, and may not reflect actual system parameters for either MSS system. However, as no detailed information was made available to WG SE on these parameters, the gamma used in this report is sufficient to illustrate the possible difference between the two methodologies.

Some factors which could reduce the risk of interference have not been taken into account in this report in the calculations of the results. In particular it has been stated by several manufacturers that it is likely that most HIPERLANs type 1 commercialised devices will include a mechanism of power control, in order to improve the frequency reuse capability and to reduce the power consumption. This has not been taken into account because such a mechanism is not mandatory in the ETS 300 652.

Moreover it has been noted that the impact on MSS feeder links will depend also on the number of channels allocated to HIPERLANs. It is likely that additional spectrum will be allocated to HIPERLANs in the near future within CEPT. Indeed, when reading the results and in particular the bottom line in the tables in annex 1, one should keep in mind that all those numbers should be multiplied by the number of channels allocated to HIPERLANs in the long term. This is true if one assumes that HIPERLANs will be equally distributed on all the channels.

Another parameter which is not considered is the shielding effect for those users which are located outdoors. If outdoor operation will become a reality this would only be the case in highly urban areas, due to the limited range of HIPERLANs. In an urban environment there is not always a direct path between the HIPERLAN and the satellite; this fact has not been taken into account in the current calculations.

6 SUMMARY OF RESULTS

The results of the calculations show that the maximum tolerable number of HIPERLAN is rather limited when considering the worst combination of methodology and criteria .

The criteria of 1 % increase of the satellite noise[1] would lead to the conclusion that sharing is not possible.

On the other hand, the criteria of 6% increase of the link noise[1] would lead to the conclusion that sharing is feasible.

7 CONCLUSIONS

Given that an increase of noise of 6% was generally considered to be acceptable, the sharing between MSS Feeder links and HIPERLAN in the frequency band 5150-5250 MHz remains feasible, even considering a large deployment of HIPERLAN terminals under the condition that some restrictions are put to the HIPERLAN operations.

These restrictions are in the frequency band 5150-5250 MHz:

1) To limit the HIPERLAN mean EIRP to 200 mW (§4.2.4)
2) To restrict the HIPERLAN operations to indoor use.

According to the HIPERLAN community, these restrictions, while constraining the use of the band 5150-5250 MHz, would not prevent the introduction of HIPERLAN. However, they are stressing that such limitation should not also occur in the extension bands currently under study and that such extension band should be made available as soon as possible to enable the development of all possible applications of HIPERLAN.

Left blank

ANNEX 1: EXAMPLES OF CALCULATION RESULTS

Case A): ΔTsat/Tsat, Criterion 6%	1 W, 1% out		0.1 W, 1% out		1 W, 15% out		0.1 W, 15% out	
	ICO	**Globalstar**	**ICO**	**Globalstar**	**ICO**	**Globalstar**	**ICO**	**Globalstar**
Pb (dBW) (pw/user for GLB, pw/channel for ICO)	~~-156.0~~	~~-164.0~~	~~-156.0~~	~~-164.0~~	~~-156.0~~	~~-164.0~~	~~-156.0~~	~~-164.0~~
Pa (dBW) (pw/user for GLB, pw/channel for ICO)	~~-140.0~~	~~-141.2~~	~~-140.0~~	~~-141.2~~	~~-140.0~~	~~-141.2~~	~~-140.0~~	~~-141.2~~
gamma (dB)	~~-8.0~~	~~-22.8~~	~~-8.0~~	~~-22.8~~	~~-8.0~~	~~-22.8~~	~~-8.0~~	~~-22.8~~
Tsat (K)	400.0	549.5	400.0	549.5	400.0	549.5	400.0	549.5
Tearth (K)	~~288.0~~	~~293.7~~	~~288.0~~	~~293.7~~	~~288.0~~	~~293.7~~	~~288.0~~	~~293.7~~
Criteria	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
DeltaTsat (K)	24.0	33.0	24.0	33.0	24.0	33.0	24.0	33.0
Afs (dB)	-188.0	-170.0	-188.0	-170.0	-188.0	-170.0	-188.0	-170.0
Pol_discr (dB)	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Afl (dB)	0.0[2]	2.9	0.0[2]	2.9	0.0[2]	2.9	0.0[2]	2.9
Satellite antenna gain (dB)	10.0	6.0	10.0	6.0	10.0	6.0	10.0	6.0
Tolerable Hiperlan power per MSS ch (dBW)	**9.2**	**16.4**	**9.2**	**16.4**	**9.2**	**16.4**	**9.2**	**16.4**
BWfl (MHz)	0.025	1.230	0.025	1.230	0.025	1.230	0.025	1.230
Bwhip (MHz)	24.00	24.00	24.00	24.00	24.00	24.00	24.00	24.00
Bandwith factor (BWhip/BWfl)dB	29.8	12.9	29.8	12.9	29.8	12.9	29.8	12.9
	39.0	**29.3**	**39.0**	**29.3**	**39.0**	**29.3**	**39.0**	**29.3**
Percentage of outdoor usage	1	1	1	1	15	15	15	15
Loss in excess to free space for indoor(dB)	11	10.5	11	10.5	11	10.5	11	10.5
Av. effect due to loss in excess of f.s. (dB)	**10.52**	**10.08**	**10.52**	**10.08**	**6.63**	**6.46**	**6.63**	**6.46**
Maximum tolerable interference per H. ch. (dBW)	**49.5**	**39.4**	**49.5**	**39.4**	**45.6**	**35.7**	**45.6**	**35.7**
Av. Hiperlan EIRP for HBR (mW)	1000	1000	100	100	1000	1000	100	100
Contention factor (linear, H/1 only)	4	4	4	4	4	4	4	4
Av. EIRP with contention period (dBW)	4000	4000	400	400	4000	4000	400	400
Number of active users	22308	2158	223084	21578	9091	939	90907	9389
Silent to transmit ratio	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Max tolerable number of Hiperlans (per ch.)	**446 168**	**43 156**	**4 461 685**	**431 558**	**181 814**	**18 778**	**1 818 136**	**187 785**

