DISCUSSION PAPER SERIES

No. 813

THE EUROPEAN SATELLITE INDUSTRY: PROSPECTS FOR LIBERALIZATION

Damien J Neven, Lars-Hendrik Röller and Len Waverman

Centre for Economic Policy Research

25–28 Old Burlington Street, London W1X 1LB

ISSN 0265-8003

THE EUROPEAN SATELLITE INDUSTRY: PROSPECTS FOR LIBERALIZATION

Damien J Neven, Lars-Hendrik Röller and Len Waverman

Discussion Paper No. 813
September 1993

Centre for Economic Policy Research
25-28 Old Burlington Street
London W1X 1LB
Tel: (44 71) 734 9110

CEPR Discussion Paper No. 813

September 1993

ABSTRACT

The European Satellite Industry: Prospects for Liberalization*

This paper evaluates the effects of liberalizing access to the space sector, as currently envisaged by the EC Commission. We undertake an econometric evaluation of the degree of scale economies in satellite operations and calibrate a Cournot model of competition in which the effect of liberalization is modelled as the segmentation of national markets that currently prevails. We conclude that existing players in the satellite operations industry would make negative profits under liberalization. We find that four players would break even and operate close to the minimum efficient scale (of about ten satellites). We also conclude that some consolidation is required in the production of satellites. In both cases it seems that intervention by a supra-national authority like the EC Commission would be useful.

JEL classification: L13, L50, L80
Keywords: satellite industry, deregulation, space

Damien Neven
Université de Liège
Département d'Economie
Boulevard du Rectorat 7 (B31)
4000 Liège
BELGIUM
Tel: (32 41) 56 3077

Lars-Hendrik Röller
INSEAD
Boulevard de Constance
77305 Fontainebleau Cedex
FRANCE
Tel: (331) 6072 4251

Len Waverman
Centre for International Studies
University of Toronto
170 Bloor Street West, Suite 500
Toronto, Ontario
CANADA
M5S 1T9
Tel: (1 416) 978 8637

*This paper is produced as part of a CEPR research programme on *Market Structure, Industrial Organization and Competition Policy in Europe,* supported by a grant from the Commission of the European Communities under its SPES Programme (no. SPESCT910071). It draws on a study undertaken for the

European Space Agency (ESA), whose support is gratefully acknowledged. We would also like to thank EUTELSAT, INTELSAT and satellite manufacturers for providing us with data. We are grateful to Pierre Bartolomé (ESA) and Olivier Millies-Lacroix (EUTELSAT) for helpful discussions and numerous comments. Arnoud Francq provided excellent research assistance. The views expressed are those of the authors and not necessarily those of ESA.

Submitted 4 May 1993

NON-TECHNICAL SUMMARY

A significant liberalization of the satellite communications industry is currently under discussion, following the green paper on satellite communication tabled by the Commission of the European Communities. The objective of this paper is to evaluate the widespread liberalization envisaged by the Commission.

At the moment, access to the space sector is restricted; space sector operators include mostly public companies, Post, Telephone and Telegraph (PTT) operators and international cooperatives of PTT operators like EUTELSAT and INTELSAT. Providers of final services can only obtain space capacity from public operators through their national PTT operators, so that national markets are by and large segmented. In addition, some final services, like telephony, cannot be provided by private operators. As a result, in any given national market, competition is limited.

The Commission's green paper proposes first that entry into network operations should be greatly facilitated. It suggests also that service providers should have a direct access to international cooperatives and 'multiple access' to any European PTT operators. Finally, the Commission's proposal recommends a liberalization of the exclusive rights on some services currently enjoyed by the PTTs to facilitate entry by private operators and progressively achieve competitive access.

A priori, the proposed liberalization might have adverse consequences. Indeed, there are some indications that scale and learning economies exist in satellite operations. As a result of deregulation, existing players might become unprofitable and some exit might be required. Free entry into the space sector might lead to an excessive number of operators, each operating at a sub-optimal scale. In the production sector, European producers currently operate below the minimum efficient scale and are not in a position to compete with their US counterparts. Will liberalization of the space sector increase demand for satellites to such an extent that existing producers might operate at an efficient scale?

Accordingly, this paper evaluates the extent to which satellite operations and production are subject to scale economies, and simulates the effect of liberalization. We compare the minimum efficient scale in production with the potential increase in demand for satellites, which could arise in a liberalized environment – by calibrating a Cournot model of competition.

We undertake an econometric estimation of the degree of scale economies in operations, and conclude that there are significant scale economies (around 10%) up to the operation of about ten satellites. The results of the simulations suggest that scale economies in the satellite operations industry are such that

under full liberalization, only four operators would break even and operate close to an efficient scale. Current operators would make negative profits if no exit takes place. With respect to satellite production, the European market could support at most two independent producers of satellites. Rationalization of both production and operation is therefore required. In these circumstances, given that most players are publicly owned, a supra-national authority like the European Commission might play an important role by encouraging the consolidation. Moreover, given that the US market is closed in the medium term and that predation by US firms is a matter of concern, a careful but firm implementation of the EC anti-dumping policy would seem appropriate.

I. Introduction

A significant liberalisation of the satellite communications industry is currently under discussion following the green paper on satellite communication proposed by the Commission of the European Communities. The objective of this paper is to evaluate the widespread liberalisation envisaged by the Commission. We conclude that scale economies in the satellite operation industry are such that under a full liberalisation, as recommended by the Commission, existing operators will make substantial losses. Some exit is likely to be required. We find that four operators would probably ensure an efficient outcome. We also find that, in spite of the large increase in demand for satellites which might result from the liberalisation of the space segment, some rationalisation of the satellite production industry is necessary.

The satellite industry at large comprises a number of vertically related segments; the core activity is the satellite operations sector, which involves the management of satellites in space including transmission and reception (for low power satellites) of signals as well as constant repositioning of the satellite. This segment generates a significant demand for satellite and earth equipment. The satellite operations segment sells its output, which can be measured in terms of power (watts) and frequency (megahertz), to network operators, which themselves sell their output to producers of services like TV stations and telephone operators. In the current situation, the operations of the space segments and that of networks are however often integrated vertically. The operation of networks involves the implentation of complex software and can be in principle be separated from the space segment itself.

Currently, access to the space segment is restricted; space segment operators include mostly public companies, PTT operators and international cooperatives of PTT operators like EUTELSAT and INTELSAT. In addition, there are two small independent private operators over Europe (Pan Am Sat and SES/ASTRA). Providers of final services can only obtain space capacity from public operators through their national PTT operators, which sell their own capacity but also retail capacity over their national market on behalf of the international cooperatives. As far as the publicly owned capacity is concerned, national markets are therefore by and large segmented. In addition, some (final) services (like telephony) cannot be provided by private operators and few licenses to operate private satellites have been awarded so far; as a result, in any given national market, competition is at best limited and monopolies prevail for some services. The operation of networks is also restricted by licenses; in the curent situation, public operators undertake most of the network management.

