RADIO RESEARCH & DEVELOPMENT INSTITUTE (FGUP NIIR)

ASSESSMENT OF ORBITAL-FREQUENCY RESOURCE OCCUPIED BY FSS NETWORKS in Ka-BAND

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It is well known that the Radio Regulations allocate~~s~~ a wide frequency band for FSS networks in the Ka-band (e.g. in Region 1 18.1–21.2 GHz for downlink and 27–31 GHz for uplink).

This enables to the development of wideband multichannel communication networks competitive to with terrestrial fiber-optic networks.

However, the orbital-frequency resource is limited not only by the allocated frequency band, but also by the GSO itself.

The orbital-frequency resource occupied by a certain FSS network may be determined by means of the methodology described in doc. 4A/61. Att.7, Study 1.

The document suggests estimating the occupied orbital-frequency resource with regard to a reference network, taking into account the number of satellites N in the system, using the relation:

$$R = \sum_{n=1}^{N} (\Delta F \cdot \Delta\varphi \cdot k \cdot s)_n \quad \textit{(Hertz×degree)}$$

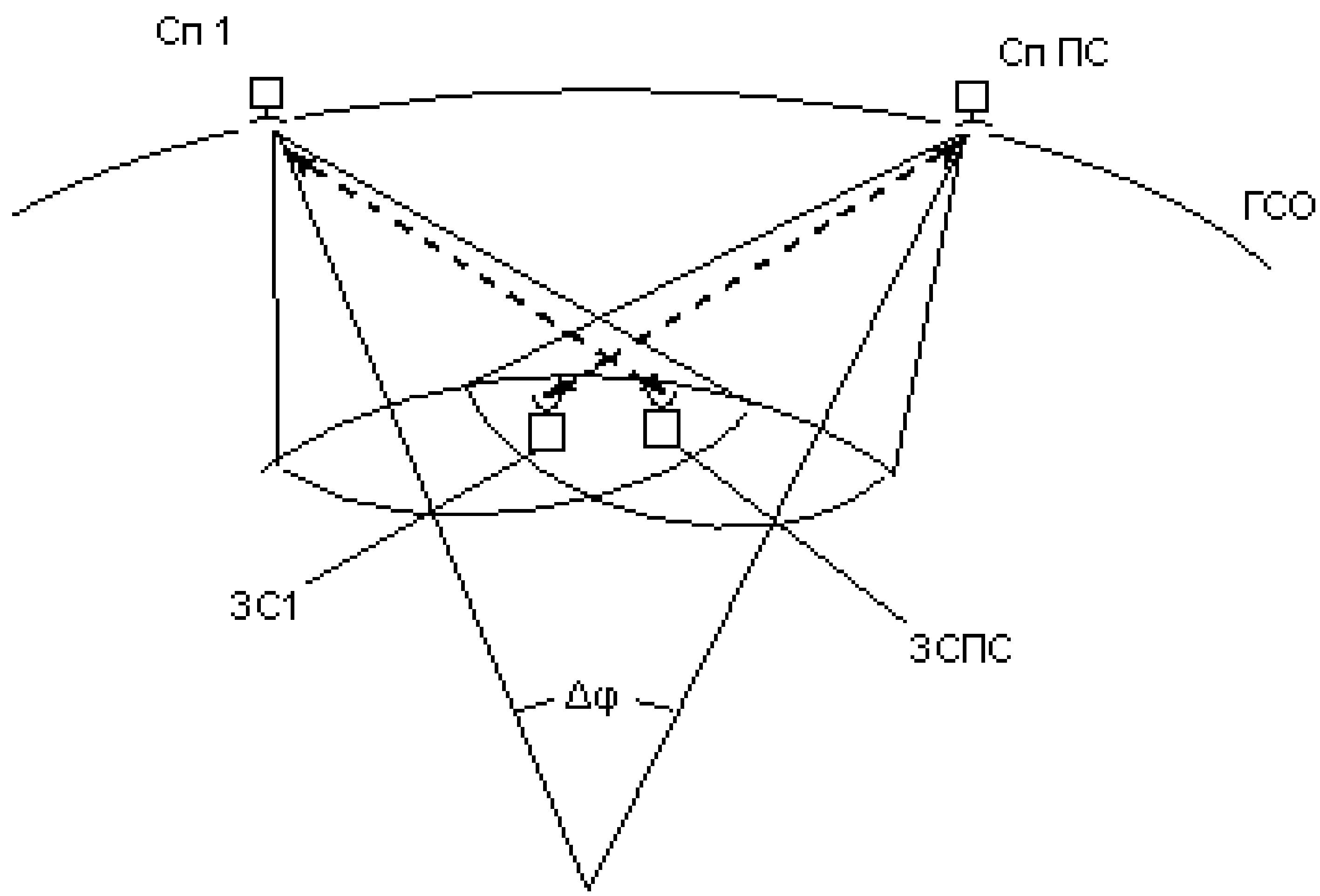

Рис. 1

СпПС – reference system satellite; **Сп1 – estimated system satellite;**
ЗСПС – ES of reference system ; **ЗС1 – ES of estimated system.**

