



**SPECTRUM PRICING:
THIRD STAGE
UPDATE AND
CONSULTATION**

**Appendix 4
Satellite Links, Permanent Earth Stations**

Your views on the proposals set out in this document are sought by 9 February 2001. Comments should be sent to the address below. It would be helpful if lengthy written documents could be sent via email or on disk in Word 7:

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Spectrum Pricing Proposals for Permanent Earth Stations

INTRODUCTION

The increasing need to communicate via the airwaves and the demand for spectrum in shared bands is leading to an overall shortage of available radio spectrum. It is therefore proposed that in line with other services assigned significant tranches of spectrum which are already subject to spectrum pricing, Permanent Earth Station licence fees should in future reflect the value of the spectrum accessed by their transmissions. The proposed spectrum pricing regime also includes an element attributed to the receive side of the satellite earth stations that need to be taken into account when planning these bands.

Currently, licence fee pricing is calculated depending on the signal with the largest bandwidth being transmitted by the Earth Station to an associated satellite. It does not take into account the number of transmission frequencies being used or, in some cases, reserved.

Fixed Terrestrial Point-to-Point Services (FS) and Fixed Satellite Services (FSS) are often allocated the same radio spectrum. For the two services to co-exist in the shared bands there is a need to co-ordinate the proposed systems in order to avoid mutual interference.

Proposed Permanent Earth Station Pricing Structure

1

Fixed Satellite Service Reference Fee

To maintain compatibility with the current spectrum priced terrestrial fixed link licence fee structure, a sectoral reference fee based on a 28 MHz bandwidth Analogue/STM-1 155 Mbs unidirectional terrestrial link in a congested region has been selected as a suitable starting point. This terrestrial fee is currently set at £768.75, and the equivalent Fixed Satellite Service reference fee, encompassing access to a full 575 MHz bandwidth has been calculated as follows:

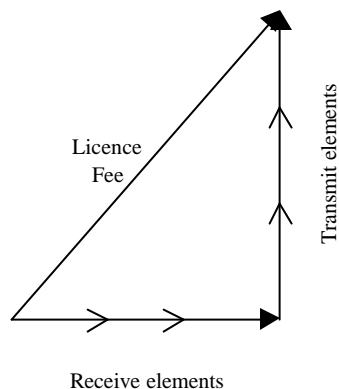
$$\begin{aligned} \text{FSS Reference Fee} &= \frac{\text{Terrestrial Fixed Link Fee} \times \text{FSS Available Access Bandwidth}}{\text{Terrestrial Fixed Link Reference Bandwidth}} \\ &= £768.75 \times (575 / 28) = £15,787 \end{aligned}$$

This reference fee is one factor used in developing the fees algorithm described in detail in the following paragraphs of the document.

Formulation of a Generic Permanent Earth Station Licence Fee Algorithm

Background

Future Permanent Earth Station Licence fees will reflect the authorisation of the frequencies of operation from a given site, the maximum powers and bandwidths of transmissions, as well as reception, and the number of satellites to which the Earth Station is permitted to access.



Since the receive and transmit frequencies are in different parts of the band these elements of the calculation are treated separately and are plotted on an orthogonal axis. The Licence Fee is the vector addition of the receive and transmit elements.

These requirements are reflected in the development of the Licence Fee calculation algorithm, shown below.

$$Fee = \sqrt{Rx^2 + Tx^2} \quad \text{----- (1)}$$

Where Rx is the sum of all the receive elements
 Tx is the sum of all the transmit elements

The Receive elements need to include reference to the receive bandwidth, receiver sensitivity and the operational arc over which the Earth Station receiver operates.

The Transmit element takes into account the full bandwidth to which access is authorised, and the peak transmit power measured at the input of the antenna (at the antenna flange).

THE WAY FORWARD

Taking all these elements into account

$$PES \text{ Fee} = v((\text{Sum of } \mathbf{Rx} \text{ terms}) + (\text{Sum of } \mathbf{Tx} \text{ terms})) \quad \text{----- (2)}$$

Note that because the power elements are proportional to bandwidth and bandwidth is also included in its own right the terms under the square root sign do NOT need to be squared.

$$PES \text{ Fee} = \sqrt{\mathbf{bR} \sum_i (\mathbf{RBW}_i \times \mathbf{RS}_i \times \mathbf{RArc}_i \times \mathbf{RMOD}_i) + \mathbf{bT} \sum_{ijk} (\mathbf{TBW}_{ijk} \times \mathbf{TP}_{ijk} \times \mathbf{TMOD}_{ijk})} \quad \text{--- (3)}$$

where:

βR	= Receive Scaling Factor
RBW_i	= Receive Bandwidth Factor
RS_i	= Receive Sensitivity Factor
$RArc_i$	= Receive Arc Factor
$RMOD_i$	= Receive Modifier (see table 1)
βT	= Transmit Scaling Factor
TBW_{ijk}	= Transmit Authorised bandwidth (MHz)
TP_{ijk}	= Transmit Peak power (Watts)
$TMOD_{ijk}$	= Transmit Modifier (see table 1)

i = number of Earth Station terminals on a site

j = number of satellites

k = number of transmission paths

It is generally accepted that radio transmissions have a greater impact on the radio spectrum and hence attention has concentrated initially on the development of the transmission element of

equation (3). As a result the receive element of this equation will form part of further studies. And hence the receive element of equation 3

$$bR \sum_i (RBW_i \times RS_i \times RARC_i \times RMOD_i) \text{ ----- (4)}$$

can be simplified to $(a \times i)$ in the initial implementation where alpha is a constant of substitution.