---

2 The figure Afl = 0 doesn't correspond to a physical reality, but it takes into account the fact that the system noise temperature provided by ICO is referred to the output of the receiving antenna, while in the case of Globalstar the figure refers (as in the methodology explained in paragraph 3.1) to the input of the LNA receiver.

ANNEX 1: EXAMPLES OF CALCULATION RESULTS

Case B): ΔTsat/Tsat, Criterion 1%	1 W, 1% out		0.1 W, 1% out		1 W, 15% out		0.1 W, 15% out	
	ICO	**Globalstar**	**ICO**	**Globalstar**	**ICO**	**Globalstar**	**ICO**	**Globalstar**
Pb (dBW) (pw/user for GLB, pw/channel for ICO)	~~*-156.0*~~	~~*-164.0*~~	~~*-156.0*~~	~~*-164.0*~~	~~*-156.0*~~	~~*-164.0*~~	~~*-156.0*~~	~~*-164.0*~~
Pa (dBW) (pw/user for GLB, pw/channel for ICO)	~~*-140.0*~~	~~*-141.2*~~	~~*-140.0*~~	~~*-141.2*~~	~~*-140.0*~~	~~*-141.2*~~	~~*-140.0*~~	~~*-141.2*~~
gamma (dB)	~~*-8.0*~~	~~*-22.8*~~	~~*-8.0*~~	~~*-22.8*~~	~~*-8.0*~~	~~*-22.8*~~	~~*-8.0*~~	~~*-22.8*~~
Tsat (K)	400.0	549.5	400.0	549.5	400.0	549.5	400.0	549.5
Tearth (K)	~~*288.0*~~	~~*293.7*~~	~~*288.0*~~	~~*293.7*~~	~~*288.0*~~	~~*293.7*~~	~~*288.0*~~	~~*293.7*~~
Criteria	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
DeltaTsat (K)	4.0	5.5	4.0	5.5	4.0	5.5	4.0	5.5
Afs (dB)	-188.0	-170.0	-188.0	-170.0	-188.0	-170.0	-188.0	-170.0
Pol_discr (dB)	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Afl (dB)	0.0[1]	2.9	0.0[2]	2.9	0.0[2]	2.9	0.0[2]	2.9
Satellite antenna gain (dB)	10.0	6.0	10.0	6.0	10.0	6.0	10.0	6.0
Tolerable Hiperlan power per MSS ch (dBW)	**1.4**	**8.6**	**1.4**	**8.6**	**1.4**	**8.6**	**1.4**	**8.6**
BWfl (MHz)	0.025	1.230	0.025	1.230	0.025	1.230	0.025	1.230
Bwhip (MHz)	24.00	24.00	24.00	24.00	24.00	24.00	24.00	24.00
Bandwith factor (BWhip/BWfl)dB	29.8	12.9	29.8	12.9	29.8	12.9	29.8	12.9
	31.2	**21.5**	**31.2**	**21.5**	**31.2**	**21.5**	**31.2**	**21.5**
Percentage of outdoor usage	1	1	1	1	15	15	15	15
Loss in excess to free space for indoor(dB)	11	10.5	11	10.5	11	10.5	11	10.5
Av. effect due to loss in excess of f.s. (dB)	**10.52**	**10.08**	**10.52**	**10.08**	**6.63**	**6.46**	**6.63**	**6.46**
Maximum tolerable interference per H. ch. (dBW)	**41.7**	**31.6**	**41.7**	**31.6**	**37.8**	**28.0**	**37.8**	**28.0**
Av. Hiperlan EIRP for HBR (mW)	1000	1000	100	100	1000	1000	100	100
Contention factor (linear, H/1 only)	4	4	4	4	4	4	4	4
Av. EIRP with contention period (dBW)	4000	4000	400	400	4000	4000	400	400
Number of active users	3718	360	37181	3596	1515	156	15151	1565
Silent to transmit ratio	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Max tolerable number of Hiperlans (per ch.)	**74 361**	**7 193**	**743 614**	**71 926**	**30 302**	**3 130**	**303 023**	**31 297**