Significant liberalisation is currently considered for the access to the space segment, the provision of final services and the operation of networks. The Commission's green paper on satellite Communications proposes first that entry into network operations should be greatly facilitated. Concerning the acess to the space segment, the Commission suggests first that service providers should have a "direct access" to international cooperatives. In addition, it favours a policy of "multiple access" requiring that service providers should be able to buy space capacity from any European PTT operator[1]. If direct and multiple access were granted, virtual monopolies (if one excludes the private finge) will therefore be transformed into oligopolies with possibly as many as fourteen players (twelve national operators and two international cooperatives to the extent that those can be seen as independent of their signatories). Finally, the Commission proposal also recommends that "competitive access" should be progressively achieved. This entails a removal of the exclusive rights on some services currently enjoyed by the PTTs and the liberalisation of licenses so that entry by private operators is greatly facilitated [2].

This study evaluates the potential consequences of a full reform which involves both direct and competitive access to the space segment, as well as liberalisation of final services and network operations. Significant policy issues arise both in the space segment industry itself and in the satellite production industry.

A priori, one can be concerned that the proposed liberalisation might have adverse consequences. Indeed, there are some indications that scale economies might prevail in satellite operations. The minimum efficient scale might then be such that existing operators cannot survive and that exit is required. Given that most operators are publicly owned and that much of existing capacity in space is sunk, exit might not occur at the appropriate pace. In addition, it is not clear that free entry into the space segment is adequate in the first place. This process might lead to an excessive number of operators, each operating at a sub-optimal scale (see Mankiw and Winston, 1986). In such case, restrictions on entry might be warranted together with some price regulation. Assessing

[1] In early April 1993, it was announced that the UK, the Netherlands and Germany had commited themselves to grant mutual multiple access.

[2] Currently the space available above EEC countries does not seem to be a constraint (at least on the Ku band). Accordingly, a satellite location in space has little option value. As space became scarce, some auction mechanism would presumably have to be considered.

both of these matters requires an evaluation of the competitive situation that would prevail in case of liberalisation. Key parameters in this evaluation will include an estimate of demand elasticities and an estimate of the minimum efficient scale in space segment operations. Accordingly, this paper will first evaluate the extent to which satellite operations are subject to scale economies by estimating a cost function, using data from EUTELSAT and INTELSAT operations. Second, we calibrate a model of competition which is used to evaluate the effect of liberalisation on the industry equilibrium.

Concerns for the production sector are similar to those arising for the space segment. Indeed, there is some indication[3] that the production of satellites is itself subject to significant scale and learning economies and that European producers currently operate below the minimun efficient scale. According to this analysis, European producers, which, it is claimed by most industry observers[4], do not have access to the US market are not in a position to compete with their American competitors which operate at adequate scale. Currently, the markets are fairly segmented; satellites over Europe, except most of those operated by ASTRA and INTELSAT, have been purchased from European producers. In turn, European producers have not sold any satellite in the US. The question then arises as to whether the increase in demand for satellites which could be generated by the liberalisation of the space segment would suffice to bring the operations of European manufacturers to the minimum efficient scale. More generally, one can wonder about the maximum number of European producers which could operate at the minimum efficient scale in an environnement where the space segment is liberalised. Up to now, entry into the production sector has been encouraged by various national governments and indirectly by the European Space Agency through the principle of Juste Retour, such that research grants are allocated across member countries in proportion with their contribution to the overall budget of the Agency. Satellite producers are currently unprofitatble and a consolidation might be necessary. An assessment of this matter requires a comparison of the minimum efficient scale in production with the potential demand for satellites which could arise in a liberalised environnement. The latter will be obtained from our analysis of the space segment. As to the former, we provide some gross estimate of the degree of scale and learning economies in satellite production using cost data from one European producer.

[3] See for instance Euroconsult, (1990).
[4] See for instance ESA Working group on satellite communication, (1992), or Euroconsult (1993).

The paper is organised as follows. Section 2 briefly describes the satellite operation industry in Europe. Section 3 presents our econometric estimates of the cost structure in the space segment operations. Section 4 analyses the results of our simulation model encompassing both satellite production and space segment operations. Finally, section 5 draws some policy implications.

At the outset, some caveats are in order regarding the quality of the data that is used in the analysis. In particular the information that we obtained regarding costs of satellite production are highly imprecise; estimates of demand parameters from industry sources are also subject to a wide margin of error. In addition, some drastic assumptions had to made in order to carry out the simulations. The results of our model should therefore be interpreted cautiously. One should not attach too much significance to the precise numbers that we have calculated but rather focus on their order of magnitude.

II. The space segment operation in Europe

Communication satellites in fixed orbital positions receive signals from earth stations, amplify them and send them back to earth over a given area, commonly referred to as the footprint of the satellite. Each signal which is received and transmitted is handled by a transponder. Satellites are differentiated according to the number of transponders that they carry, by the bandwith over which they operate and by the power of their transmission[5]. In order to evaluate costs and demand in common units, we define a standard transponder as operating at 36 Mhz and 50 watts and a standard satellite as carrying 15 standard transponders. In what follows, demand, cost and supply will be expressed in terms of standard transponder equivalent or in terms of standard satellite[6] equivalent.

Civil synchronous satellites are used for a number of services including television broadcasting, telephony, private voice and video communication netwoks (VSATs), news gathering (SNG) and land mobile communication (LMSS). Table 1 presents the number of transponders used over Europe in each market segment as well as the revenues to satellite operators from the provision of space capacity for each application.

[5] In what follows, we concentrate on satellite operating in the Ku band; most civil applications are provided in this bandwith except for some of transantlantic telephony which is operated in C band. This band is however saturated and additional uses of satellites for telephony use the Ku band.
[6] The mapping between actual transponders and satellites into standard transponder equivalent and standard satellite equivalent has been validated with ESA.

Insert table 1 about here

On the whole, we find that the TV market is by far the largest market for satellite services in Europe. Telephony in the Ku band represents less than 20 % of the total market for television[7] (that is TV, BTV and SNG together). The provision of VSAT services is still fairly modest. In what follows, we shall concentrate on three market segments, namely television broadcating (including SNG and BTV), telephony and VSAT. We neglect the LMSS segment which is small and according to industry sources is more likely to shrink than to develop further. Table 2 presents the current supply of transponders from the various operators using the same definition of transponders as above.

Insert table 2 about here

Overall, we observe that capacity utilisation is around 86 %. The bulk of capacity is provided by the international cooperatives, France Telecom (with Telecom and TDF satellites), the German Bundespost (with DFS Kopernicus) and the private operator Astra/BSB. There are five significant players and a fringe.

As indicated above, the current regulatory regime is such that national markets are segmented and subject to limited competition. We model the current situation as if it were a duopoly in which firms compete à la Cournot in each national market taken individually. The assumption that there is a duopoly in each country is supported by the observation that in any given country there are at most two fully independent players (Astra/BSB and the national PTT which also retails the capacity of the cooperatives) and that there is no capacity constraint at the country level. This arises because the vast majority of the current supply of transponders have a full European footprint. Next, we also observe that the margins charged by the firms are by and large constant across countries. Such an outcome will arise (given that the market structure is constant across countries) when demand has a constant elasticity (so that mark-ups are independent of

[7] In the US, telephony is relatively more important. This may arise because distance are typically shorter in Europe or because PTT operators have favored the terrestrial links that they operate in parallel with satellites.

market size). In this context, a sequence of duopoly in individual countries is equivalent to a duopoly at the European level. Accordingly, we model the initial situation as a duopoly at the level of the European market.

