

AN OVERVIEW OF THE USE OF SUBMARINE CABLE TECHNOLOGY BY UK PLC

MARCH 2006

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Executive summary

This report examines the sub-sea fibre optic infrastructure terminating in the UK and considers its importance in terms of supporting critical national infrastructure and its vulnerability to electronic attack.

Early systems based on PDH have been progressively phased out in favour of higher capacity SDH and SDH/WDM systems which offer better resilience and improved management characteristics. Three main system architectures are in use: repeaterless, branching and ring. These architectures have been developed to match the needs of connecting the UK to Europe, SE Asia and the Americas. Examples are given.

The major operators and equipment providers are identified and their contact details are recorded in Appendix A and B. BT has been identified as a Significant Market Provider (SMP) on almost half of the 235 (or so) routes to other countries terminating in the UK. Cable and Wireless are SMP on about 4 of the routes while the remainder are deemed to be competitive with no single provider dominating the route.

Sub-sea systems carry the same types of end user services as the UK SDH and fibre optic network as described in the sister report [1]. Although a detailed breakdown of the service volumes has not been identified for the sub-sea systems, it seems likely that the proportion of voice, Internet and corporate data is comparable to the UK traffic, although it is possible that the proportion of mobile voice calls may be lower. So just as optical fibre technologies provide reliable, high capacity, network connections for UK telecommunications services, the international connectivity for those same services is provided very largely by sub-sea SDH and optical fibre systems. System capacity is leased through 6 basic service types, like private circuit capacity is leased in terrestrial networks.

According to the Oftel review in July 2003 [3], the United Kingdom was reported to be the largest EU, and second largest worldwide international telecommunications market, with a total international traffic of approximately 20 billion switched minutes in 2001/2002. BT was the largest EU carrier and third largest world carrier of international traffic. C&W is the fourth largest EU carrier and seventh largest world carrier. The United Kingdom is the main European landing point of transatlantic, African and Asian submarine telecommunications cables.

Sub-sea systems are designed to have very high resilience against failure. The most common reason for failure is through physical cable damage from shipping, particularly in shallow seas. Newer ring systems and paired cable systems have adequate redundant capacity and employ automatic protection switching in the event of failure. It is not clear how this automatic protection switching is implemented in branched cable systems.

Management systems are based on the Telecommunications Management Network (TMN) standard which offers some security against electronic attack. As for the terrestrial systems described in the sister report [1], there are potential opportunities for compromise if an attacker were to gain access to the data communications network or to the management system. Unauthorised access to network or element managers could lead to major service disruption, but providing that security policies are carefully implemented the disruption could be contained.

Given the open source nature of this report, a number of recommendations are made for further study which would involve specific discussion with owners and operators.

Scope and approach

This report describes the use of 'Submarine cable technology by UK PLC' and will be used by NISCC in their role to protect the UK Critical National Infrastructure (CNI) against an electronic attack. The report sets out the UK environment in terms of the Infrastructure Technology, Service Routes, Providers and the Regulatory position using mainly open source material identified and listed in the reports bibliography. Much of the carrier technology is common with that described in the sister report on the use of 'Wide area network fibre optic and SDH technology by UK PLC' [1] and reference will be made to this report to avoid too much duplication.

In order to assess the dependency of the CNI on this technology, first the major architectures are identified and described. The three main architectures are shown to be allied to the three major service routes as shown below:

- Repeaterless – used between UK and Europe;
- Branching – used between UK and SE Asia and terminating on route in a number of countries;
- Ring – used between the UK and the Americas across the Atlantic.

The dependency relating to these major service routes is then summarised. The relevant owners and operators are identified and their location and contact details are listed in an annex to the report.

Liberalisation and regulation in recent years have had a major impact on shaping the UK telecommunications industry and in ensuring competition and diversity in suppliers. This is dealt with in detail in the SDH and fibre infrastructure report and aspects relating to sub-sea systems only are addressed here for consistency; however regulation has less impact on the submarine cable industry.

Following this analysis, the key features of submarine cable technology are examined and the dominant technology issues identified as the first stage in an assessment of the security and resilience.

Given the open source constraints of this high level study, specific security issues are not detailed, however areas of potential concern are identified. These areas can be used in any follow-up discussions with the owners and operators, as it is only they who can validate and comment authoritatively given the sensitivity surrounding potential vulnerabilities. Finally, conclusions are presented and recommendations made on how this report could be taken forward.

