Report on present status of international connectivity in Europe and to other continents

IST-2001-34925

Study into European Research and Education Networking As Targeted by *e*Europe

SERENATE

Deliverable no. D6

Delivery type: Report
Security: Public document (with confidential annex)

Author: Dai Davies, DANTE

Date: 11 February 2003

CONTENTS

Executive Summary

The SERENATE studies represent a strategic perspective of the future development of research networking in Europe. A key aspect of a network is the technology used in its implementation. An important component in the construction of any network is the connectivity provided by the telecommunications infrastructure that interconnects the nodes of the network. This deliverable reviews the current status of international connectivity within Europe that can meet the requirements of pan-European research networking. It looks at the way the market for connectivity has developed in the last several years and analyses the effects of liberalisation on the marketplace. Finally, a number of scenarios describing the way that the market may develop in the future are presented, together with some conclusions about the future of pan-European research networking.

Research networks require access to the most advanced telecommunications building blocks to achieve their twin purpose of supporting advanced research into networking and supporting the communications needs of collaborative work among researchers. Historically, this has been difficult to achieve because of the monopolistic state of the European telecommunications market. The recent liberalisation of the international market in Europe has had a major effect in allowing access to the most advanced building blocks (currently 10 Gb/s wavelengths) for much of Europe. GÉANT, the current generation of pan-European research network has been able to exploit this to build a world-leading research infrastructure. However, the effects of liberalisation have been patchy. Today, the full benefits of liberalisation are only available in about half of the European countries connected to GÉANT.

The trend in pricing of telecommunications has been one of decreasing prices over the period 1996-2001, with large reductions in the costs of the most competitive international connections. In parallel, however, the divergence of connectivity prices has increased greatly in this period. The difference in cost between the cheapest and the most expensive locations is now very significant. Of the European countries currently connected to GÉANT, a little over half can be considered to have competitive international markets for telecommunications. In the remaining countries, prices remain high and, in some countries, the availability of advanced building blocks is very restricted. There is a strong correlation between the number of suppliers providing international connectivity in any market and the competitiveness of that market. From analysis of the GÉANT tender data, it is apparent that at least four international suppliers are necessary to create a reasonably competitive market.

The EU has studied the effects of liberalisation and concludes that it has generally been effective in opening the European telecommunications market for international services. This conclusion is very suspect when one compares the cost data collected by the EU surveys with the costs currently involved in pan-European research networking. The overall costs of international connections for research networks are significantly lower than those observed in the general marketplace. From this point of view, liberalisation of the market, as measured by the EU, has a long way to go. In addition, if all European researchers are to gain access to the most advanced technology at competitive prices, there needs to be considerable action in the marketplace to ensure that this will be achieved.

The current state of the market is turbulent. In the last ten years a major change has occurred as a result of the emergence of “alternative operators” who have invested heavily in pan-European network infrastructure and created a much more competitive market in Europe. There have recently been a number of failures among these alternative operators. There is a significant risk that the benefits of liberalisation that have been achieved in parts of Europe may start to disappear. In addition, for a large number of countries, the benefits of liberalisation in terms of access to the most advanced technology, at prices comparable with those in the cheapest locations, is something that they have yet to experience. In order to ensure the continuing success of research networking and to share this success equally across Europe, political action will be required to foster the continuing development of a well functioning international market in telecommunications.

1. Introduction

This deliverable describes the current state of the international transport infrastructure available within Europe to support research networking. It is based upon market knowledge gained during the GÉANT network tender, together with additional market information currently available. An important element of the analysis is a statement of the relative cost and availability of connectivity between the different European countries. In addition, the effectiveness of deregulation in creating a competitive and transparent market is assessed by comparing GÉANT cost data with that collected by the European Commission to track progress in market liberalisation. A view of the future market development is also presented. It should be noted that there are a number of instabilities in the current marketplace that make future predictions quite difficult. Consequently, three scenarios are outlined which represent potential future development of international research networking in Europe. In addition, a general overview of the connectivity between Europe and other continents is provided.

2. Networking Requirements of the Research Community

The networking requirements of researchers are demanding. All researchers have an interest in using networks to support their own research activity. Researchers in specific areas of information and communications technology have an additional interest in using networks as a tool for carrying out research into networking techniques and technology. As a consequence, it is a basic objective of research networking to use the most advanced telecommunications building blocks available to construct networks.

Co-operation amongst researchers is becoming increasingly global. The power of computers has increased, and the quantity of data produced in experimentation has multiplied. In consequence, the communications requirements amongst groups of researchers have increased rapidly. In some recent European tests, the data transferred between two research sites was of the order of 600 Mb/s. This was larger, by a factor of two, than the normal aggregate research data flowing between the national research and education networks concerned.

Many of the successful developments in telecommunications in the last twenty years have been pioneered and tested within the research networks. Internet technology and the World Wide Web are two very powerful examples. There is less relevance in a research network that is not using advanced technology since, in that case, the services provided could possibly be obtained in the general marketplace. However, the general marketplace is not capable of supporting the advanced services required by demanding researchers.

Until recently, it has proved difficult within individual European countries to gain access to the most advanced network technology. The key element in this context is the transmission capacity of data links. Networks are built from a combination of switches and routers interconnected by data links. The market for switches and routers is global and it is, therefore, always possible to gain access to advanced technology. In contrast, the market for data links is, necessarily, regional and defined by the geography of the network. The situation in Europe with regard to the availability of high-performance data links for research networking purposes has only improved significantly in the last four years, mainly due to market liberalisation. Many European researchers now have access to the most advanced data link technology available across much of the geography of Europe.

Historically, the monopolistic state of the European telecommunications market, with international connections having to be provided by a combination of national monopoly operators, meant that access to infrastructure for the pan-European research network was, effectively, ‘rationed’. Although advanced data link technology was available internationally in much of Europe, it was not made available for research networks or, indeed, for any third-party networks. It was, instead, kept purely for the internal use of the PTTs, as the monopoly operators were then known. The objective of obtaining access to advanced building blocks internationally was effectively frustrated. The position was not as bad for some of the national research and education networks because the liberalisation of national markets occurred earlier than that of the international market. A number of European national research and education networks were able to deploy advanced building blocks within their own countries. The pan-European interconnection was effectively the bottleneck for international connectivity.

This changed significantly in 1999 with the opening-up of international competition in telecommunications within much of Europe. As a result, the GÉANT network, which was commissioned in 2001, was able to gain access to advanced building blocks for a large section of the geography of the network at much more competitive prices. Historically, the market for transatlantic connectivity has always been more competitive; partly because there has long been a competitive market for telecommunications in the United States and partly because a number of European countries competed against each other to be the European landing point for transatlantic connections. The effect of this was to encourage individual transatlantic connections, but to inhibit the development of a pan-European network that offered data link capacities equivalent to national research networks.

It is relevant to look at the way access to network technology has developed in Europe over the last ten years and to compare this with what has been available in North-American research networks. Table 1, below, sets out the comparisons. It can be seen from this data that, until 2000, European researchers lagged far behind their North-American counterparts in gaining access to advanced data link technology internationally within Europe.

Table 1 Technology Available 1991-2002

Period	Most performant Data Link technology available	Technology available in pan-European network	Technology available in United States network
1991 - 1995	34/45 Mb/s PDH	2 Mb/s PDH	45 Mb/s PDH
1996 - 1997	155 Mb/s SDH	45 Mb/s PDH	155 Mb/s SDH
1997 - 2000	622 Mb/s SDH	155 Mb/s SDH	622 Mb/s SDH
2000 +	10 Gb/s DWDM	10 Gb/s DWDM	2.5 Gb/s DWDM

The period of "rationing" effectively came to an end for many countries with the liberalisation of international telecommunications in Europe. In the last two years, the research networks in many European countries have been able to gain access to transmission building blocks at the leading edge of technology (10 Gb/s DWDM connectivity). The GÉANT network has nine such connections. This represents a significant improvement. GÉANT has a network capacity 40 times greater than its predecessor network (TEN-155), although the budget for the two networks is essentially the same. It has led to the European network being currently more advanced, in capacity terms, than its United States counterpart.