Substituting the above term into equation (3) gives

$$PES \text{ Fee} = \sqrt{(a \times i) + bT \sum_{ijk} (TBW_{ijk} \times TP_{ijk} \times TMOD_{ijk})} \text{ ----- (5)}$$

DERIVATION OF CONSTANTS a and β

Given that typical permanent Earth Stations necessarily have an associated wide bandwidth for reception it is initially considered appropriate to have a minimum fee (with no transmission paths) of £500 – this covers the full range of services provided by the RA.

$$\text{i.e } £500 = \sqrt{(a \times i)}$$

For a single Earth Station terminal $i = 1$, then

$$a = 500^2 = 250000$$

Substituting the following reference values: FSS Reference Fee of £15787, $a = 250000$, a reference bandwidth of 575 MHz and a reference power of 1000 watts into equation (5):

$$15787 = \sqrt{(250000 \times 1) + b(1000 \times 575 \times 1)}$$

$$b = \frac{(15787^2 - 250000)}{1000 \times 575 \times 1}$$

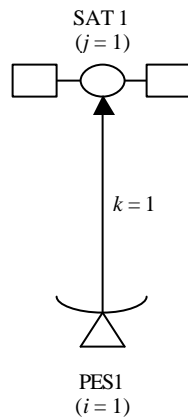
$$b = 433.0$$

PROPOSED FEE ALGORITHM

Substituting values for a and β: in equation (5)

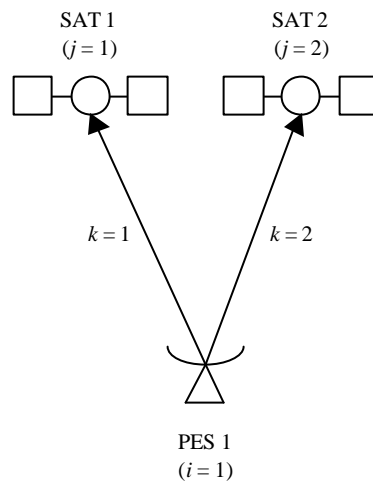
$$PES \text{ Fee} = \sqrt{(250 \times 10^3 \times i) + 433 \sum_{ijk} (TBW_{ijk} \times TP_{ijk} \times TMOD_{ijk})} \text{ ----- (6)}$$

In the above equation, the terms i , j and k refer to the number of Earth Station terminals (i) on a site, the number of satellites accessed (j) and the number of paths (k) as illustrated in the following diagrams.



$$Fee = \sqrt{(250 \times 10^3 \times 1) + 433(TBW_{111} \times TP_{111} \times TMOD_{111})}$$

Fig 1: One ES with one Satellite



$$Fee = \sqrt{(250 \times 10^3 \times 1) + 433[(TBW_{111} \times TP_{111} \times TMOD_{111}) + (TBW_{122} \times TP_{122} \times TMOD_{122})]}$$

Fig 2: One ES with two Satellites

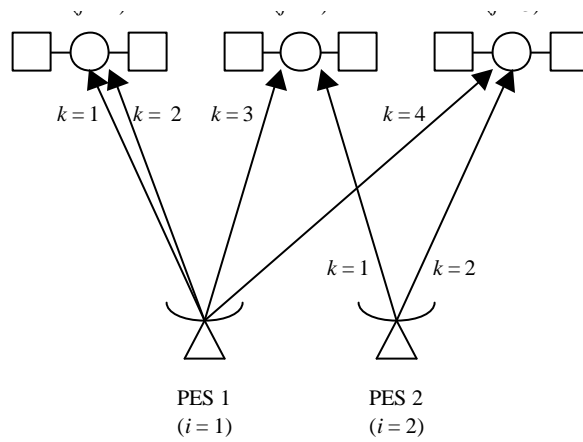


Fig 3: Two ES with three Satellites

$$Fee = \sqrt{\begin{aligned} & (250 \times 10^3 \times 2) + 433[(TBW_{111} \times TP_{111} \times TMOD_{111}) + (TBW_{112} \times TP_{112} \times TMOD_{112}) + \\ & (TBW_{123} \times TP_{123} \times TMOD_{123}) + (TBW_{134} \times TP_{134} \times TMOD_{134}) + \\ & (TBW_{221} \times TP_{221} \times TMOD_{221}) + (TBW_{232} \times TP_{232} \times TMOD_{232})] \end{aligned}}$$

It can be seen that the term i describes the number of Earth Station terminals on a site. The industry Group in their deliberations defined a site as an area encompassed within a radius of 500m from a user defined reference point. It was further agreed that all Earth Stations operated by a single entity within any site could be included in equation (6) for fee calculation purposes.