References

For the purposes of this document, the following references apply:

- [1] NISCC Report - The use of wide area network fibre optic and SDH technology by UK plc, published March 2006
- [2] Telegeography: <http://www.telegeography.com/>
- [3] Oftel Explanatory Note 'Wholesale international services markets', published 26 August 2003
- [4] "Recent Trends in Submarine Cable System Faults", by Featherstone, Cronin, Kordahi and Shapiro, presented at SubOptic 2001, Kyoto, Japan.

Definitions and abbreviations

Definitions

For the purposes of this document, the following terms and definitions apply:

Backhaul:	Connection from shore terminal (station) back to the Network Operating Centre or Network Hub
Dark fibre:	The name given to optic fibre that is not yet used
Dominant technology issues:	Those technology issues which are likely to have the greatest impact on the security and resilience of the CNI
Private circuits or leased lines:	A point to point private line used by an organisation to provide a telecommunication connection between remote sites
Shared ownership:	Cable consortia share the ownership of cable systems and have agreements about how capacity usage will be shared.

Abbreviations

For the purposes of this document, the following abbreviations apply:

BU	Branching Unit
BUTEC	British Underwater Test and Evaluation Centre
CNI:	Critical National Infrastructure
CCTV	Closed Circuit Television
DCN	Digital International Switching Centre
EDFA	Erbium Doped Fibre Amplifier
EMP	Electromagnetic Protection
FCC	Federal Communications Commission
FEC	Forward Error Correction
G.652	ITU recommendation number for standard single mode fibre
HF	High Frequency
IP	Internet Protocol
ISR	International Simple Resale
IRU	Indefeasible Right to Use
ITU	International Telecommunications Union
ITU-T	International Telecommunications Union - Telecommunications

NOC	Network Operations Centre
NPE	Network Protection Equipment
PC	Personal Computer
PDH	Plesiochronous Digital Hierarchy
PFE	Power Feed Equipment
Psi	pounds per square inch
RFS	Ready For Service
SDH	Synchronous Distribution Hierarchy
SLTE	Sub-sea Line Terminating Equipment
SMP	Significant Market Player
SONET	Synchronous Optical Network
STM	Synchronous Transport Module
TMN	Telecommunications Management Network
VoIP	Voice over Internet Protocol
VPN	Virtual Private Network
WDM	Wavelength Division Multiplexing

Submarine cable infrastructure relating to UK

For more than 150 years, submarine cables have been laid from the shores of the UK to a variety of global destinations, for the same purpose - telecommunications. In 1850, the first telegraph cable from Dover to Calais was attempted – it did not sink without lead weights added, and unfortunately it failed irreparably after one day of operation due to weak design and the rocky seabed conditions. Design, manufacturing and installation processes have all improved dramatically since that time although the pioneers would still recognise and understand the key physical features of today's cables. Technology has moved from digital to analogue and back to digital, and the transmission medium has moved from copper to optical fibre. The operator industry has moved from private ownership through nationalisation and back to private ownership. Cables now radiate in all directions from the UK coastline connecting us to our nearest and furthest neighbours, from France and Belgium to Japan and Australia.

Long-distance cable has faced competition from HF radio and satellite technology at different times, but has reigned supreme as the only viable medium for heavy traffic routes since submarine optical fibre arrived in the mid-1980s. The economics of increasing capacity without greatly increased cost, resulted in collapsing per-unit capacity costs. This was an essential ingredient of the internet roll-out and ultimately contributed to the dot-com bubble and crash. The apparently endless growth of technology allowing more and more capacity, and lower prices translating into demand growth became fixtures in business modelling and very few saw the danger signs.

Around year 2000, the global network was already overbuilt in many areas, with considerable untapped upgrade potential. System manufacturers needed to keep factories busy so they pushed vendor-financing schemes for private ventures to install even more cables. When the markets saw the folly of the situation, a number of operators and their networks fell into bankruptcy, dumping cable systems and capacity on the open market at fire-sale prices, stunning the supply market further.

The capabilities of the technology as it developed, combined with the industry evolution as described, have led to different topologies of network on the various routes from the UK, and the following section illustrates the variations that have arisen in system architectures.

System architectures

Sub-sea system designs have been proprietary and largely in advance of the standards bodies, therefore the study at this stage focuses on the characteristics of the generalised architectures rather than on the specific features of a given deployment. The extent of equipment miniaturisation and integration has varied greatly between generations of product and this is another reason to begin with generalised properties.

Some specific information has been gathered from expert opinion but it will not be possible to extend the knowledge base to cover all systems in this way. Even the extent to which existing cables are filled is not generally known for commercial privacy reasons although some analyst houses produce useful reports based on extensive data reviews and surveys – Telegeography [2] for example.