The picture across Europe is, unfortunately, not at all homogeneous when it comes to access to advanced transmission technology. Although GÉANT is able to deploy 10 Gb/s DWDM in twelve locations today, this remains a subset of the total number of countries connected to GÉANT. For the remaining fifteen countries, it is not yet possible to gain access to this technology. In addition, for twelve countries it is not possible to access DWDM technology at all for international connections. Thus, although there has been a significant improvement in access to advanced technology, it remains the case that the basic technical objective of being able to deploy the most advanced technology across Europe is still not met for 55% of the currently connected countries. The position is, therefore, far from homogeneous. In fact, in many countries liberalisation has yet to take effect. An extremely large divide has developed between countries where there is a performant and competitive market for international connectivity and the remaining countries. All signs indicate that there are no forces operating to close this divide. A fundamental political objective is that European researchers should have equality of access to research facilities, including network infrastructure. This is not achieved today.

3. International Connectivity – a European Overview

The GÉANT procurement carried out in the period 2000-2001 represented a major exercise in the analysis of international connectivity within Europe. Thirty-one suppliers presented a total of more than 4,000 offers of connectivity. The data from this procurement, together with the resulting offers selected, has been used to create a picture of the current state of competitiveness of the market as well as to give an overview of the type of suppliers operating in the market today. This data has been complemented by interviews with key potential suppliers and by the addition of further pricing data acquired in subsequent tender activities.

3.1. Status of the Market

International connectivity within Europe still varies quite considerably, depending on the country concerned. There are four groupings that can be identified and applied:

(i) Liberal market, well connected with multiple providers and a reasonably transparent pricing structure.

(ii) Liberal market, with several providers and a less transparent market pricing structure.

(iii) Emerging market, with some competition, where the pricing structure is not particularly competitive or transparent.

(iv) Traditional monopoly telecommunications market with monopoly pricing. These exist both in European Union countries, where the European Union directives apply, and also more commonly in the Accession States where there is less formal political pressure for liberalisation.

3.2. Description of Supplier Type

To complement the market structure, it is important to recognise the number of different categories of suppliers that exist in this marketplace. There are at least four different categories of supplier that can be identified:

3.2.1. Alternative network providers

These have emerged within the last ten years. They have typically built new infrastructure to create their own dedicated pan-European networks. This is used partly to support their own business activities and partly to act as a wholesaler within the European market for telecommunications. Key suppliers are Colt, Level 3, Global Crossing, Telia International Carrier, Viatel and Worldcom.

In general, these networks are based on owned and constructed infrastructure, although the geographic footprint may well be extended by exchanges of connectivity with other carriers. Therefore, the networks are not necessarily homogenous in terms of their quality or capacity. There have been a number of failures in this sector of the market in the last twelve months.

3.2.2. Pan-European networks owned by traditional incumbent operators

Many of the former telecommunications operators have developed international networks in Europe, partly to support their own national customers but, for a large part, as general telecommunications networks on which they can sell their services. The networks may have been constructed or, more typically, bought in the wholesale market. In some cases, the geographic footprint of these networks is limited and the capacity may also be limited. Typically such networks are provided by BT, France Telecom, Deutsche Telekom, Telecom Italia, Swisscom, KPN.

3.2.3. Regional Network providers

These providers do not come from the traditional PNOs. They, typically, own or have acquired alternative infrastructure. The main distinction between this group and the alternative network providers is that the networks concerned have a much more limited geographic coverage.

3.2.4. Links providers

This group of providers belongs to the traditional PNO monopolies. In general, they continue to operate the old 'half-circuit' model of provisioning.

3.3. Developments in Market Competitiveness and Pricing

The comparison of prices and price trends in telecommunications is not entirely straightforward. There are economies of scale which imply that large-capacity circuits, although more expensive in absolute terms, will be more cost-effective than smaller-capacity circuits. The commercial terms for leasing connectivity generally require a minimum commitment of twelve months. To provide a simple measure of comparison, it is possible to divide the annual cost of a circuit by its transmission capacity expressed in Mb/s. This gives a very basic indicator of the cost of connectivity, expressed in euro/Mb/s/year. It is useful for describing price trends over time and for making geographic price comparisons. Users cannot necessarily be expected to be aware of the structure of prices in a market. This is, therefore, a helpful way of conveying pricing information.

More generally, the relationship between prices of connections operating at different speeds is defined by a set of multipliers that have some industry-wide acceptance. These multipliers are usually based on the underlying technology involved in providing service. They can be used to predict, with reasonable accuracy, the cost of different connection speeds, thereby enabling more precise comparisons, over time, of relative costs, allowing for the economies of scale.

During the last five years, the international market for telecommunications in Europe has changed very significantly. In general, it has become much more competitive. However, this trend is not uniform and an extremely large gap has opened up between the most competitive routes and those where competition is limited, or non-existent. Figure 1 illustrates the development of international connectivity costs as measured by the response to pan-European tenders over the five years 1996-2001. It can be seen that, in 1996, prices for international connectivity in Europe were uniform and high. Over a five-year period, this picture has changed dramatically. The cheapest connectivity is a factor of 6,000 cheaper than was the case in 1996. From this factor of 6,000 a factor of 30, based on the general economies of scale, represents the difference between the much larger capacities available in 2001 compared with offers in 1996. These figures show that prices in real terms, taking into account improving economies of scale, have dropped by a factor of 200 in the most competitive parts of the market. This has to be compared with the average trend line of Figure 1, which shows a much more limited general reduction in prices.

Telecommunications is a scale business. Generally, higher capacities represent better value for money. Figure 2 charts the relationship between capacity and relative cost according to the set of multipliers derived from offers in the marketplace. This chart is normalised to 34 Mb/s. As an example, it shows that the cost of bandwidth expressed in Mb/s/year at 2500 Mb/s is 13% of the cost at 34 Mb/s. This relationship is used in the subsequent analysis of price comparisons. It should be noted that Figure 2 is derived from costs of connectivity implemented using SDH technology. The underlying cost of connectivity supplied by directly using DWDM technology, i.e. connectivity at 2.5 Gb/s and higher speeds, is relatively lower because less equipment is involved in its provision. It is, therefore, not possible simply to extend the curve of Figure 2 to higher speeds. There is limited comparative data of the relative costs of SDH and DWDM connectivity at 2.5 Gb/s. From such available comparative data, it appears that DWDM connectivity is approximately half of the cost of equivalent SDH connectivity.

Much of the reduction in price since 1996 is a result of the changing market structure. In 1996, the market was still dominated by traditional operators. A key development in the creation of a competitive market for international connectivity was the emergence of the set of alternative network service providers who built their own pan-European networks and whose business was focussed on the provision of international connectivity. These operators do not cover the complete geography of Europe. Figure 3 shows the current balance between pan-European operators and the more limited offerings of regional and monopoly operators. This is expressed as the total number of operators capable of offering convincing international service from each country. Figure 4 gives some definition of the state of liberalisation of the international connectivity market in Europe as it affects individual countries.

Further analysis of price shows that it clusters around the market groupings identified in section 3.1. It is difficult to make direct comparisons, as, particularly for the less advanced market segments, only slower-speed connectivity is available. The general relationship between the cost of connectivity and the speed of connectivity, as expressed by offers in the marketplace identified in Figure 2, has been used to normalise prices in the different market segments and produces the following table. This represents a reasonable comparison of the relative connectivity costs in the different market segments.