It is possible for any given geographical area (eg a fenced area where Earth Stations of two or more operators are co-located) to be considered as several sites for Earth Station licensing purposes. Each entity's collection of Earth Stations will be separately licensed within their own site.

Modifiers:

Modifiers are introduced to deal with any anomalies generated by the general approach. These may include issues such as: operation, location, etc as listed in the following table.

Band (MHz)	Initial Value	Notes
5850 – 5925	1	Shared
5925 – 6425	1	Shared
6425 – 7075	1	Shared
12500 – 12750	0.75	No Fixed Links
12750 – 13250	1	Shared
13750 – 14000	0.75	No Fixed Links
14000 – 14250	0.75	No Fixed Links
14250 – 14500	1	Shared
17300 – 17700	0.75	No Fixed Links
17700 – 18100	1	Shared
18100 – 18400	1	Shared
27500 – 29500	1	Shared
29500 – 30000	0.75	No Fixed Links
Other factors	Initial Value	
Elevation Angle	1	
Azimuth	1	
Antenna Pattern	1	
Height	1	
Location	1	
Screening	1	
Multiple satellite clearances to a single Earth Station	1	
Occasional Use	1	

Table 1: Proposed Modifiers and Initial Values

The values detailed to in the above table are the initial values set by the industry Group. Any changes will form part of future work.

Examples of New Permanent Earth Station Fees

Example fees, at the end of the three year transitional period, for a single transmission from one Earth Station to a single satellite with maximum licensed transmit powers of 30, 25 and 20 dBW (measured at the antenna’s flange) and clearance bandwidths of 36 and 575 MHz, are shown in table 2 below. The calculations assume that all modifier values are 1. All fees are rounded down to the nearest five pounds. For comparison, the current fee for a single 36 MHz transmission is £10,000.

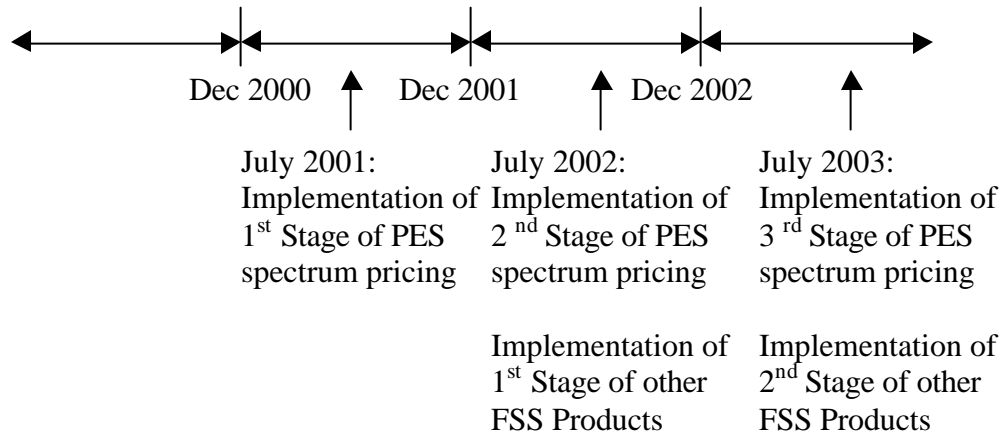
Cleared/Access Bandwidth (MHz)	Licensed Transmit Power At the Flange of the Antenna		
	30 dBW	25 dBW	20 dBW
36	£3975	£2275	£1340
575	£15785	£8885	£5010

Table 2: Example Fees

Implementation Timescale

There will be a phased introduction of the revised PES licence fees over a three year period beginning in July 2001.

The diagram below shows the implementation stages and the timing of the proposals for other products:



The industry Group identified the following areas to be addressed for implementation during the next stages of Spectrum Pricing for Satellite Earth Stations (July 2002.)

1. Transportable Earth Stations (TES).
2. Satellite User Terminals (SUTS)
Satellite Interactive Terminals SITS
Very Small Aperture Terminals (VSATS) for network Licences.
3. Non-Geostationary Orbit (non-GSO) terminals
4. Modifiers
5. Review of Existing Licence Products.

Summary

The approach adopted allows the introduction of FSS spectrum pricing in an equitable and adaptable manner and provides advantages to both Earth Station operators and the Agency.

This proposal also enables the use of modifiers, where appropriate, to correct for any anomalies created by the general approach.

The basic structure of the fee algorithm proposed is such that it can be easily extended to other satellite Earth Station licensing products.