In the following description the three principle general architectures of sub-sea systems are described: repeaterless systems, branched systems and ring systems.

Repeaterless systems

As fibre and its transmission equipment developed, it soon became realistic to reach destinations up to 50km away without intermediate amplification. The original repeaterless systems offered cost benefits because they didn't require sub-sea regenerator units or power feed equipment. Optical amplifiers are now commonly used at the terminals of repeaterless systems to boost transmitted signals or to pre-amplify received signals. A further benefit is that, with these amplifiers, the terminal configuration can also be simpler with the landing sites containing amplifiers only with all traffic relayed back to the switching hub.

Development work over the years has taken these 'repeaterless' systems from single channel per fibre carrying 140Mb/s PDH and reaching 100km, to WDM systems able to carry, for example, 16 x 10Gb/s SDH and reaching 300km. Some systems use Raman amplification (by adding high power terminal lasers) to increase spans a little further, but repeaterless system ranges seem unlikely to exceed 500km in the foreseeable future.

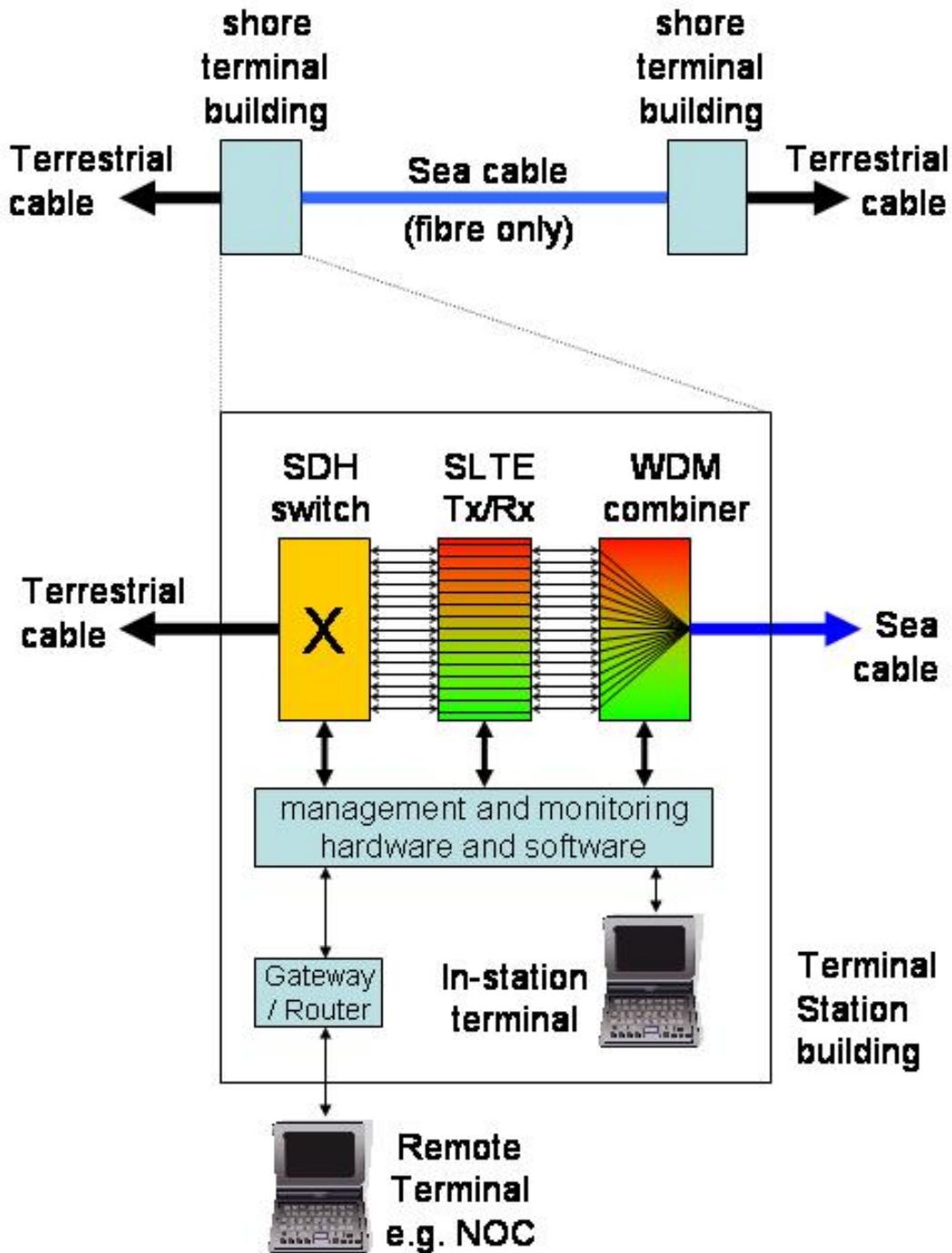
The maximum fibre count is determined by the cable design, and more than 100 pairs of fibres is possible, however the time taken to repair such cables in the event of breakage must be compatible with the periods of likely good weather (smooth seas) required to make repairs. For this reason, and because of the enormous WDM upgrade potential of just a few fibres, operators have often kept fibre count relatively low.