The assumption that firms compete à la Cournot can be justified on the ground that price competition after capacity decisions tends to yield Cournot outcomes (see Kreps and Scheinkman, 1983). After they have been launched, satellites are sunk and represent a fixed capacity so that the Cournot model fits particularly well the structure of the industry.

The widespread liberalisation considered by the Commission involves both direct and competitive access to the space segment and the liberalisation of the provision of final services. Such liberalisation is likely to occur for TV broadcasting and VSAT services but rather less likely at this point for telephony. In this last segment, cheaper access to the space segment might not lead to proportionate falls in the price of the final service, to the extent that the provision of the service remains a monopoly of the PTTs. In principle, the effect of this liberalisation is to open up national markets to competition from operators located in different countries as well as allowing for entry. We will thus model this liberalisation as an increase in the number of Cournot players operating across the European market. We will consider a symmetric equilibrium which can be seen as a long term situation in which all firms have had enough time to adjust capacity[8].

In order to undertake the calibration, we need to estimate cost and demand parameters. The next section deals with the estimate of costs.

III. Economies of Satellite Operation

Each satellite launched is an individual 'plant' producing telecommunications and television services in conjunction with equipment and labor on earth. Once launched, much of the costs (the costs of the satellite, the launch and launch insurance) are fixed and sunk. However, technological progress matters and each new generation of satellites embodies some new technology; the lifetime of the satellite and antennae

[8] The only significant constraint to capacity expansion that may arise relates to the launching. It seems however that the availability of Chinese and especially Russian launchers might relax this constraint.

technology are the prime characteristics which vary across generations.

Besides the high costs of satellite purchase, launch costs, and launch insurance, satellites must be constantly monitored and moved in space in order to maintain their 'fixed' orbit. Orbit control stations also involve high sunk costs. Each orbit control station consists of a large antennae and control equipment to monitor and control orbits. An orbit control station can control up to 5 satellites; additional satellites then require a new orbit control station.

As mentioned above, the degree of scale economies in satellite operation is central to the argument that full liberalisation of the space segment might not be appropriate. A priori, one can wonder about the cost savings associated with the operation of multiple satellites. As mentioned above, orbit control involves a cost which is somewhat independent of the number of satellites. Scale economies in operation may also arise from the management of spare capacity; it is necessary to hold 'hot' spare capacity, i.e. spare capacity in the sky ready to take over if there is a transponder failure. 'Cold' capacity, i.e. a satellite on the ground, ready to be launched is not an effective source of reliability. Accordingly, a number of transponders are kept free in satellites in order to be able to restore service if a failure occurs. In a system of one satellite, one-half the capacity would be kept free for service restoration purposes; the addition of other satellites to the system reduces the probably of catastrophic failure and the percentage of transponders kept empty falls as the number of satellites in the system increases but reaches a steady state after some six satellites are jointly controlled.

A last feature of the technology of satellite operations warrants attention; it seems, according to industry sources, that the cost of operating a satellite varies according to the service which is provided (even on a standardised satellite). The transmission of telephone conversations requires less sophisticated technology and less precision in the positioning of the satellite than transmission of video signals. It also seems that VSAT services are more costly relative to TV and telephony because they often involve two-way video transmission (TV only requires one way video transmission). Both fixed and marginal costs of operations could be significantly affected by the mix of services and in estimating the costs of satellite operations, we should ideally control for the mix of service provided by the operators.

In order to measure scale economies in satellite operations, one should also be cautious to disentangle proper scale economies from technological progress and economies associated with capacity utilisation (or economies of fill). The latter economies could be particularly misleading; economies of fill are only associated with discrete variation in capacity; the fact that unit costs of satellite operators fall as an existing satellite is used more intensively is not surprising. Most costs (satellite, launch, insurance) are "sunk" once the satellite is in orbit, these costs as well as the costs of satellite control and much management, sales and operational staff (labour) costs are incurred whether that satellite is unused or used to capacity. This "economies of fill" is not a crucial component of any public policy issue, for any satellite, whether operated in a system or separately, will exhibit economies of fill. The issue of economies of scale is the extent of cost savings (if any) when an additional satellite is placed in orbit comparing whether: i) that satellite is operated in a system of other satellites or ii) that satellite is operated independently.

Our brief description of satellite operations "technology" indicated potential economies of scale in coordination and satellite control. In order to quantify these economies, we carry out an econometric analysis. As discussed above we control for various effects of economies of scale, economies of fill, new generations of satellites (technical change), and changes in labor and capital costs on total operating costs, that is

$$C = C(S, P_L, P_K, U, G) \qquad (1)$$

Total costs are related econometrically to the number of satellites (S), two input prices (labour and capital) P_L and P_K, capacity utilization (U), and a generation variable accounting for the average "technology" of the satellites operated (G). The effect of an increase in the number of satellites on costs - holding input prices, capacity utilization, and satellite generation constant - allows us to assess the extent of economies of scale in satellite operations. Similarly, the impact of an increase in the capacity utilization rate on costs - holding input prices, number of satellites, and satellite generation constant - allows us to identify and measure economies of fill in satellites[9]. As mentioned above, one should ideally control for the mix of services provided by the operators; at this point, we have not however been able to obtain precise information on this variable. It still clear that INTELSAT is providing more telephone services (as much as 80-90 % of

[9]In a previous study Snow (1987a, b, 1988) has examined economies of scale for INTELSAT. He finds scale economies (near 2.0) and large subadditivity (-.78 to -.96), which seem excessively high in light of our brief dicussion of satellite technology above. Snow then concludes that INTELSAT is a natural monopoly. Examining Snow's cost function more closely, suggests a misspecifications which could bias estimates of scale economies upwards. He does not account for capacity utilization ot the number of satellites. Output increases, whether through adding capacity (launching a new satellite) or increasing utilization is hypothesised, by Snow, as increasing cost in the same way. Snow then cannot distinguish between scale economies and fill economies, attributing the presumably large fill economies to scale economies.

the total amount of service provided) than EUTELSAT (where telephony might not account for more than 40 %). Even if more precise data could be obtained, the number of degrees of freedom available would still prevent us from estimating a proper multi-output cost function.

We obtain data on the above variables from the operations of EUTELSAT for the period of 1984 to 1995 (with forecasted data for the 1991 to 1995 period), and for INTELSAT for the period of 1967-1989. The data and their construction are described in the Appendix[10]. Our approximation of the cost function (1) is a reduced translog specification and has the following functional form[11] :

$$\log(c)=\alpha_0+\sum_{i=1}^{2}\alpha_i\log(P_i)+\beta_1\log(S)+\phi\cdot U+\mu_0\cdot G+(d+\mu_I\cdot G)I$$
$$+\sum_{i=1}^{j}\sum_{j=1}^{2}\alpha_{ij}\log(P_i)\log(P_j)+\beta_{11}\log(S)^2+\sum_{i=1}^{2}\delta_i\log(P_i)\log(S)+\varepsilon \qquad (2)$$

where I is a dummy for INTELSAT and G is the dummy representing technological generations. The parameter μ_i allows for a firm-specific, inter-generational technology effect, whereas the parameter *d* is just a fixed effect. Interpreting the fixed effect within the context of a frontier model will, in addition, allow us to identify possible productivity differentials between the two firms, INTELSAT and EUTELSAT. Note that the specification (2) is not Diewert-flexible. Due to data limitations we are not able to estimate a more general version of (1)[12]. Applying Shephard's lemma we obtain the system of factor demands leading to the usual cost share equations to be jointly estimated with (2).