Table 2 International Connectivity Costs in the Different Market Segments

Market segment	Number of Countries	Cost Range
Liberal Market with transparent pricing	8	1-1.4
Liberal Market with less transparent pricing structure	7	1.8-3.3
Emerging Market without transparent pricing	3	7.5-7.8
Traditional Monopolist market	9	18-39

Table 2 shows that the cost of international connectivity in the traditional monopolistic market is between 18 and 39 times greater than the cost in the most efficient market segment, even when allowance is made for the lower speed of connectivity available.

It is sometimes argued that distance is a factor in the underlying cost of provision of service and that more expensive countries are not centrally located in Europe. However, this is also true for the Nordic region of Europe and prices for connectivity to this region are no more than 40% higher than the most cost-effective short routes in Europe. Similar analysis regarding connectivity costs between Europe and North America shows that issues of distance can in no way justify the very large spread of prices within Europe.

It is also relevant to look at some comparisons between the international market in Europe and the domestic US inter-state market. The regulatory and commercial structure of the two markets is quite different and therefore direct analogies cannot be drawn. The behaviour of the two markets in the last two years has, however, been quite similar. In the United States there have been commercial failures of carriers and carriers seeking protection via Chapter 11 of the bankruptcy code. In general, prices, which declined significantly in 2001, have shown signs of stabilising and some increases have been observed. One noticeable difference between Europe and the United States is the structure of prices. In the United States prices are very ‘distance dependant’, often being quoted in dollars per mile. This represents a very cost-oriented approach to pricing in the United States. There is some evidence that the marginal cost of inter-state wavelength services in the United States is somewhat less than the most cost-effective wavelengths in GÉANT.

The liberalisation of the marketplace for international connectivity in Europe in the last five years has had a significant effect on the availability and price of connectivity offered for the construction of the pan-European research network. This effect is, however, not uniform. In some locations in Europe, there is an efficient and transparent market but this is not generally the case. Of the twenty-seven European locations analysed, only eight can be considered to have reasonably transparent and liberal markets for international connectivity. In the case of

the remaining nineteen, there are, for a number of countries, some real signs that competition is beginning to have a significant effect on prices. It is apparent that the number of competing suppliers is an important factor. Figure 5 plots relative costs of connectivity against the number of suppliers. In the eight countries where there is a monopoly or duopoly provision remains stubbornly expensive.

4. Effects of Liberalisation

The liberalisation, by the European Commission in 1999, of the international market for telecommunications in Europe had a significant effect on the price and availability of data communications links. Table 2 illustrates some of the effects achieved. Probably the most significant change was the ability to access advanced technology data links. Prior to this, the links available internationally to build the pan-European research network were essentially the same as those available to general users in the commercial marketplace. The other major change was the very large reduction in price for links. Neither of these changes was homogeneous across Europe. The differences that now exist between liberalised countries, where access to advanced data links at relatively cost effective prices is available, and the other countries, where such access is not available, or is very expensive, are extremely large.

The European Commission has instituted a comprehensive monitoring activity relating to the effect of liberalisation on the telecommunications market. This has been carried out both for the current European Union (EU) states and also for the Accession States. It is apparent, looking at the results of this work, that liberalisation of the international market in Europe is seen as a result of the effects of national liberalisation. There is no separate study of the international market and no regulatory overview. This is perhaps not surprising as there is no European regulator. Instead, international regulation within Europe is overseen by a committee of national regulators. The international market has historically been the most monopolistic. It is the market of greatest importance to pan-European research networking. The absence of direct regulatory oversight represents a great weakness in a market where, as this study shows, there is very considerable room for improvement in transparency and efficiency.

In order to relate the liberalisation experienced by pan–European research networking with the more general measures of market liberalisation observed by the EU surveys of Member States and Accession States, a number of comparisons have been made between the data collected/analysed in the GÉANT tenders and the EU data. There is a striking and important difference. The EU makes no attempt to collect data relating to higher-capacity data links. The maximum capacity of data links studied in the EU survey is 34 Mb/s, which bears very limited relationship to the connectivity that is required for pan-European research networking. This is disappointing. It means that there is no EU perspective on the effects of liberalisation of high-performance data links. Such links, which constitute a “wholesale market,” represent a vital component in the creation of a diverse and competitive market for service supply. By concentrating purely on the retail market, the EU is ignorant of changes occurring in the wholesale market, which are necessary to develop a competitive international telecommunications market.

In order to relate the EU data with the cost data available for pan-European research networking, comparisons have been made between the EU cost data and normalised cost data for equivalent connectivity in GÉANT. This has been done on a per-country basis, as well as on an aggregate basis. Figures 7, 8 and 9 summarise the results of this comparison. The results are quite remarkable. They show that the current equivalent cost of connectivity available to research networking is very significantly lower, in all countries for which the EU has data, when compared with the benchmark prices reported in the EU surveys. The average costs for research networking connectivity in the EU countries are very significantly lower (on average a factor of 26) compared with the compatible cost-data collected in the EU survey. Although the Accession States for which the EU has comparative cost-data, are significantly more expensive than comparable EU countries, the same comparison between research networking connectivity costs and benchmark costs reported in the EU survey applies. In itself, this conclusion is not surprising. The cost data trend for research networking plotted in Figure 1 shows very large reductions in cost for this period. When normalised to take account of larger-capacity connectivity being procured, this factor reduces to 200 in the most competitive locations. When further analysed on a geographic basis, this reduces to a factor of seven in the least competitive areas. These factors have to be compared with the average reduction of about 0.4 (zero point four) recorded in the Commission surveys monitoring the implementation of the EU regulatory framework.

An analysis of this data indicates a number of conclusions, notably:

(i) Although the liberalisation of the telecommunications market in Europe has had some effect on the cost of international data links in the general marketplace, this effect is small when compared with the

benefits experienced by research networks. The European Commission has recently announced the closure of its enquiry into the telecommunications sector pricing of leased lines due to a significant drop in prices. This is very surprising, given the data collected for research networks, which shows that significantly greater reductions have been achieved, even in the worst cases. In addition, there is a broad spread of reductions, which indicates very considerable scope for additional price reductions.

(ii) The effect of liberalisation in the Accession States is significantly less than within the EU. To make certain that researchers within these countries are not disadvantaged in access to international communications when compared with their EU counterparts, there is a serious need to ensure that an efficient market develops within the Accession States. An analysis of potential underlying reasons for the relative lack of competitiveness in the Accession States, taking into consideration factors such as the dominance of incumbent operators in new markets, i.e. mobile and Internet, has not identified any specific factors to explain the situation. It is apparent that liberalisation requires continuing political pressure to achieve a homogeneous international market within Europe.

(iii) There has been no serious attempt to measure the effect of market liberalisation on high-capacity connectivity. This is a serious shortcoming in all the work that the EU has done in examining the progress of market liberalisation. These connections are of particular importance for research networking, as they are necessary for the creation of very high-performance infrastructure to support research. High-capacity connectivity is also the basic building block necessary for the creation of competitive alternative telecommunications services and for the high-capacity optical networking that will be required by future pan-European research networking. As such, knowledge of the effectiveness of liberalisation in this, essentially wholesale, market would give a much greater insight into the progress of creating an efficient market in telecommunications.

(iv) Using the results of the tender actions for GÉANT as an indication of the effect of liberalisation of the marketplace, particularly in relation to high capacity connectivity, produces a very mixed picture. In some countries, liberalisation has had a marked positive effect, both on the availability of high-speed data links and on pricing, to the extent that 10 Gb/s wavelengths are available internationally at prices that have improved dramatically over a three-year period. However, for a majority of countries, the picture is one of much more limited progress.

5. Global Connectivity

The primary global route from Europe is that between Europe and the United States. It is characterised by multiple, modern, DWDM based, cable systems. As a consequence, when considering the much greater distances involved, prices for wavelengths on these systems, although higher by a factor of 2-3 than equivalent intra-European wavelengths in the liberalised market sector, are comparable with the most competitive intra-European prices. In absolute terms, they are competitive when compared with the non-liberalised market in Europe. It does mean that it is relevant and sensible for Europe to interconnect as a region with North America as a region. In comparison, connectivity between Europe and other world regions, most notably Africa, Latin America and Asia-Pacific, is much more fragmented and expensive. The only continent to which direct high-capacity data links are available is North America.