Many of the older repeaterless systems contain G.652 (single mode) fibre which remains in operation today, with the original PDH terminal equipment replaced several times to now deliver SDH-WDM links. The first cables had first choice of the most suitable sea beds and landings, and combined with the varying degrees of over-engineering on early links, they remain attractive and viable as communication links. Most still have considerable upgrade potential.

The characteristic length of these systems, typically 200-300 kilometres, means that they reach between the British Isles, and between the UK and its adjacent European neighbours – France, Belgium and the Netherlands. The point-to-point nature of these links, together with the heavily shipped and fished shallow water in which they run demands heavily armoured cable and efficient cable burial if damage and outage is to be avoided. Later cables have been organised in pairs to form mutual restoration services as can be seen in Table 1.

The general architecture of the terminal station for repeaterless links follows in Figure 1.

Figure 1: Repeaterless System Architecture



Branched systems

For distances beyond the limits imposed by repeaterless technology, it is necessary to include electrically powered amplifiers along the cable. The Power Feed Equipment ('PFE') converts the terminal station supply to high voltage regulated direct current and it is conducted along the internal metal structures of the cable before being extracted and used at the amplifier housings ('repeaters') on the cable. Early generations of long optical systems carried a single optical channel per fibre, and used repeaters that converted the signal to electrical form before cleaning it up and re-transmitting it. Current generation systems amplify all the optical channels in a fibre together in an Erbium Doped Fibre Amplifier ('EDFA'). The repeaters require electrical power to light and regulate the pump lasers. The main developments of recent years have been to increase the bandwidth and optical output power of repeaters, thereby increasing the upgraded channel count, and using high-gain Forward Error Control ('FEC') to improve the ability of receivers to dig the signal out of accumulated noise, thereby allowing reasonable spacing of repeaters.

As there are only a few point-to-point repeatered systems relevant to the UK and none of them are critical, these have not been considered in detail. Essentially, they are a dying breed as new cables superseding them are always built as branched systems or rings.