---

[10] It is important to note here that only the space segment is modelled here - satellites and orbit control. Data on earth stations are not included. Earth stations are owned by many different operators and data are difficult to obtain.

[11] Since our primary interest here is to analyze single output economies of scale and fill, the translog specification is quite appropriate. The degeneracy of the multi-output translog functional form when modelling product specific costs (such as in scope economies) is not a concern here (see Röller 1990).

[12] Limited degrees of freedom also prevent us from including a number of other relevant variables for which we have data. We have estimated the above system including a number of variables representing other 'technology characteristics' of satellites such as the band width, the number of transponders per satellite, the cumulative number of satellites launched (learning), and a simple time trend (disembodied technological change). As expected given our sample, many of these variables turn out to be insignificant. Nevertheless, our main findings regarding the economies of scale and fill, as well as efficiency remain essentially unchanged.

$$\frac{\partial \log(C)}{\partial \log(P_i)} = x_i = \alpha_i + \sum_{j=1}^{2} \alpha_{ij} \log(P_j) + \delta_i \log(S) + \upsilon \quad i=1,2 \qquad (3)$$

In accordance with standard economic theory we impose homogeneity and symmetry, but not monotonicity. The additive stochastic terms in the system (2) and (3) are assumed to be temporally uncorrelated, contemporaneously correlated across equations, and multinominally distributed. After deleting the capital share equation, we estimate the above system (2) and (3) by seemingly unrelated regression techniques[13]. Table 3 gives the estimated parameters of the cost function.

Insert Table 3 about here

Most of the estimates have the expected signs and are significant. Note that for specification (2), the elasticity of capacity utilization is constant. Our estimate implies that a 10% increase in utilization rates increases costs by only 3.75%, underscoring the importance of capacity utilization for competitive cost advantages.

Since we have a panel data set, the within parameter estimate for INTELSAT can be interpreted as an efficiency or productivity differential between INTELSAT and EUTELSAT in the context of a stochastic frontier model. Given the translog cost function (2) we can compute the relative technical efficiency by *exp(d)*= .45. This implies that the relative cost advantage of INTELSAT is some 45%, in other words INTELSAT's costs of producing a given output at a given set of factor prices and technology are about 45% of EUTELSAT's costs. This seems rather large indeed and the result might be associated with the different mix of services provided by two operators. The apparently higher productivity of INTELSAT might thus be due to the fact that it is providing relatively more of the cheaper telephone services[14]. Clearly, our fixed effects model will pick up any other fixed heterogeneities which might be present in the data. Nevertheless, our results point towards a potentially substantial productivity gap between the two operations.

---

[13] The results obtained by seemingly unrelated regression are not invariant with respect to which of the cost share equations is dropped. Unfortunately, we encountered convergence problems when employing the iterative seemingly unrelated procedure. Invariance can also be achieved via maximium likelihood.

[14] Alternatively, we may not be controlling well the difference in the technology used by EUTELSAT and INTELSAT. .

The effect of the GENER variable suggests that EUTELSAT's acquisition of new satellite technology might not have been cost effective at all. In other words, we find some evidence that a new technology actually increases costs of providing a given output, that is we have negative inter-generational technological progress. On the other hand, we also find no evidence that inter-generational technical progress is significant for INTELSAT.

For the specification in (2) economies of fill are defined as,

$$\frac{1}{Fill} = \frac{\partial \log(C)}{\partial \log(Q)} = \frac{\partial \log(C)}{\partial U} \times \frac{Q}{CAP} = \phi \cdot U \qquad (4)$$

where Q is output (transponders), CAP is the total transponder-capacity in space, and ϕ is the elasticity of capacity utilization which is constant in our case. In words, economies of fill measure the increase in costs from an increase in output, holding the number of satellites in space constant. Note that for the cost function specification (2), economies of fill are a decreasing function of capacity utilisation. That is to say that raising output through increases in utilization is more expensive the higher the utilization rate, resulting in an average cost curve that is flattening as capacity utilization (and output) increases.

Table 4 reports our estimates of in sample economies of scale and fill for the two firms at yearly sample values between 1984 and 1991. It should be noted that EUTELSAT is operating at much lower levels of satellite capacities. As expected, high economies of fill are present for both firms, ranging from 2.7 to almost 5. The average costs per transponder for a satellite already launched fall at a very significant rate as output increases. For example, increasing EUTELSAT's output in 1990 by 10% (through higher utilization rates) increases costs by 3.7% (10%/2.7). As is shown in (4), economies of fill are a decreasing function of the capacity utilization rate, which implies that the utilization is usually lower for INTELSAT. For INTELSAT's cost structure in 1986, when utilization is lowest, a 10% increase in transponders use can be achieved with only a 2.03 % increase in costs.

Insert table 4 about here

As expected with lumpy investment, the economies of scale are much smaller than the economies of fill. Economies of scale are estimated as being between 12% to 20% for the years 1984-1991 (see Table 4), with little difference between EUTELSAT's and INTELSAT's technology. Moreover, it appears from Table 4 that the economies of scale are marginally diminishing over time. We do however conclude that some economies of scale exist. Our estimates of scale economies appear consistent with engineering evidence on scale economies (10% - 15%) and far lower than previous estimates of scale economies (see Snow op.cit.).

To analyze economies of scale as more satellites are added, we report in Table 5 the out-of-sample scale and fill estimates for EUTELSAT's operations, holding all other variables constant at their '91 and '92 levels.

Insert table 5 about here

It is clear that the economies of scale are levelling off from 27% for one satellite to 2% for ten satellites. At EUTELSAT's size in 1991 of four satellites, adding one satellite (which increases capacity by 25%) increases costs by 22%. However, a small fringe entrant could double capacity from one to two satellites at a cost increase of only 79% (in 1991) . This implies that most of the economies of scale are exhausted at modest levels of operation, and that economies of fill can play a relatively important role. However it is clear that fragmenting operations to a number of small firms (1 to 3 satellites each) as is currently the case in Europe, involves signficant losses of scale economies.

Figure 1 graphs a simulated cost function for a firm operating between one and twenty satellites. All independent variables are held constant at 1992 levels (technology, aggregate satellites, factor prices and utilisation etc). Costs are shown in MECU/transponder. The fall in costs are shown, with a near levelling off for a firm operating 15 satellites. Two other cost functions are shown on Figure 1, one at a 10% productivity gain, the second at a 20% productivity gain. These two cost functions will be used in the simulations of the next section.