Looking at each of these regions in turn:

5.1. Africa

Infrastructure in Africa is generally very poorly developed with a heavy reliance on satellite systems. There are some coastal systems connecting Atlantic-Ocean and Mediterranean countries to Europe, but prices are generally higher than historic European prices. In addition the maximum building blocks available are slow-speed connections.

5.2 Latin America

There is a reasonable amount of infrastructure that has recently been implemented within Latin America, with three competing cable/terrestrial fibre-optic systems covering a number of Latin-American countries and providing connectivity to Europe. The CAESAR study envisages the creation of an evolving pan-Latin America network with direct connectivity to Europe at speeds of 45-155 Mb/s.[1]

5.3 Asia-Pacific

There are two modern, directly routed, cable systems between Europe and Asia-Pacific. However, these have multiple landing points and are relatively expensive when compared to equivalent transatlantic systems, which are basically point-to point. Connectivity on these directly routed cable systems is typically a factor of 10-100 more expensive. In addition, the maximum building block available is a 155 Mb/s connection. Asia-Pacific is well connected to the United States at higher capacities. As an alternative to direct connection, a connection transiting the United States can be more cost-effective. The lack of a well-connected intra-regional infrastructure connecting research networks in Asia-Pacific is also a factor. When considering inter-regional connectivity between Europe and Asia-Pacific, current connectivity is focussed on Japan and Korea. The Trans Euro-Asia Informatics Network (TEIN) initiative is seeking to find a pervasive inter-regional solution.

5.4 North America

There are five modern transatlantic cable systems. All of these systems terminate on the East coast of the United States. In Europe, the systems terminate in European countries with an Atlantic seaboard. The main cables land in Ireland, the United Kingdom, France, the Netherlands, Denmark and Germany. Although it is possible to obtain transatlantic connections between the principal cities of Europe and the United States, the cables generally

[1] See www.dante.net/caesar/

terminate at a limited number of locations and the most cost-effective connectivity is available between these limited landing points. The price evolution of transatlantic connectivity is very similar to that for intra-European connectivity. Figure 6 shows the way this has evolved in the last four years. The most advanced connectivity building blocks are available on these systems. It is possible today to get transatlantic access to 10 Gb/s wavelengths.

6. Status of the Supply Industry

Although deregulation has had significant beneficial effects on a number of countries in the European market, the recent downturn in the telecommunications industry has made prediction of future developments very difficult. In the last twelve months, four pan-European carriers have been declared bankrupt: Carrier One, KPN/Qwest, GTS-Ebone and Interoute. Of these, there is some prospect that Interoute will survive. In addition, Teleglobe has left the international market for communications. Global Crossing and FLAG have taken advantage of the protection from creditors offered under Chapter 11 of the United States bankruptcy code.

There are diverse reasons for this state of the market. The enormous premiums paid for Third-Generation mobile telephony licences (100 billion euro) have taken very large sums of money from the industry. The general over-optimism about the opportunities for Internet services and e-commerce has proved to be unfounded. It is also to be noted that none of the alternative service providers are yet profitable. All of these factors have had a very dramatic effect on the development of prices in the last twelve months. Over the last four years, we have seen price declines of the order of 60% per year cumulatively. However, between 2002 and 2003, the total price reductions for high-capacity connectivity within GÉANT were only of the order of 3%. It has generally been assumed that some form of "Moore's Law" applies to telecommunications, namely that a doubling of capacity can be expected on an annual basis for the same price. Even taking a five-year view, it is difficult to see this being achieved under the current market conditions. Whilst there is some likelihood that there will be more corporate failures[2], there are encouraging signs that significant cost reductions, mainly as a result of major reductions in headcount, will lead these businesses to achieve profitability in the next couple of years.

From a pan-European perspective, the highest connectivity costs occur in the less competitive parts of the market where liberalisation has been less effective. There is very considerable scope for potential price reductions here and, as far as research networking is concerned, it seems reasonable to look to greater market competition in the more monopolistic parts of the market to yield cost reductions. Such a movement would have the very desirable effect of reducing the significant digital divide that has developed over the last five years. It is, however, not at all clear that any forces exist, politically or economically, to make this happen.

In a somewhat surprising development, the EC has announced its intention to stop monitoring the key market for international leased connectivity even though, as shown in Section 4, the reductions in price that have taken place in this market are relatively trivial. Market liberalisation in Europe is, at most, partial. As described above there are very large variations in the cost and availability of high-capacity connections. If all of Europe is to benefit from a competitive and performant international research network, it is apparent that there needs to be significant political action, particularly in the Accession States. It is, today, not at all clear whether this will happen. Section 7 below outlines three potential development scenarios of varying degrees of optimism setting out future market developments over the next five years.

[2] See SERENATE deliverable D4 “Report on workshop on operators’ views on infrastructure and likely evolution”

7. Market Development Scenarios

It is not possible, with any accuracy, to predict the way that the market for international telecommunications in Europe will develop in the next five years. In order to give some future perspective for the further development of pan-European research networking, the following scenarios have been developed.

7.1. Scenario 1

In this scenario there is growing market competitiveness, particularly in the Accession States and in the less liberalised parts of the European market. The very large divergence of costs between cheap and expensive locations essentially disappears. Direct access to infrastructure, or to very high speed data links, becomes ubiquitously available internationally at prices that relate directly to the cost of provision of service. The GÉANT network today shares costs according to a country's access speed and underlying international costs of service provision to that country. In general the more expensive countries pay more than the cheaper countries in absolute terms but significantly less in relative terms. Table 3, below, shows the current relationship between costs and revenues, divided between those countries that have access to wavelength connectivity and those restricted to slower-speed SDH connectivity.

Table 3 Types of International Access

Type of international Access	Percentage connectivity cost	Percentage revenue contribution
Wavelength	55	79
SDH	45	21

It also needs to be recognised that, in general, the SDH-connected countries have poorer quality connections with less international bandwidth to support the access and, in some cases, no resilience because the only affordable way to provide international connectivity is via a single international connection. In contrast all wavelength-connected countries have at least two independent connections at 2.5 or 10 Gb/s.

The ubiquitous availability of high-performance cost-effective connectivity would have a significant effect on this picture:

(i) It would allow all connected networks to gain access to high-capacity connectivity.

(ii) It would enable resilient international connectivity to be provided to all connected countries today. Currently ten countries do not have this resilience.

(iii) It would enable a significant additional capacity to be made available within the network to support new activities within the current budget.

This scenario is very unlikely to occur without significant political initiatives to foster and develop a competitive and transparent market in telecommunications.

7.2. Scenario 2

In this scenario, there is more limited development of the market with little, if any, regulatory intervention to encourage a competitive international marketplace. As a consequence, the underlying cost differences between cheap and expensive countries will remain. The availability of direct access to infrastructure, or to very high

capacity connectivity, for part of the geography of the European network will be seriously limited. As market liberalisation gradually develops, it is likely that there will be some modest reduction in costs of connectivity, together with an increase in the availability of direct access to high-capacity wavelength connectivity. As a result, the commercial and technical distortions apparent in GÉANT today, will continue for the foreseeable future. The overall picture is one of stability, in terms of maintaining an infrastructure that will provide pan-European connectivity. The goal of allowing equality of access for researchers to networking will not be achieved.