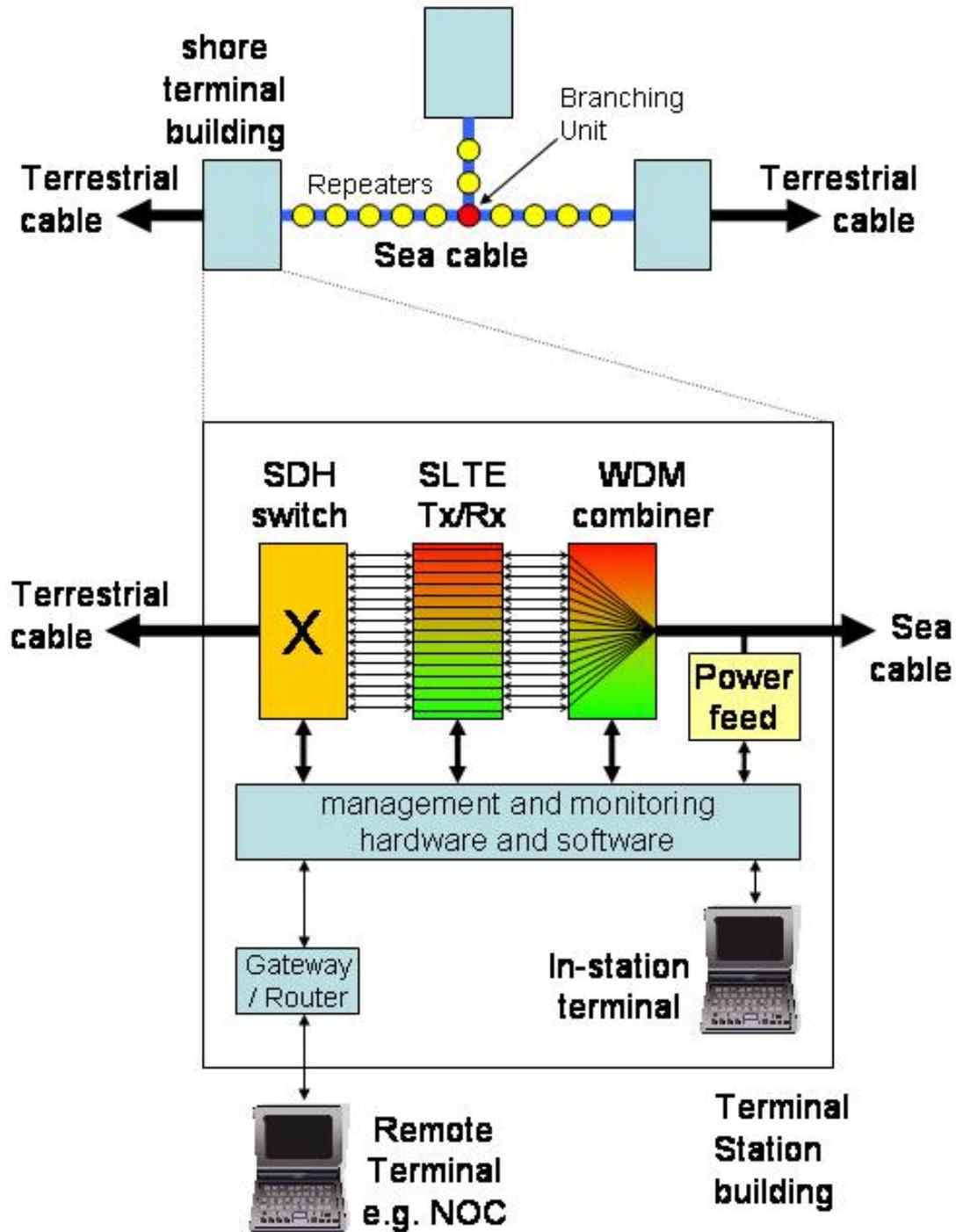
Branched systems suit long routes which pass by a number of countries. A single fibre system has huge potential capacity. Many of the point to point and ring systems are only lightly loaded, so a configuration that allows more than one country to share the system capacity can increase the traffic load carried by a cable and therefore offer significant cost advantages.

Moreover if the cable could be branched in a sub-sea Branching Unit ('BU') then it would be possible for a country to access traffic on the network without crossing the infrastructure or territory of another country. Early PDH branched systems (now decommissioned) included TAT-8 (1988, UK, France, USA) and TAT-9 (1992, UK, France, Spain, USA, Canada). The function of the BU can be chosen according to the circumstance, for example offering fixed or switchable routing of fibres or wavelengths. TAT-9 stands alone as the only system where the PDH signal was de-multiplexed at every BU and switched in accordance with a fairly fine granularity; it was expensive, complex and was not as useful as expected though it never failed in-service.

The major area of the world where branched systems have really found an application is the Europe to the Far East corridor. The ability of correctly configured branching units to service mutually hostile neighbouring countries has allowed a single shared network to meet the needs of countries which would not have had the business case to install their own dedicated cables.

The outline architecture of a Branched system is shown in Figure 2.