Insert figure 1 about here

IV. Simulations

This section reports the results of our simulations, where, as indicated above, the widespread liberalisation considered by the Commission is represented by an increase in the number of players in a Cournot competition. Our simulation considers both the satellite production and satellite operations sectors. The cost function of the satellite operations sector is the central element of the simulation and it has been described in the previous section. Additional parameters include estimates of the demand for the space segment and the cost function of the satellite production sector. We first discuss the specification of these parameters and subsequently turn to the results.

IV.1. Production Sector

A priori, the production industry is likely to be characterized by signifiicant scale economies. Such scale economies arise from the existence of large set up costs, development costs and cost savings in procurement. According to industry sources (see e.g. EUROCONSULT, 1991), there are also significant economies of learning.

Existing sources suggest fairly substantial scale and learning economies; for instance, Euroconsult estimates that there is a 15% savings from producing 5 (the production level of Hughes for exemple) as compared to 1 (the level of British Aerospace) satellite per year; and higher savings from the spreading of non-recurring costs of a certain series or platform over more units. Johnson and Casselman (1991) examine the economies of direct broadcast satellites in comparison to cable TV. Their estimates of satellite costs include an estimate of scale and learning effects. They put forward a 33% increase in unit costs as output changes from the production of 10 high power satellites to only 5 units; however they overestimated the development cost of these high power satellite. With a development cost closer to actual figures, one would obtain a 15% to 25% savings from producing a series of 10 instead of a series of 5. This estimate of scale economies is comparable to the aggregate savings estimated by Euroconsult.

Data made available to us by European satellite prime contractors[15] suggested somewhat lower cost savings from the spreading of fixed costs and from learning effects. The prime

[15] This manufacturer wishes to remain anonymous for commercial reasons.

contractors stated that scale economies are relatively modest. Non-recurring costs were estimated to be in the order of 17% for a single satellite, and cost savings of increasing production from one to two satellites to 6% of overall costs. These data indicate a 15% savings in moving from one to two satellites in a single series.

Using these various pieces of information, we have constructed a unit cost function, which is presented in table 6. This cost function has been validated with ESA and indicates that a satellite contractor producing five satellites per period would have a 32% cost advantage over a contractor producing at the rate of one per year. These cost savings fall off as production increases. A producer of 15 satellites per period would have a cost advantage of 22% over a producer of 5 satellites per period.

We will assume that the cost savings resulting from economies of scale will be passed on to the satellite operations industry[16]. Therefore, the number of players in the production industry (denoted by M) affects profitability only through exploitation of scale economies. In addition we will consider that European producers only meet demand from European satellite operators (including INTELSAT for its European operations). This assumption might be acceptable given the European producers have never sold a satellite in the US and that third markets are currently rather small.

Throughout the simulation we will also compare the costs per satellite of the production industry in Europe to that of the larger U.S. competitors. We assume that a "typical" U.S. competitor is operating at a scale of 15 satellites[17]. Economies of scale of 15 satellites would imply an average cost per transponder of ECU 2.44 million. Assuming a production cycle of three years for the European producers as well, we will compare their average costs under various market structures (M).

IV.2. The demand for the space segment

As indicated above, we consider three separate segments, namely TV, VSAT and telephony over a long term horizon and we assume that the demand for these services has a constant elasticity. We consider a transition period of 8 years so that our simulations are meant to describe the situation in the year 2000. Over such a period of

17 This assumption is not unrealistic in light of the bargaining power enjoyed by the satellite operators (satellite manufacturers in Europe are not profitable).

17 This is based on the fact that Hughes operated at that scale during the 1980's, assuming that the production cycle is three years.

time, one can expect that the penetration of services using the space segment will progress further so that demand will grow independently of any change in price. Accordingly, we need to estimate for each segment an elasticity of demand and some growth in market size. These parameters, presented in table 7, are obtained or inferred from various industry sources (Booz-Allen-Hamilton, ESA, EUTELSAT, British Aerospace, Matra). According to these estimate, the market for VSATs services will increase by a factor of 2.5 whereas that for telephony will double.

Insert table 7 about here

IV.3. Results

Having derived the cost function and the demand parameters, the model is calibrated by estimating constant marginal costs in each segment to ensure that observed prices for each segment correspond to the initial equilibrium of a Cournot duopoly. The price of a transponder for VSAT and TV services is equal to 3.9 Mecus per year whereas the price for telephony is somewhat lower at 3.25 Mecus. The lower price observed for telephone service, relative to TV which is assumed to have the same elasticity of demand, reflects the lower marginal cost associated with the provision of this service. The fact that VSAT and TV services are provided at the same price also reflect the higher marginal cost associated with the former services[18].

In undertaking the simulations, we compute the profits of the operators under the various scenarios, in addition to changes in prices and quantities. This is necessary in order to evaluate whether liberalisation is feasible with the existing number of players and to assess whether free entry is desirable. In order to compute the costs, we have used the cost function estimated in the previous section; this function does not however control for the mix of services provided by the firms and accordingly does not provide separate estimates of marginal costs across segments. These estimates of the cost function presented above do not imply either that marginal cost is constant given that some second order terms are significant[19]. There is therefore a potential inconsistency between the assumption of the simulations that there are different (but constant) marginal costs across segments and the way in which profits are computed. This is a significant

[18] The observed prices suggest, given the elasticities assumed here, that the marginal cost of VSAT is 30% lower than that TV services, which in turn is 17 % lower than that of telephony. These differences may seem large and may suggest that the differences in elasticities across markets that we use are excessive.

[19] According to the estimates, the marginal cost (aggregated over the three segments) increases, albeit slowly. This could reflect a higher proportion of TV and VSAT services provided at high output levels.

weakness of our simulation but one that we can do very little about without proper data on the mix of services provided by INTELSAT and EUTELSAT.

Over the horizon 1992-2000, market size will grow exogenously and liberalisation may occur. As indicated above, the effect of liberalisation is modelled as an increase in the number of players and we trace out the new equilibrium of the Cournot game that will arise for increasing numbers of symmetric firms. The main feedbacks of the model can be described as follows ; as the number of players (N) in the operations industry increases, competition is enhanced, and prices will fall. Moreover, the increase in demand for satellite services increases the demand for satellites, which in turns raises the scale of operation in the production industry. Lower production costs will be passed on to reduce the costs of the operation industry[20]. In addition, the increase in demand for satellite services allows the operations industry to operate at higher scale, lowering its costs further[21].

Table 8 illustrates the outcome of this simulation for three market segments (VSAT, TELE, TV), assuming that the production industry has four players (M=4), and that players in the production as well as operations industries are symmetric (see the bottom of the table for further parameter assumptions).

The first experiment presented in the upper part of table 8 relates to a situation where maket size grows over the horizon but where liberalisation does not take place. Under this scenario dubbed "status quo", competition in 2000 is still characterized by Cournot duopoly; firms still compete by pair in segmented national markets. Prices remain at the same level as those observed today[22]. The table describes how costs and profits vary as a function of the number of players in the industry; if six firms[23] remain in the industry and compete by pair in each segmented market (as in the current situation), they will remain profitable and earn a collective profits of about 220 Mecus per year. Alternative scenarios are presented, with the number of firms in the industry varying from 2 to 12. In all cases, the firms remain profitable. All that happens is that higher costs are incurred as the number of firms increase because scale economies are not exhausted; for instance,

20 Clearly, as costs are reduced, a further round of price reduction can be triggered in the operations sector to the extent that marginal costs are affected. Our estimates only take into account the direct consequence of increased demand for satellites and neglect these further induced effects.