7.3. Scenario 3

This is the most pessimistic of the scenarios in which further market failures occur among the alternative operators that have done so much to create an internationally competitive market in parts of Europe. As a consequence, the market will revert towards its former structure, where dominant national operators are the major providers of international service. They may well extend their networks with a limited footprint to meet the basic requirements for international connectivity, but the majority of connectivity is provided via interconnection agreements similar to the old 'half-circuit' arrangements for the provision of international connectivity prior to de-regulation. In this scenario, there will be very considerable divergence of price with a reasonably competitive market between those countries where there is maximum investment today, namely France, Germany, the Netherlands, the United Kingdom and Belgium, and much more limited competition in other regions. This scenario will lead to greater divergence of price to the extent where it will be difficult to organise effective cost sharing and where access to infrastructure will vary significantly between countries. It is likely that this will lead to a minimum pan-European interconnection at relatively low speeds. It could lead to a complete fragmentation of the provision of research networking.

8. Conclusions

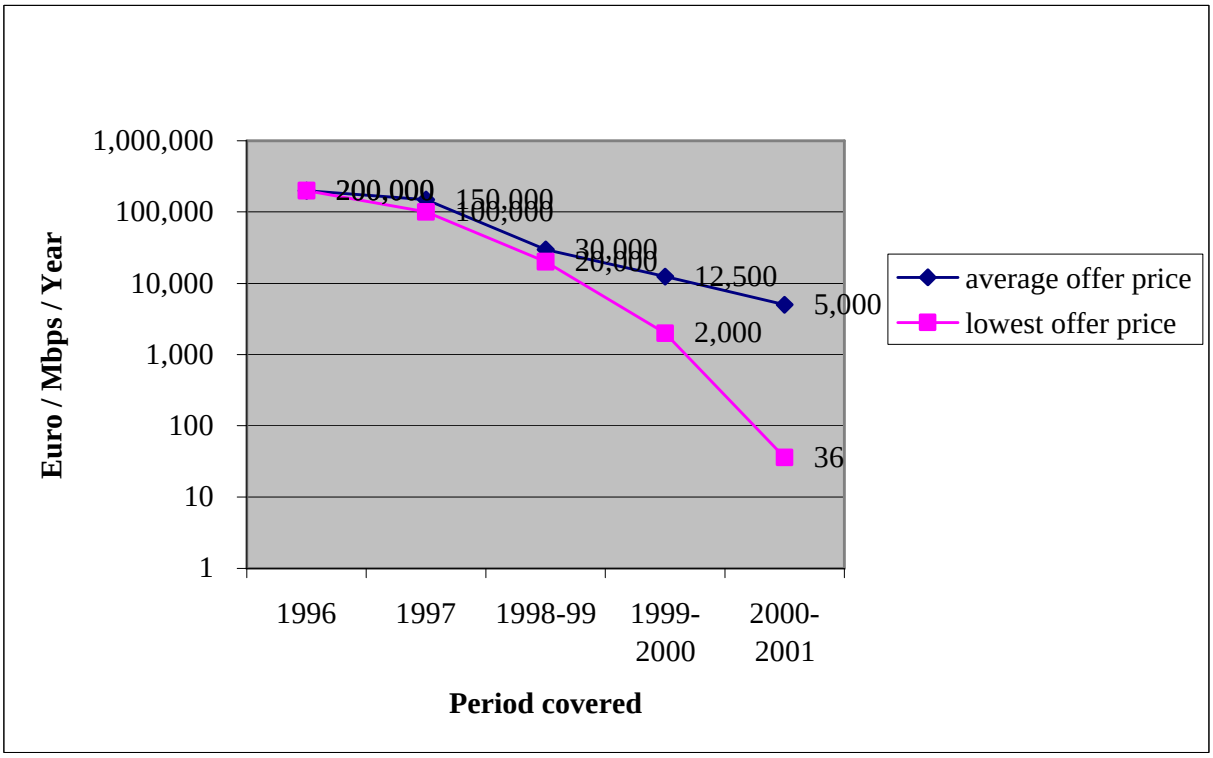
1. There has been a significant reduction in the cost of international telecommunications within Europe in the last five years. This has enabled the pan-European research network to deploy the most advanced technology for much of its geography. There is, however, now a huge variation in the cost of international connectivity within Europe, with the most expensive connectivity being 39 times as expensive as the cheapest and with advanced technology being available only in the more competitive locations.

2. In all the countries connected to GÉANT, the research interconnection cost is significantly cheaper than the average cost reported in the EU surveys of liberalisation. Whilst liberalisation has almost certainly acted as a catalyst to achieve this, the overall effects of liberalisation, as recorded in the EU surveys, are quite disappointing. The intention of the EU to cease monitoring the effects of liberalisation is to be deplored.

3. There are eight European countries where there is an efficient market for international intra-European connectivity, but that effectively only covers connectivity between those countries. There are a further seven countries that, although not as competitive as the first group, nevertheless offer relatively cost-effective and performant connectivity. There are three more countries, where costs are significantly higher, but access to performant connectivity is available. The remaining nine countries are characterised by very high prices and limited or non-existent choice of supplier. This implies that only a little more than half of the European countries connected to GÉANT have competitive international telecommunications markets. There are no underlying cost reasons why differences of this size should exist.

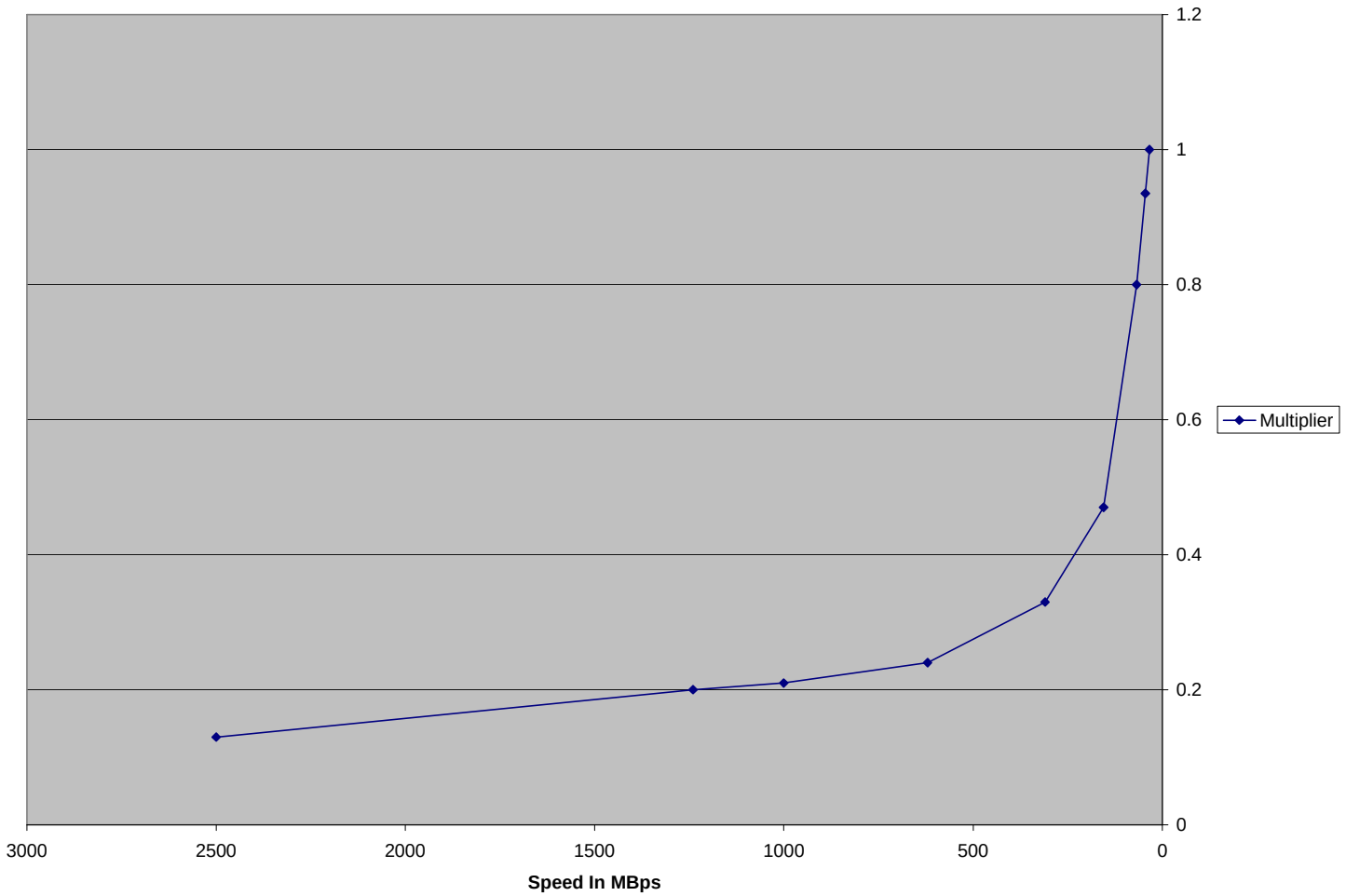
4. There is a strong correlation between competitive pricing and the number of suppliers operating in a market. In order to stimulate competition and reduce the very large variations in cost and availability of high-capacity links, political action is required to ensure the development of a much more efficient and transparent market for international telecommunications. Without such intervention, the current fragmented state of international research interconnection in Europe will remain. There is a real danger that the achievements of GÉANT will shrink to a limited set of the most competitive European telecommunications markets.