Figure 2: Branched System Architecture



Ringed systems

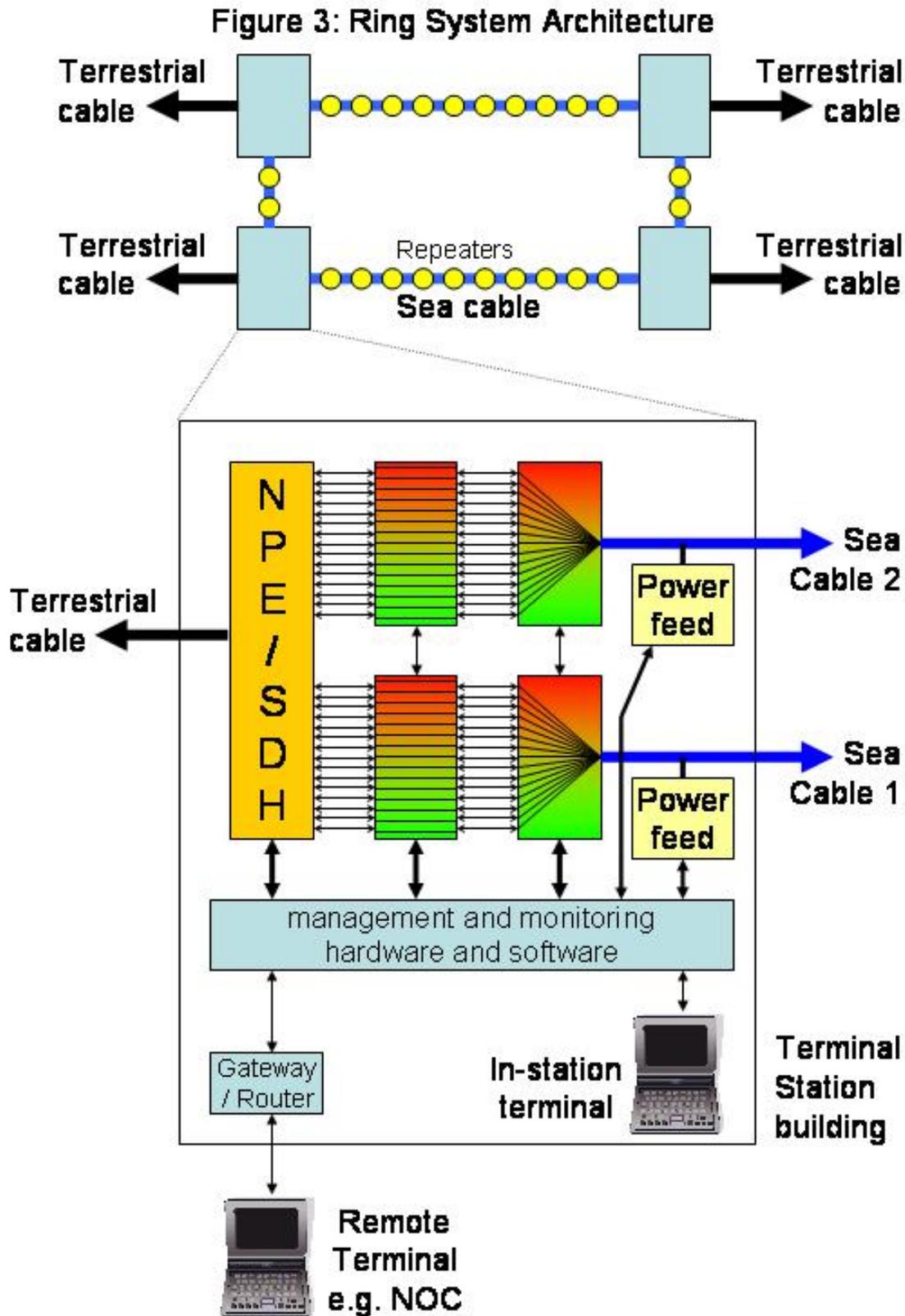
There came a point in the development of Atlantic and Pacific cables where each new branched cable could carry more traffic than all its predecessor cables put together. This made it impossible to organise a restoration path over existing cables in the event of cable damage or failure. For this reason, the TAT-12 and TAT-13 cables were conceived together to operate as a ring, intended to be half-filled so that the traffic from one failed cable could be carried in the reserved space on the other. The rapid switching to the alternative path demanded automation of the process and the introduction of Network Protection Equipment ('NPE') into the shore terminal stations.

The abundant capacity and stiff competition between the cable consortia caused the per unit capacity price to tumble. By this point, the cost of carrying voice traffic across the Atlantic and Pacific oceans had become so cheap that the cost of a call was dominated by the tariffs that were set in the terrestrial and last-mile portions of the network. However, driven on by forecasted growth in data and internet services, the private venture market saw the opportunity to install new rings of even higher capacity, where the cost per unit on the fully upgraded system would be tiny. Unfortunately these networks never became fully loaded and many continue to this day operating at a small fraction of their potential. The manufacturing market dried up on these routes and the manufacturers were forced to fund additional build in order to keep the factories operating. The result was even more nearly-empty cables.

The resulting oversupply has meant that upgrade cards have been the only real sales business on these routes for the last few years, and only very recently has there begun any discussion of potential new cables on the Pacific route. It seems very likely that new Atlantic build is still some way off due to the capacity still to be 'mined' through installation of upgrade cards.

With such a glut of low cost capacity the older PDH systems have become uneconomic to maintain and a number of factors have combined to cause the decommissioning of older cables. As well as being low-capacity PDH and therefore incompatible with high-capacity SDH networks, administration and maintenance of the old cables also helped make them uneconomic. In the last few years, all remaining point-to-point and branched Atlantic cables up to TAT-11 have been taken out of service. CANTAT-3 is due to be out-of-service any time now even though it is 2.5GHz SDH, as it is not WDM-capable and it remains relatively unreliable. What remains on the Atlantic route is a more than adequate number of partially equipped WDM rings on a variety of routes and under a variety of ownerships (and nationalities of ownership).