21 Furthermore, learning effects can lower costs even further. Our cost function here does not allow for lerning effects.

22 With constant marginal costs and constant elasticity, prices are independent of market size.

23 As indicated above, there are currently five significant players and a fringe.

the cost of fragmentation for N=12 amounts to some ECU 274 million.

Under this scenario, 22 new satellites (NEWSAT) have to be launched between 1992 and 2000 to satisfy demand[24]. This demand determines the scale of operation for the production industry. Using the cost function of the production industry, PTR is defined as the cost of producing a transponder. The variable P-RATIO in any scenario is defined as the PTR relative to the PTR in the 'Status Quo'. In the case of the 'Status Quo' the P-RATIO is obviously equal to one and represents the benchmark against which cost savings in other scenarios are compared to.

Insert table 8 about here

In the second scenario, presented in the lower part of table 8, liberalization in the space segment takes place. The effect of competition on prices is quite large, in particular when the number of competing firms increases from 2 to 6-8. Interestingly, prices with 6 firms would correspond by and large to the price currently observed in the US where access to the space segment is liberalised. It can also be seen that the market grows by over 50% when liberalized, resulting in significant development of downstream industries and services. In the space segment, the increase in demand lowers costs signficantly as firms operate at larger scale; for instance, if the number of active players remains at the current level (6 players), the average cost of a transponder falls by about 18%. In this baseline case where neither entry nor exit occurs, revenues still do not increase in line with total costs and profits become sharply negative (-253 Mecus). In this case, positive profits could just be restored if productivity gains of 20 % (over current EUTELSAT levels) can be achieved. Some 10 % productivity gains are still required to make sure that four firms will break even.

As indicated above, economies of scale are exhausted when firms operate about ten satellites; it appears therefore that an industry structure with about four firms competing à la Cournot would actually ensure that all firms operate at the bottom of their average cost curve (with 636/4 = 159 transponders each) and would also ensure positive profits provided some reasonable productivity gains are achieved.

[24] NEWSAT is defined as demand minus excess supply plus replacements.

Under these various scenarios, the demand for satellites increases by at least 60% (for N=2), and as much as 100% (for N=12). The increased scale in the production industry results in a cost savings of up to 25%. Despite the very significant increases in the demand for satellites, the production industry is too fragmented and not competitive with their larger U.S. counterparts (scale allows U.S. firms to produce at a PTR of 2.44, which corresponds to 15 satellites per production cycle). The four existing European producers of satellites can thus not achieve adequate scale even if full liberalisation of the space segment is undertaken and further entry occurs in operations.

Given that four producers do not achieve a scale sufficient to compete internationally under liberalisation, we consider a scenario where the production industry consolidates into one player (M=1). The results, given in Table 9, show that liberalization with around 4 or 6 players in the operations industry allows the production industry to operate at very low costs, which in turn guarantees that the operations industry becomes viable with smaller productivity gains. In this case, the 6 existing players in the operations industry could break even with modest productivity gains. These firms would still operate below the minimum efficient scale[25].

Insert table 9 about here

V. Policy implications

With respect to the space segment, our simulations suggest that, if the production industry is not consolidated, four operators would break even in a liberalised environment and would operate at the scale of about 10 satellites each, at which most scale economies should be exhausted. Additional operators will put the industry in the red and would involve additional losses of scale economies. An equilibrium with four firms can thus be seen as a zero profit outcome; such an outcome would also guarantee that firms operate close to the efficient scale. If full liberalisation (free entry and exit) occurs, a reduction of the number of players from the current level (about six) has to be contemplated. However, even if no exit occurs so that six players remain in the industry, the net benefit from liberalisation[26] amounts to some 243 Mecus per year (consumers

[25] Taking into account the induced effect of changes in satellite costs on prices in the space segment might however modify this conclusion.

[26] We do not take into account any changes in productive efficiency associated with competition. In this regard,

surplus increases by about 715 Mecus and profits fall by 472 Mecus).

Whether free entry in the operations industry is adequate is harder to evaluate. Our estimates still suggest that a consolidation of the industry into a duopoly[27] (rather than six firms) would improve profits and net benefits by 141 Mecus. Free entry would lead to a (zero profit) four firm oligopoly leading to a net benefit of 272 Mecus (a fall in profit by 310 Mecus and an increase in consumers surplus by 582 Mecus). What is not clear is whether an explicit reduction of the number of firms to three would be superior to the outcome of free entry and exit. Given that there is a large degree of imprecision in undertaking these calculations, and that the imposition of a regulatory scheme might involve significant cost (in terms of errors in the selection of firms), it seems that full liberalisation might indeed be preferable.

Whether exit will occur at the appropriate pace in case of liberalisation is not clear. Both EUTELSAT and INTELSAT are likely to remain active in the industry. So is ASTRA albeit at a much lower scale than the cooperatives. In this context, there might thus still be room for one additional player in the industry (possibly two given that ASTRA cannot be counted as a full player). Potentially, France Telecom, the Bundespost, PANAMSAT and TELE X could remain. Two additional players are also entering this year, namely ITALSAT and HISPASAT. If all these players stay in the industry, everybody is likely to run unprofitable operations (except maybe EUTELSAT and INTELSAT). Some consolidation between remaining players should therefore be strongly encouraged. However, the majority of these players are government owned; some of them may have deep pockets and their operations might not necessarily respond to strict financial criteria. By running unprofitable operations (at sub-optimal scale), these firms will impose an external cost on other operators, which cannot reach adequate scale either. It seems that this externality could only be properly internalised by a supra-national authority.

The European Commission actually has the power (under article 92 of the treaty) to investigate and (in some cases) curb the amount of state aids. Unfortunately, satellite operations do not currently fall under the scope of this article. To enlarge it to comprise satellites could thus be useful to ensure an efficient consolidation.

According to our simulations, the European market can support at most two independent

---

our estimates could be biased downwards.

[27] Where only two firms are licensed and behave as unconstrained duopolists.

producers of satellites under the assumption that they get the whole European market. If US producers get a share of the European market, the European producers would have to compensate lower European sales by exports (either to the US or the Rest of the World). This raises the question of whether a European producer could reasonably have access to the US market; it also gives rise to some concern that American producers might attempt to drive their European competitor(s) out of the market. Indeed, it would seem relatively easy for an American producer operating at say 15 units a year to undercut a European manufacturer at the early stages of its production run; this might deprive the European producer from the early units that is requires to gain learning and achieve long term profitability. If indeed the US market is closed and predation by US firms is a matter of concern, the question arises whether some form of protection of the European market could be appropriate.