Figure 1 Evolution of Market Competitiveness : International Intra-European Connectivity



This figure shows the development of international connectivity prices in the period 1996 - 2001 as measured by the response to tenders for the various pan-European networks that have been implemented during this period. It is expressed in the simple measure of euro per Mb/s per year using a logarithmic scale.

Figure 2 Multipliers for Differing Circuit Speeds



This figure shows the relative cost of connectivity at differing circuit speeds.

Figure 3 Graph of International Suppliers per country (GÉANT tender data)

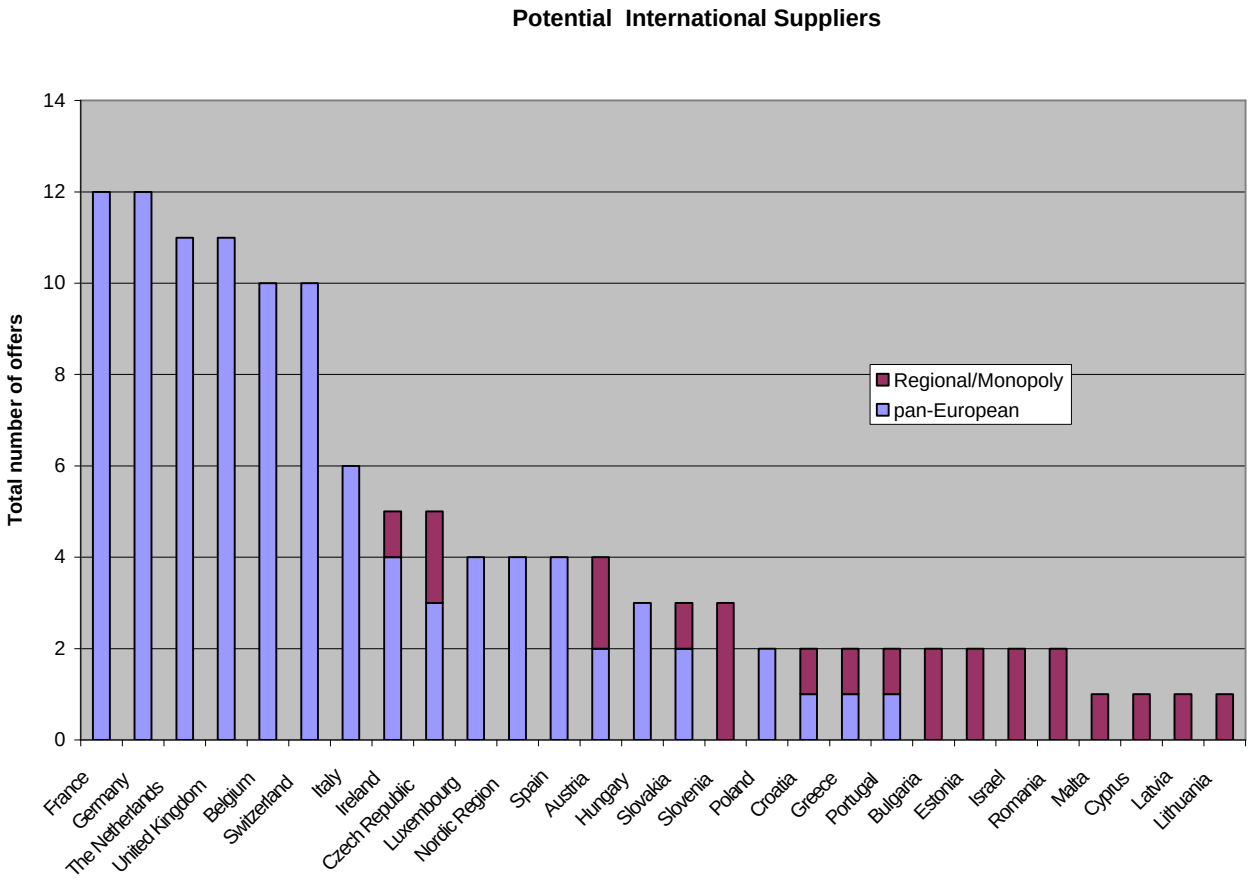
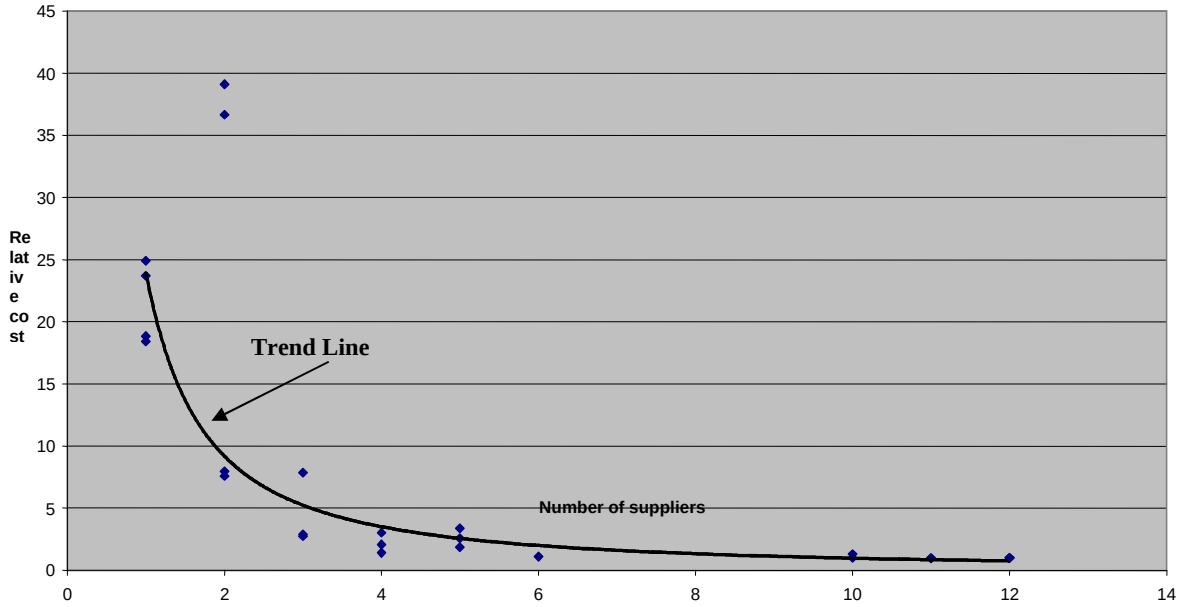