The outline architecture of a Ring system is shown in Figure 3.



Operators and equipment providers

Within the broad subdivisions of repeaterless, branched and ring systems, the repeatered cables represent the product of perhaps three main manufacturers (Tyco, Alcatel, and 'Japan Inc') and the repeaterless cables represent the same suppliers plus a few others without repeater capability.

The table in Appendix K suggests that BT is the dominant operator on about 113 routes from the UK while C&W is dominant on 4 routes. Another 118 routes are deemed to be competitive. Cable consortia have shared ownership of a cable system and have agreements about how capacity usage will be shared. Consortia typically include both equipment providers and operators. A list of equipment providers and operators is given in Appendices A and B.

Other types of submarine cable system

Oil, gas and windfarm submarine cables

Liverpool Bay BHP: In search to date, this is the only documented development which specifically mentions submarine cables to oil and gas installations, however, maps indicate similar cables between North Sea oil and gas rigs. The development website implies that there is a cable from shore to the main platform and that will be buried.

Most oil and gas installations will use microwave or tropospheric scatter links from the shore and these will probably be backed up by Inmarsat.

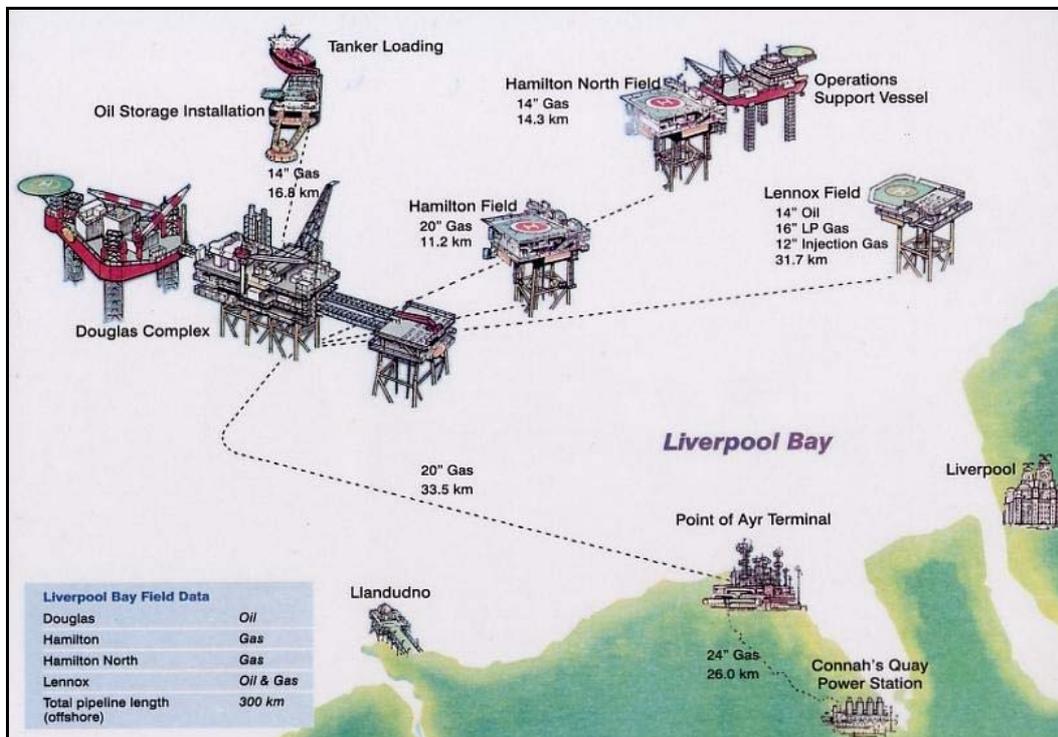


Figure 4: Submarine cables serving oil and gas fields in Liverpool Bay

MoD submarine cables: There is information in the public domain on the BUTEC ranges off Rona where there are short cables attached to listening devices. It would be reasonable to conclude that there may be other such cables in strategic locations around the UK.

Backhaul networks

A number of associated international facilities are required to carry traffic between sub-sea landing stations and international exchanges in order to provide wholesale international services (and ultimately to provide network access to retail providers). These facilities vary for satellite and via submarine cable traffic.