ANNEX 1: EXAMPLES OF CALCULATION RESULTS

Case C): ΔTlink/Tlink (See note 3), Criterion 6%	1 W, 1% out		0.1 W, 1% out		1 W, 15% out		0.1 W, 15% out	
	ICO	**Globalstar**	**ICO**	**Globalstar**	**ICO**	**Globalstar**	**ICO**	**Globalstar**
Pb (dBW) (pw/user for GLB, pw/channel for ICO)	-156.0	-164.0	-156.0	-164.0	-156.0	-164.0	-156.0	-164.0
Pa (dBW) (pw/user for GLB, pw/channel for ICO)	-140.0	-141.2	-140.0	-141.2	-140.0	-141.2	-140.0	-141.2
gamma (dB)	-8.0	-22.8	-8.0	-22.8	-8.0	-22.8	-8.0	-22.8
Tsat (K)	400.0	549.5	400.0	549.5	400.0	549.5	400.0	549.5
Tearth (K)	288.0	293.7	288.0	293.7	288.0	293.7	288.0	293.7
Criteria	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
DeltaTsat (K)	133.0	3390.8	133.0	3390.8	133.0	3390.8	133.0	3390.8
Afs (dB)	-188.0	-170.0	-188.0	-170.0	-188.0	-170.0	-188.0	-170.0
Pol_discr (dB)	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Afl (dB)	0.0[2]	2.9	0.0[2]	2.9	0.0[2]	2.9	0.0[2]	2.9
Satellite antenna gain (dB)	10.0	6.0	10.0	6.0	10.0	6.0	10.0	6.0
Tolerable Hiperlan power per MSS ch (dBW)	**16.6**	**36.5**	**16.6**	**36.5**	**16.6**	**36.5**	**16.6**	**36.5**
BWfl (MHz)	0.025	1.230	0.025	1.230	0.025	1.230	0.025	1.230
Bwhip (MHz)	24.00	24.00	24.00	24.00	24.00	24.00	24.00	24.00
Bandwith factor (BWhip/BWfl)dB	29.8	12.9	29.8	12.9	29.8	12.9	29.8	12.9
	46.4	**49.4**	**46.4**	**49.4**	**46.4**	**49.4**	**46.4**	**49.4**
Percentage of outdoor usage	1	1	1	1	15	15	15	15
Loss in excess to free space for indoor(dB)	11	10.5	11	10.5	11	10.5	11	10.5
Av. effect due to loss in excess of f.s. (dB)	**10.52**	**10.08**	**10.52**	**10.08**	**6.63**	**6.46**	**6.63**	**6.46**
Maximum tolerable interference per H. ch. (dBW)	**56.9**	**59.5**	**56.9**	**59.5**	**53.0**	**55.9**	**53.0**	**55.9**
Av. Hiperlan EIRP for HBR (mW)	1000	1000	100	100	1000	1000	100	100
Contention factor (linear, H/1 only)	4	4	4	4	4	4	4	4
Av. EIRP with contention period (dBW)	4000	4000	400	400	4000	4000	400	400
Number of active users	123653	221916	1236532	2219161	50389	96563	503887	965628
Silent to transmit ratio	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Max tolerable number of Hiperlans (per ch.)	**2 473 064**	**4 438 322**	**24 730 641**	**44 383 221**	**1 007 773**	**1 931 257**	**10 077 730**	**19 312 567**