Figure 4 Market Characteristic for International Connectivity by Country

Country	Multiple Suppliers Transparent Pricing	Several Suppliers Less Transparent Pricing	Few Suppliers No Transparency of Pricing	Monopolistic Pricing
Austria		x		
Belgium	x			
Bulgaria				x
Croatia			x	
Cyprus				x
Czech Republic		x		
Estonia				x
France	x			
Germany	x			
Greece				x
Hungary		x		
Ireland		x		
Italy	x			
Latvia				x
Lithuania				x
Luxembourg		x		
Malta				x
The Netherlands	x			
Nordic Region	x			
Poland			x	
Portugal				x
Romania				x
Slovakia		x		
Slovenia			x	
Spain		x		
Switzerland	x			
United Kingdom	x			

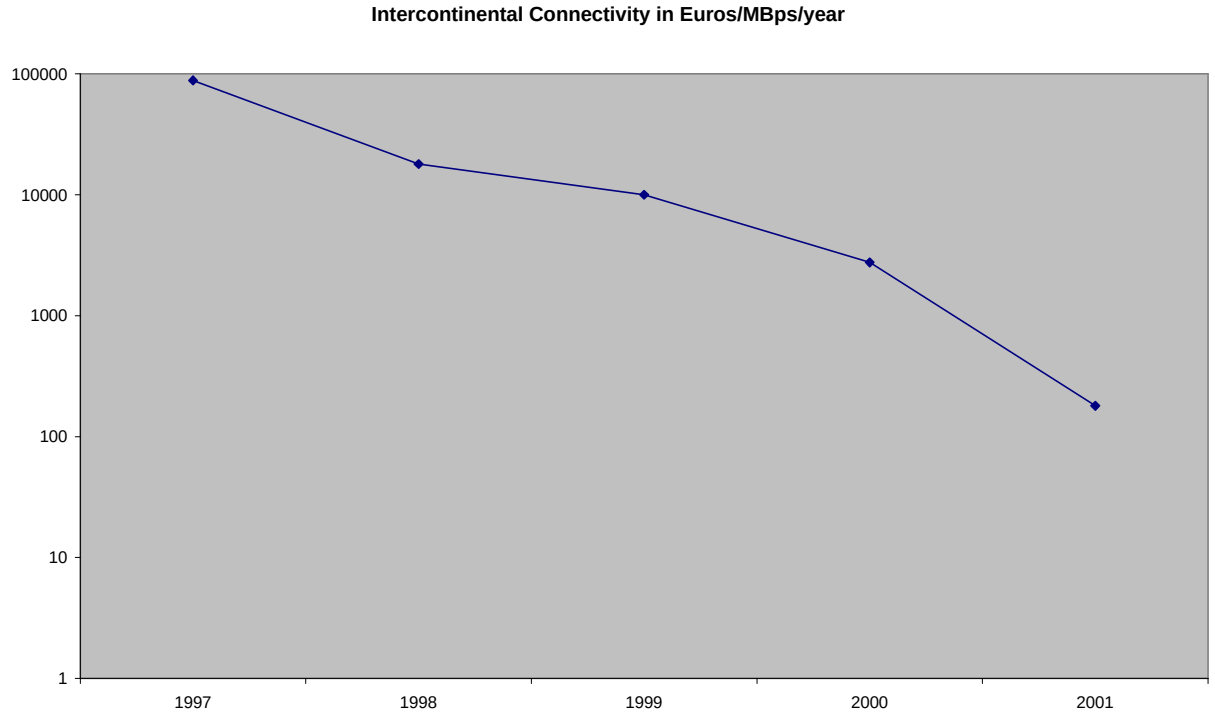
Figure 5 Relative Cost of Connectivity Compared with Number of Suppliers [3]



This figure plots the relative cost of connectivity in response to the GÉANT tender when compared with the number of suppliers offering international connectivity. Each data point represents a country and the relative costs of connectivity have been normalised to take account of the fact that slower-speed connections are more expensive than higher-speed connections. The trend line represents the best fit among these data points excluding the two outlying data points at the top left-hand corner of the graph.

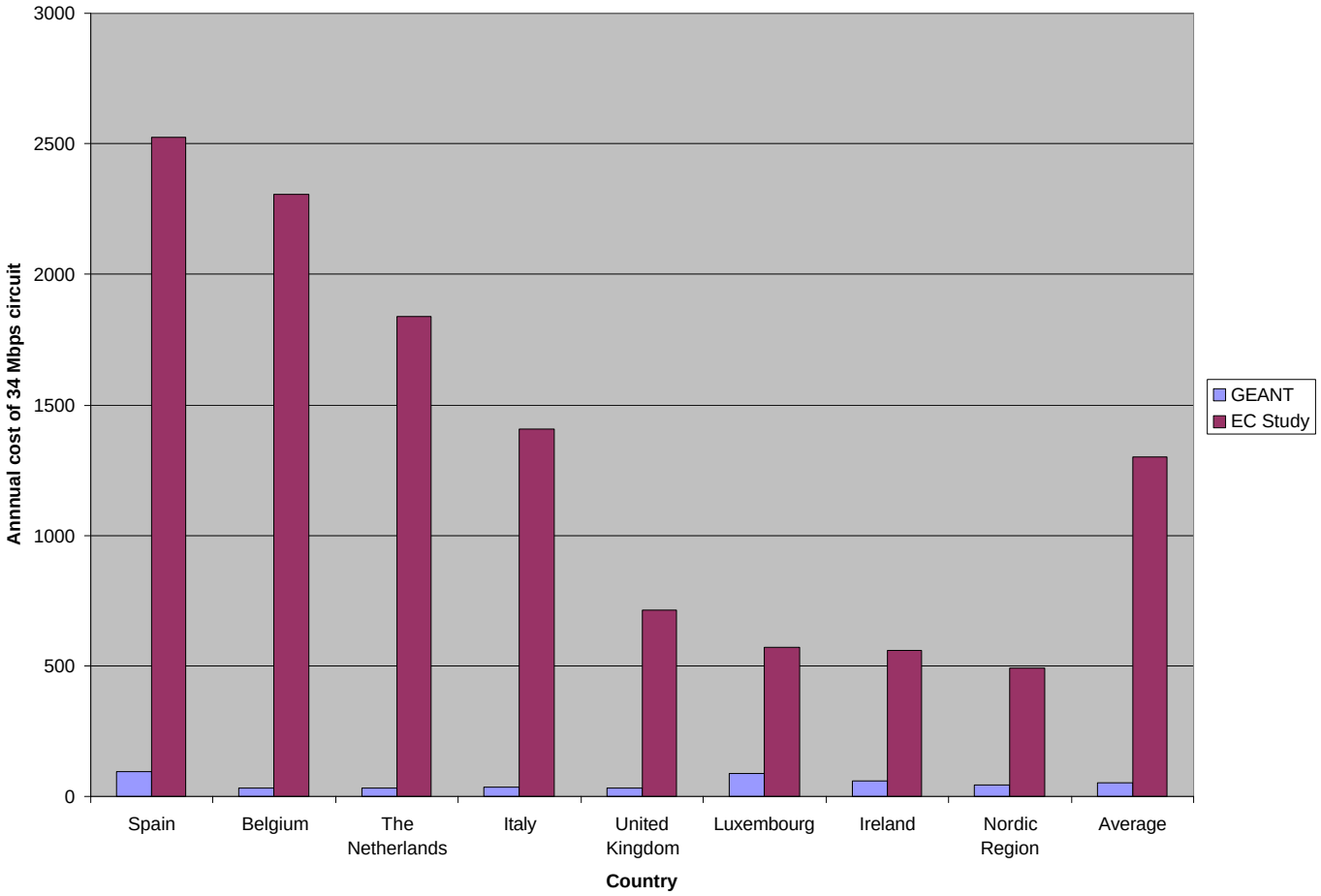
[3] A confidential Annex is available to the European Commission that details the base data on which this analysis is made

Figure 6 Intercontinental Connectivity price evolution Europe-USA route



This figure plots the development of inter-continental connectivity prices between Europe and North America on the same basis as the intra European connectivity costs in Figure 1. As is the case in figure 1, the more recent data represents much higher speed connections. The connectivity has evolved from 34 Mb/s connections in 1997 to 2.5 Gb/s in 2001.