The extent to which the US market is closed to European producers is hard to assess; the main barrier to entry which is usually put forward is the extent to which US producers are vertically integrated into space segment operations. According to recent estimates by the US department of Commerce and the OECD, over half of the existing US satellite capacity in 1991 was owned by leading satellite manufacturers. In particular, Hughes owned 33 % and GE (Martin Marietta) some 23 %. This leaves less than 50 % of the commercial market potentially open to European producers. Even though vertical integration has increased in the last few years, some have expressed doubts as to the viability of this strategy. First, it is not clear that satellite producers have the appropriate skills to undertake space operations. In this regard, traditional network operators (like ATT) might be better positioned. In addition, a key competitive advantage of satellite operators is probably the flexibility to adapt satellite specifications to an evolving demand. Being locked in to one supplier could impair this flexibility. However reasonable these considerations may be, still, it seems realistic to consider that in the medium term the US market will remain by and large closed to European firms.

In these circumstances, to encourage the consolidation of the European industry into one or at most two producers appears as a reasonable option. Here again, the European Commission (or any other quasi-executive supra-national power) might have play an important role given that it is not necessarily in the interest of national governments to allow (or encourage) such consolidation.

Given that the US market might be seen as closed in the medium term, the prospect of a successful predation by US firms towards a consolidated European firm has to be taken seriously[28]. It does not follow however that the best policy response is to close the European market. Such a policy would run the risk of seeing existing European producers exploit their monopoly power and would attract additional entry into an industry which badly needs consolidation. The optimal response should thus combine the threat of competition from US producers while avoiding predation. It seems that a careful but ferm implementation of the EC anti-dumping policy could achieve most of this.

28 According to industry sources (see ESA working party, EUROCONSULT, 1990), European satellite producers have the same technology as their US competitors. US firms had a technological advance in the 1970's which has been caught up by Europeans. According to these sources, the competitive disadvantage of European firms only arises from their inability to exhaust scale and learning economies because of insufficient production in a small market.

Appendix - Data Description

INTELSAT data were taken from Annual Reports, supplemented by data provided by INTELSAT on launch dates, in service dates, size of satellite and retirement dates. No attempt was made to distinguish between service over the Atlantic and over the Pacific as in Snow (1987). The technology or generational dummy was set at one for INTELSAT 1 and goes up by one for each generation. A second generation dummy was estimated, which is proportional to the bandwith in the generation. The simpler generation dummy worked as well (or as badly) as the more sophisticated one, principally because of the high correlation between the number of satellites operated and the generation.

Capacity was determined by measuring the number of transponders in operational satellites. Capacity utilization is the number of transponders earning revenues, divided by capacity.

INTELSAT annual reports provide data on operating costs, capital costs and depreciation. Since INTELSAT is a non-profit cooperative, capital costs are the difference between revenue, operating costs and depreciation. We ensured that the capital costs in the books was equal to the rate of return on capital established by the INTELSAT board. In years where this was not true, the "rate of return" was increased. Thus the costs we use are in some years higher than INTELSAT revenues.

In the cost function analysis, the price of labour was taken as the hourly compensation rate (total compensation) in the USA (INTELSAT is headquartered in Washington). The cost of capital in these regressions was the sum of the rate of return (as described above) and the depreciation rate multiplied by the equipment and construction plant price index in the USA for the aerospace industry.

EUTELSAT data for 1985-1991 were taken from Annual Reports. Data for 1992-1995 are forecasted data provided by EUTELSAT. Total costs as reported by EUTELSAT do not include a provision for a return on the equity that the shareholders have invested; except for one year 1988 where the return was 14%. We added such a return for all years. The price of labour is taken from US Bureau of Labour Statistics and represents the wage rate in the European telecommunications sector including all compensation and fringe payments. The cost of capital consists of three components - a 14% return, depreciation as given in EUTELSAT accounts and an equipment price index for the

European communications industry. The number of satellites, launch dates, in service dates and retirements were obtained from EUTELSAT. The generation dummy was estimated using the methodology as for INTELSAT.

REFERENCES

Euroconsult 1989, "Impact industrial et commercial des depenses publiques de R&D dans les satellites de telecommunications".

Euroconsult 1991, "The Competitiveness of the European Space Industry", Final Report, January.

Johnson, Leland L. and Deborah R. Castleman 1991, "Direct Broadcast Satellites: A Competitive Alternative to Cable Television?", Santa Monica, CA., RAND Corporation.

Mankiw and Whinston 1986, Free Entry and Social Inefficiency, Rand Journal of Economics, 17 (1), 48-58

Palmer, Michael and Jeremy Tunstall 1990, Liberating Communications, Policy-Making in France and Britain, London, Blackwell.

Röller, L.-H., 1990a, "Proper Quadratic Cost Functions with an Application to the bell System", Review of Economics ans Statistics, Vol. LXXII, No.2, May.

Smith, Delbert D. 1976, Communication Via Satellite - A Vision in Retrospect, A.W. Sijthoff International Publishing Company, Boston, Mass.

Snow, Marcellus, S. 1976, International Commercial Satellite Communications, Economic and Political Issues of the First Decade of INTELSAT, New York, Praeger.

Snow, Marcellus 1987a, "National Monopoly in INTELSAT: Cost Estimation and Policy Implications for the Separate Systems Issue", Telemetics and Informatics, Vol 4, No. 2, pp 133-150

__________, 1987b, "An Economic Issue in International Telecommunications: National Monopoly in Commercial Satellite Systems", in Economics and Technology in US Space Policy, Molly M. Macauley (ed.), R.F.F. Washington

Table 1. Estimates of current demand

Segment	Market value (Mecus)	Transponders
VSAT	31.2	8
Telephony	97.5	30
TV	452.0	116
BTV	16.6	4
SNG	85.6	22
LMSS	7.8	2
TOTAL	689.7	182

Source : ESA, EUTELSAT, Booz-Allen-Hamilton (1992)

Table 2. Estimates of current supply

Supplier	Number of transponders
INTELSAT (VIF2,VA F12, VBF15, V F2, VIF5, VI F4, V F4)	45
EUTELSAT (II F1-F4, I F4-5)	83
DFS Kopernicus	15
ASTRA 1A-1B	28
TELE X	4
TELECOM 1C - 2A	17
TDF 1-2	5
TV Sat	5
BSB	5
PANAMSAT	4
TOTAL	211

Source : Space Almanach, ESA, EUTELSAT

Table 3 - Nonlinear SUR Parameter Estimates

Parameter	Estimate	t-stat
INT	2.482	8.96
INTELSAT	-.791	-2.79
LABOR	.154	2.43
SAT	1.126	6.27
CUTIL	.375	1.88
GENER	.691	3.36
GENER×INTELSAT	-.379	-2.29
LABOR×LABOR	.003	.51
CAPITAL×CAPITAL	.122	5.71
SAT×SAT	.039	.51
SAT×LABOR	-.076	-4.60
R^2	.96	

Table 4 - Returns to Scale and Fill
(evaluated at yearly sample values)

	EUTELSAT			INTELSAT	
Year	Sats	Scale	Fill	Sats	Scale
84	1.20	1.20	3.55	14.0	1.20
85	2.00	1.12	4.84	15.0	1.20
86	2.00	1.25	3.98	15.0	1.20
87	2.10	1.21	2.85	14.8	1.19
88	3.25	1.17	3.07	14.5	1.18
89	4.00	1.17	3.14	14.5	1.20
90	4.00	1.16	2.70	n.a.	n.a.
91	4.00	1.12	3.11	n.a.	n.a.