ANNEX 1: EXAMPLES OF CALCULATION RESULTS

Case D): ΔTlink/Tlink (See note 3), Criterion 1%	1 W, 1% out		0.1 W, 1% out		1 W, 15% out		0.1 W, 15% out	
	ICO	**Globalstar**	**ICO**	**Globalstar**	**ICO**	**Globalstar**	**ICO**	**Globalstar**
Pb (dBW) (pw/user for GLB, pw/channel for ICO)	-156.0	-164.0	-156.0	-164.0	-156.0	-164.0	-156.0	-164.0
Pa (dBW) (pw/user for GLB, pw/channel for ICO)	-140.0	-141.2	-140.0	-141.2	-140.0	-141.2	-140.0	-141.2
gamma (dB)	-8.0	-22.8	-8.0	-22.8	-8.0	-22.8	-8.0	-22.8
Tsat (K)	400.0	549.5	400.0	549.5	400.0	549.5	400.0	549.5
Tearth (K)	288.0	293.7	288.0	293.7	288.0	293.7	288.0	293.7
Criteria	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
DeltaTsat (K)	22.2	565.1	22.2	565.1	22.2	565.1	22.2	565.1
Afs (dB)	-188.0	-170.0	-188.0	-170.0	-188.0	-170.0	-188.0	-170.0
Pol_discr (dB)	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Afl (dB)	0.0[2]	2.9	0.0[2]	2.9	0.0[2]	2.9	0.0[2]	2.9
Satellite antenna gain (dB)	10.0	6.0	10.0	6.0	10.0	6.0	10.0	6.0
Tolerable Hiperlan power per MSS ch (dBW)	**8.8**	**28.7**	**8.8**	**28.7**	**8.8**	**28.7**	**8.8**	**28.7**
BWfl (MHz)	0.025	1.230	0.025	1.230	0.025	1.230	0.025	1.230
Bwhip (MHz)	24.00	24.00	24.00	24.00	24.00	24.00	24.00	24.00
Bandwith factor (BWhip/BWfl)dB	29.8	12.9	29.8	12.9	29.8	12.9	29.8	12.9
	38.6	**41.6**	**38.6**	**41.6**	**38.6**	**41.6**	**38.6**	**41.6**
Percentage of outdoor usage	1	1	1	1	15	15	15	15
Loss in excess to free space for indoor(dB)	11	10.5	11	10.5	11	10.5	11	10.5
Av. effect due to loss in excess of f.s. (dB)	**10.52**	**10.08**	**10.52**	**10.08**	**6.63**	**6.46**	**6.63**	**6.46**
Maximum tolerable interference per H. ch. (dBW)	**49.2**	**51.7**	**49.2**	**51.7**	**45.3**	**48.1**	**45.3**	**48.1**
Av. Hiperlan EIRP for HBR (mW)	1000	1000	100	100	1000	1000	100	100
Contention factor (linear, H/1 only)	4	4	4	4	4	4	4	4
Av. EIRP with contention period (dBW)	4000	4000	400	400	4000	4000	400	400
Number of active users	20609	36986	206089	369860	8398	16094	83981	160938
Silent to transmit ratio	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Max tolerable number of Hiperlans (per ch.)	**412 177**	**739 720**	**4 121 773**	**7 397 203**	**167 962**	**321 876**	**1 679 622**	**3 218 761**

ANNEX 2

ADDITIONAL LOSS TO FREE SPACE PATH LOSS IN THE CASE OF GSO FSS

This annex makes reference to the section 3.2 (1) of this paper. The point that is treated here is which is the additional path loss to free space path loss to be taken into account in the estimation of interference from HIPERLANs into GSO FSS.

In the case of GSO satellites, the elevation from one point on the earth depends on the satellite position and on the coordinates of the point on the earth. The common formulas can be found in the literature and in ITU-R recommendations. Taking a simple case of a satellite at e.g. 21 deg. EAST, with coverage area on Europe, we can try to see which is the range of elevation:

We consider the most of occidental Europe (without considering northern countries, which are the worst case) in the geographical area between 40 deg. and 60 deg. North of latitude and between -5 deg. and 20 deg. East of longitude. If we consider the edges of this area and a central point arbitrarily chosen, and we calculate the elevation towards a satellite at 21 deg. East, we have:

LATITUDE	LONGITUDE	ELEVATION	ATTENUATION (Model 2)
40 deg.	-5 deg.	36.5 deg.	~10 dB
60 deg.	-5 deg.	18.4 deg.	~ 9 dB
40 deg.	20 deg.	43.7 deg.	~ 11 dB
60 deg.	20 deg.	21.9 deg.	~ 9 dB
50 deg.	10 deg.	31.7 deg.	~ 10 dB

Taking into account some additional loss due to obstacles, the overall additional shielding loss can be estimated to 11 dB.