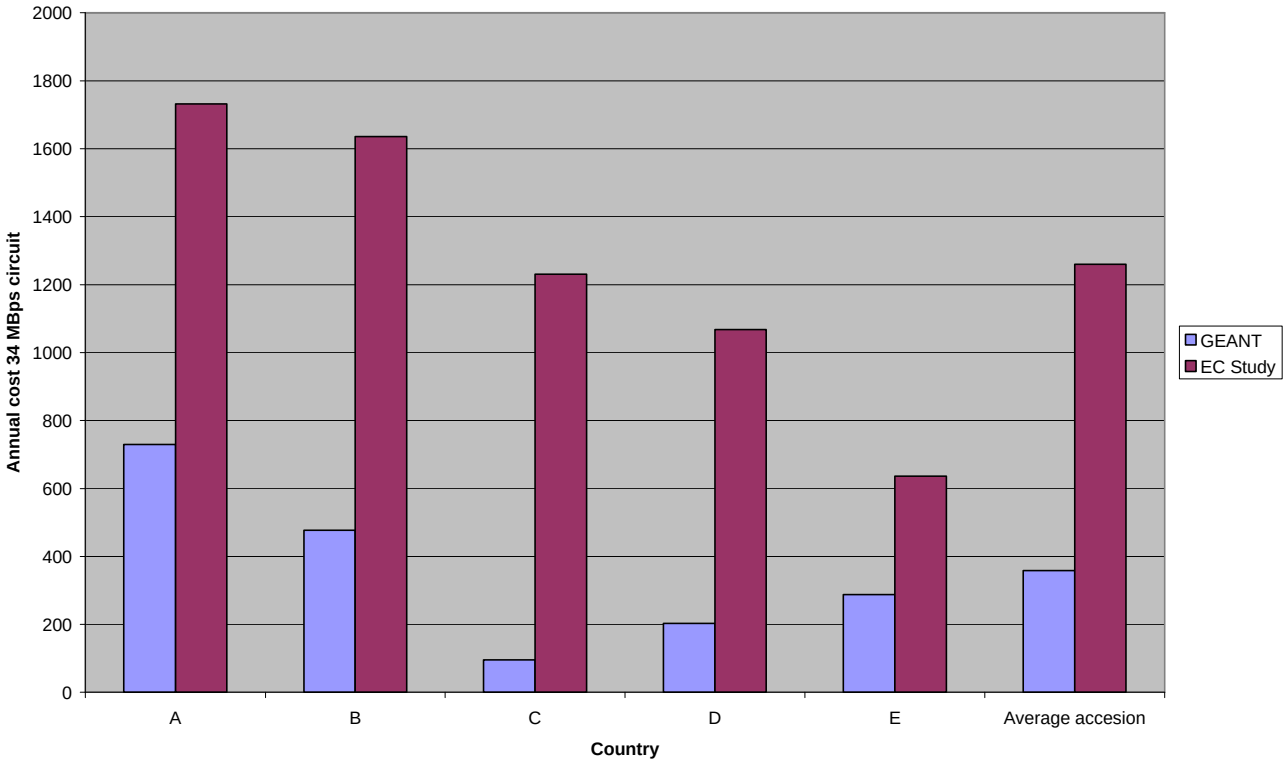
Figure 7 Comparison EU Cost surveys – GÉANT procurement cost data for EU Countries[4]



This graph compares the EU cost data for 34 Mb/s circuit to a near international country with equivalent GÉANT data for those countries where EU survey data exists.

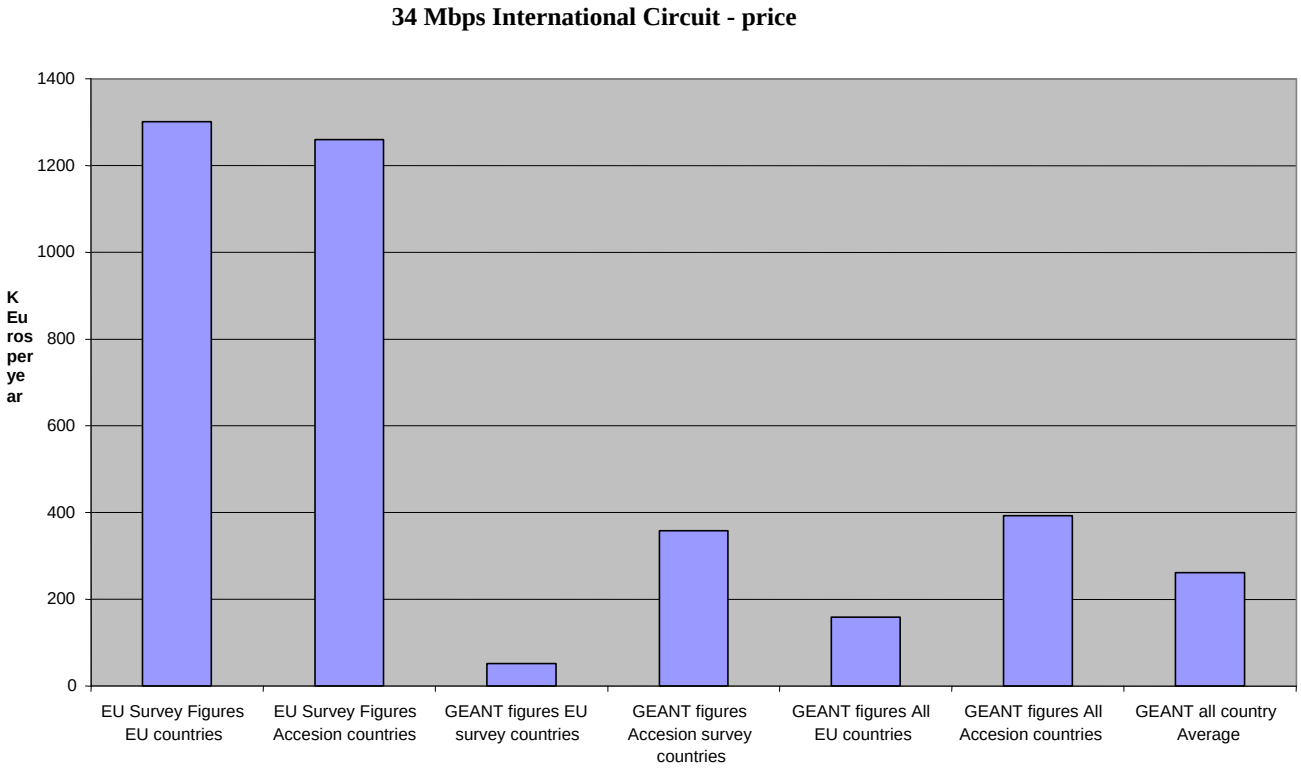
[4] A confidential Annex is available to the European Commission that details the base data on which this analysis is made

Figure 8 Comparison EU Cost surveys –
GÉANT procurement cost data for Accession States (anonymous)



This graph compares the EU cost data for a 34 Mb/s circuit to an Accession State country with equivalent GÉANT data for those countries where EU survey data exists. The identity of the countries has been made anonymous for reasons of commercial confidentiality.

Figure 9 Combined EU-Accession State Comparison



This figure compares the 34 Mb/s lease circuit price surveyed in the EU survey and the effects of liberalisation with equivalent data obtained from the GÉANT procurement. As there are very few 34 Mb/s circuits in the GÉANT network, the cost of a 34 Mb/s link is imputed from the cost data associated with a particular country. The EU survey figures do not cover all of the Accession States or member States. Comparable GÉANT figures are provided for the EU survey countries and also for countries where only GÉANT data is available.