Table 5 - EUTELSAT's Economies of Scale

Satellites	Scale 91	Fill 91	Scale
1	1.27	3.11	1.25
2	1.19	3.11	1.17
3	1.15	3.11	1.13
4	1.12	3.11	1.10
5	1.10	3.11	1.08
6	1.08	3.11	1.07
7	1.07	3.11	1.05
8	1.06	3.11	1.04
9	1.05	3.11	1.03
10	1.04	3.11	1.02

Table 6 Average costs of a transponder

Number of sat's Produced per year	Average cost of a transponder (1992 MECUs)	Relative Efficiency
1.	4.493	
2.	3.704	.8244
3.	3.376	.751
4.	3.177	.707 .
5	3.036.	.676
6	2.926	.651
7	2.836	.631
8	2.76	.614
9	2.694	.600
10	2.635	.587
11	2.582	.575
12	2.534	.564
13	2.49	.554
14	2.449	.545
15	2.41	.536

Table 7 : Demand parameters

Segment	Market size (growth 92-2000)	Elasticity
Telephony	100 %	0.9
TV	78 %	0.9
VSAT	150 %	1.36

Table 8

MARKET STRUCTURE SIMULATIONS FOR THE YEAR 2000

Scenarios	Number of Players in Satellite Operations					
(1992 MECUS)	2	4	6	8	10	12
Status Quo						
Costs	897.76	978.64	1039.34	1089.40	1132.70	1171.24
Average Costs:	2.16	2.35	2.50	2.62	2.72	2.81
10 %	1.94	2.12	2.25	2.36	2.45	2.53
20 %	1.73	1.88	2.00	2.09	2.18	2.25
Revenue:						
VSAT	78.00	78.00	78.00	78.00	78.00	78.00
TELE	195.00	195.00	195.00	195.00	195.00	195.00
TV	986.10	986.10	986.10	986.10	986.10	986.10
Price:						
PVSAT	3.90	3.90	3.90	3.90	3.90	3.90
PTELE	3.25	3.25	3.25	3.25	3.25	3.25
PTV	3.90	3.90	3.90	3.90	3.90	3.90
Transponders	416.25	416.25	416.25	416.25	416.25	416.25
New Sat	21.95	21.95	21.95	21.95	21.95	21.95
P Ratio	1.00	1.00	1.00	1.00	1.00	1.00
PTR	4.49	4.49	4.49	4.49	4.49	4.49
Profit:	361.34	280.46	219.76	169.70	126.40	87.86
10 %	451.11	378.32	323.70	278.64	239.67	204.98
20 %	540.89	476.19	427.63	387.58	352.94	322.11
Liberalization						
Costs		1298.35	1449.97	1589.92	1705.15	1787.38
Average Costs:		2.04	2.06	2.14	2.21	2.28
10 %		1.84	1.85	1.93	1.99	2.06
20 %		1.63	1.65	1.71	1.77	1.83
Revenue:						
VSAT		85.80	87.36	88.14	88.92	89.70
TELE		185.25	183.30	183.30	181.35	181.35
TV		936.79	926.93	926.93	917.07	917.07
Price:						
PVSAT		3.00	2.80	2.68	2.65	2.62
PTELE		2.00	1.79	1.70	1.62	1.59
PTV		2.40	2.14	2.04	1.94	1.91
Transponders		636.25	705.00	742.50	770.00	782.50
New Sat		35.70	40.00	42.34	44.06	44.84
P Ratio		0.82	0.75	0.75	0.75	0.75
PTR		3.70	3.38	3.38	3.38	3.38
Profit:		-90.51	-252.38	-391.55	-517.81	-599.26
10 %		39.33	-107.38	-232.55	-347.29	-420.52
20 %		169.16	37.61	-73.56	-176.78	-241.78

Parameters : Symmetric Players in Satellite operations, 4 Symmetric Players in Satellite Production, Capacity Utilization is 80%, 16 transponders/satellite, Factor Prices based on 1992 EUTELSAT prices, Satellite Production cycle is 3 years.

Table 9

MARKET STRUCTURE SIMULATIONS FOR THE YEAR 2000

Scenarios	Number of Players in Satellite Operations					
(1992 MECUS)	2	4	6	8	10	12
<u>Status Quo</u>						
Costs	723.57	814.72	881.80	936.78	984.22	1026.42
Average Costs:	1.74	1.96	2.12	2.25	2.36	2.47
10 %	1.56	1.76	1.91	2.03	2.13	2.22
20 %	1.39	1.57	1.69	1.80	1.89	1.97
Revenue:						
VSAT	78.00	78.00	78.00	78.00	78.00	78.00
TELE	195.00	195.00	195.00	195.00	195.00	195.00
TV	986.10	986.10	986.10	986.10	986.10	986.10
Price:						
PVSAT	3.90	3.90	3.90	3.90	3.90	3.90
PTELE	3.25	3.25	3.25	3.25	3.25	3.25
PTV	3.90	3.90	3.90	3.90	3.90	3.90
Transponders	416.25	416.25	416.25	416.25	416.25	416.25
New Sat	21.95	21.95	21.95	21.95	21.95	21.95
P Ratio	0.63	0.63	0.63	0.63	0.63	0.63
PTR	2.84	2.84	2.84	2.84	2.84	2.84
Profit:	535.53	444.38	377.30	322.32	274.88	232.68
10 %	607.89	525.85	465.48	416.00	373.30	335.33
20 %	680.24	607.32	553.66	509.68	471.72	437.97
<u>Liberalization</u>						
Costs		1118.93	1296.14	1424.27	1536.83	1619.71
Average Costs:		1.76	1.83	1.92	2.00	2.07
10 %		1.58	1.65	1.73	1.80	1.86
20 %		1.41	1.47	1.53	1.60	1.66
Revenue:						
VSAT		85.80	87.36	88.14	88.92	89.70
TELE		185.25	183.30	183.30	181.35	181.35
TV		936.79	926.93	926.93	917.07	917.07
Price:						
PVSAT		3.00	2.80	2.68	2.65	2.62
PTELE		2.00	1.79	1.70	1.62	1.59
PTV		2.40	2.14	2.04	1.94	1.91
Transponders		636.25	705.00	742.50	770.00	782.50
New Sat		35.70	40.00	42.34	44.06	44.84
P Ratio		0.57	0.55	0.54	0.54	0.54
PTR		2.58	2.49	2.45	2.45	2.45
Profit:		88.92	-98.55	-225.90	-349.49	-431.58
10 %		200.81	31.07	-83.47	-195.80	-269.61
20 %		312.70	160.68	58.96	-42.12	-107.64

Parameters : Symmetric Players in Satellite operations, 1 Symmetric Players in Satellite Production, Capacity Utilization is 80%, 16 transponders/satellite, Factor Prices based on 1992 EUTELSAT prices, Satellite Production cycle is 3 years.

Figure 1

Satellite Operations
Simulated Cost Function for year 2000