Left blank

ANNEX 3

CALCULATION OF γ FACTOR

1) CALCULATION OF GAMMA FACTOR FOR THE ICO NETWORK

Appendix S8 is based on the following formula (equation 1):

Where,
$$T = \gamma T_S + T_e$$

T_{Sat} = Satellite receiver temperature (400 °K)
T_{earth} = Mobile earth station temperature (288 °K)
And γ = satellite system gain, calculated as follow :

$$\gamma = \frac{P_b}{P_a}$$

with, P_a is the power of the uplink at the satellite receiver input,
and, P_b is the power of the downlink at the mobile receiver input,

with the following assumptions :

- EIRP of the gateway (70 dBm/channel for ICO)
- G_s, gain of the receiving antenna of the satellite (10 dBi for ICO)
- A_u, free space Loss (uplink) (188 dB for ICO)
- C/N required at the mobile receiver 4 dB

Regarding the different types of path loss and margins, the following remarks can be done :

- The uplink can be affected by pointing and depolarisation loss A_{pd} (e.g. 1 dB).
- The downlink is mainly affected by fading. So, a margin M has to be taken into account
- The feeder loss (A_{fl}) of the satellite (e.g. 1 dB) will affect both signal and interference.
- The aggregate RLAN interference is not polarised. So, the final interference level has to be completed with the polarisation discrimination factor between MSS and RLAN(F_d) (e.g. 2 dB).

Then, when making calculation for clear sky with no pointing error and depolarisation :

$$P_a \text{ (dBm)} = \text{EIRP} + G_s - A_u - A_{pd} - A_{fl} = -110 \text{ dBm}$$

and

$$P_b \text{ (dBm)} = kT_{earth}B + C/N + M = (M - 126) \text{ dBm}$$

And then, **γ = (M – 16) dB**

This calculation of γ enables to stress the fact that the margin of the system is correctly taken into account and that the interference is not allowed to cover the margin (the more is the margin, the more is the relative importance of the satellite noise, and the more the effect of interference from Hiperlans would be noticeable).

ICO announced a margin of 8 dB, which would correspond to γ **= - 8 dB**.

2) CALCULATION OF GAMMA FACTOR FOR GLOBALSTAR NETWORK

The analysis on ICO system is not very precise with respect to the interpretation of gamma (γ). This figure includes the path loss from the satellite towards the mobile and thus it changes with the fading variations. In fact the power P_b required at the mobile receiver may be considered in first approximation as constant (in visibility and with shadowing plus fading), because it depends on the required E_b/N_0. The P_a at the satellite on the contrary varies mainly for the implementation of power control. In the case of MSS, fading can attenuate the signal at the downlink, and in that case the emitted EIRP is increased and P_a is increased as a consequence. It is clear that it is important to choose the γ in the most critical case when an approach based on evaluate the $\Delta T_{link}/T_{link}$ has to be adopted.
Here we're going to make the analysis considering the two relevant cases of complete visibility and of maximum tolerable fading.
Considering a positive fade margin M characteristic of a system, noting with γ the figure for this parameter in the case of visibility (no fading) and with γ' the figure in the case of maximum tolerable fading, we have the relation

$$\gamma' = \gamma/M$$

In fact the path loss is multiplied by a factor M (in dB...L'=L+M). If now we consider the interference I_s before the LNA at the satellite, we obtain a general formula to evaluate the ΔT_m:

$$\Delta T_m = \gamma \, \Delta T_{sat} = \gamma \, I_s / (kB)$$

where:
ΔT_{sat} is the apparent increase of the overall noise at the satellite receiver due to the interference,
k is the Boltzman constant,
B is the receiver bandwith
In the fading case, the equation is the same, and we obtain:

$$\Delta T'_m = \gamma' \, \Delta T_{sat} = \gamma' \, I_s / (kB) = (\gamma/M) \, I_s / (kB)$$

As T_m is the same (the equivalent noise temperature at the mobile receiver), the biggest increase of the $\Delta T_m/T_m$ is found in the case of visibility ($\Delta T'_m < \Delta T_m$), that should be considered as the most critical.
This means that the tolerable $\Delta T_{link}/T_{link}$ has to be evaluated using the figure for γ as in the case of visibility. For Globalstar (see values of Pa and Pb in tables in Annex 1), in the case of visibility, γ **= -22.8 dB**.
The conclusion could seem strange, but it is explained by the fact that in the case of attenuation due to fading, the system reacts in order to have the same useful signal at the mobile receiver, while the interference is attenuated by the fading.

The resulting tolerable ΔT_{sat} is the following in the case of Globalstar:

$$\Delta T_{sat} = (Cr) \, (\gamma T_{sat} + T_{earth}) / \gamma = (Cr) * 56512 \text{ K}$$