High antenna directivity in the Ka-band facilitates the development of networks with narrow satellite beams, which, in turn, leads to the reduction of the orbital-frequency resource occupied by a network – coefficients = S_c/S_s in the previous relation (evidently, unless a network notified covers the whole visible Earth surface with narrow bands, as done in most submissions for the Ka-band networks), certainly, in the case when a notified network doesn’t cover with narrow beams the whole visible Earth surface – as it take place in most submission for Ka-band networks).

The main feature and the main disadvantage of the Ka-band is great signal rain attenuation in relatively small percentage of time.
For this reason, the Ka-band is hardly suitable for many telecommunication/broadcasting functions when a high level of availability is required.
Really, the unavailability of 0.005 (0.5%) corresponds to the loss of information during 44 hours per year.

SOHO Internet networks are able to overcome this problem for several reasons: first, since such users have lower requirements for the channel quality stability and, second, because adaptation to channel quality change has been used on terrestrial internet networks for a long time, and because information rate reduction in the case of network overloading or when downloading large-scale files has been common practice.

High rain attenuation in relatively short periods of time requires adaptation of transmitted signal parameters depending on propagation conditions.

There are 3 basic adaptation methods:

1) To increase the power flux density (PFD) of the wanted signal (without changing the data transmission rate and modulation/coding schemes);

2) To decrease data transmission rate(without changing the PFD and modulation/coding schemes);

3) To change modulation/coding schemes for a more noise-immune option.

These methods may also be combined.

In Case 1, as the probability of great signal attenuation is not significant (fractions of 1%), the probability of simultaneous high attenuation at geographically dispersed stations (useful and victim networks) is rather small, i.e. at the stations of the other network the interference level will not be reduced due to precipitation, i.e. the interference level will increase by the value of the PFD increase.
The occupied orbit arc will correspondingly increase, because an additional reduction of interference will require higher ES antenna selectivity to meet the permissible value of the interference level.

The value of the necessary increase in the angular separation between Ka-band networks due to adaptation can be assessed by the following example. Let's assume typical downlink parameters for two identical interacting FSS networks (for example, see ETSI TR 102 376 V1.1.1):

- the ES antenna diameter is 0.75 m,
- frequency = 18 GHz,
- antenna gain = 41.5 dB, station G/T=16.5,
- signal-to-noise ratio at limited attenuation (i.e. with large percentage of time) C/N=10.5 dB
- criterion of permissible single entry interference between FSS networks I/N = 6% (–12.2 dB),

and with necessary wanted signal PFD_d=–188 dB (W/m^2/Hz) and permissible interference PFD_{id}= –210.7 dB (W/m^2/Hz) and antenna gain at the corresponding point of antenna pattern: $G = 29 – 25\log\Delta\varphi$.

So to reduce the indicated interference level by 22.7dB, the necessary angular separation will be $\Delta\varphi = 2.56°$.

If satellite PFD is increased, for example by 8 dB, to compensate for the increased attenuation due to precipitation, then the necessary angular separation between the satellites will be 5.34°, i.e. the orbit arc occupied by the network and, correspondingly, the occupied resource will be increased twice.

It should be noted that these considerations refer to downlink only, where stations of interacting systems may be separated, but still remaining in the area of probable interference. The increased uplink PFD during signal rain attenuation usually will not cause any increase of interference due to high correlation of signal attenuation towards neighboring satellites.

It should be also noted that in accordance with the current ITU-R Recommendations, for GSO FSS networks interference increase during short periods of time is not allowed, i.e. the necessary separation should be provided during 100% of time period.

The 2nd adaptation method – decrease of the data transmission rate without changing PFD and modulation/coding schemes – will cause reduction of the signal radio frequency bandwidth and corresponding increase of spectral PFD.

The effect of increased interference and occupied resource will be the same as in Case 1.

And only Case 3 – change of modulation/coding schemes without change of transmitted power and occupied signal bandwidth will not cause increase of interference and occupied orbital and frequency resource,

and from this point of view it is preferable.

In summary, it seems important to note that
the problem of coordination for new submissions
in the Ka-band is not less than in the C- and Ku-bands
which have been in use for a long time,
because the networks already submitted for
coordination occupy the whole GSO and have global
coverage.
It is obvious that for the Ka-band as well as for other
frequency bands, it would be necessary to take
unpopular measures such as an increased criterion
of permissible interference and limitation of diversity
of technical parameter values and so on.

Thanks for attention!