Where traffic is carried via a submarine routing, the International traffic is handed over to the wholesale provider at its DISC. The wholesale provider will carry the traffic via international backhaul facilities to the relevant cable landing station, the traffic will then be carried via the submarine cable from that landing station.

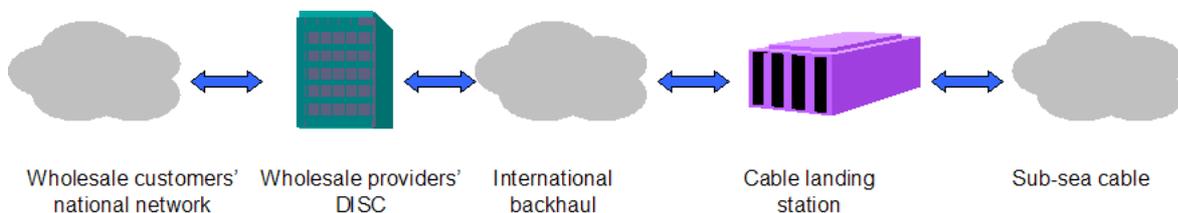


Figure 5: Architecture of a backhaul connection

International backhaul is a high capacity inland circuit used by wholesale providers to link a cable landing station to a provider's existing national network. Prior to December 1996, only CWC and BT supplied backhaul services in the UK.

Now any provider can use elements of their existing network to provide backhaul. Additionally many providers have networks that pass within relatively short distances of cable landing stations. This has resulted in increasing competition in the provision of backhaul services and a distinct market for this service has developed with numerous providers of international backhaul services in the UK who compete with BT and C&W (including Energis, ntl, Telia and Surf Telecoms). The increased competition in the supply of backhaul services has resulted in significant price reductions.

Trends

Basic outer configuration of cables hasn't changed much in 100 years. The present and next generation are buried for protection between beach manhole - at least 1000m contour. Developments are continuing to progress in two areas. There is a continuing trend towards fewer cables with higher capacities and also towards increased range of repeaterless systems. For example, the Apollo cable could carry more capacity than all in-service trans-Atlantic cables that existed at the time it was installed. Alcatel, Fujitsu and Tyco now all have systems with 16 fibres in a loose fill cable with potential for 8Tb/s capacity. The state of the art with repeaterless systems is for 192 fibres with unrepeated range of 500km.

Services connecting the UK

Position of UK in world international telecommunications traffic

At the time of the Oftel review in July 2003 [3], the United Kingdom was reported to be the largest EU and second largest worldwide international telecommunications market with total international traffic in 2001/2002 of approximately 20 billion switched minutes (source – TeleGeography [2]). BT was the largest EU carrier and third largest world carrier of international traffic (source – TeleGeography [2]). C&W is the fourth largest EU carrier and seventh largest world carrier of international traffic (source – TeleGeography [2]). The United Kingdom is the main European landing point of transatlantic, African and Asian submarine telecommunications cables.

Services dependency on sub-sea cables

Sub-sea systems carry the same types of service as the UK SDH and fibre network. A market overview of the end user services is provided in the sister report [1]. Although a detailed breakdown of the service volumes has not been identified for the sub-sea systems, it seems likely that the proportion of voice, Internet and corporate data is comparable to the UK traffic, although it is possible that the proportion of mobile voice calls may be lower than for the UK.

So just as optical fibre technologies provide reliable, high capacity, network connections for UK telecommunications services, the international connectivity for those same services is provided very largely by sub-sea SDH and optical fibre systems. Only a small proportion is carried by satellite radio. Without sub-sea cable systems, global telecommunications at the level we know today would be impossible. Critical national infrastructures therefore depend on the sub-sea cable infrastructure for their international element.

Sub-sea systems are mostly owned by a consortium that has an agreement about how capacity is to be shared. Other carriers wishing to rent capacity on the system would arrange this via one of the operating partners, rather similar to the way private circuit capacity can be leased from a UK network operator. Capacity can be rented either as an International Private Circuit where high capacity connections are required, or by dial up arrangements.

International Private Circuits (IPC) allow a client network operator to rent capacity on the system and to use it to carry any service they choose (subject to international regulations). An IPC is not switched and so is permanently available to the client and it is not shared, so it is private and secure. Because two different national network operators provide the service (one at each end of the system) each operator provides and is paid for a half circuit. This is a 'correspondent' arrangement and in some cases can require two contracts. In other cases a large operator such as BT may offer 'one stop shopping' and deal with the correspondent payments using a single customer contract.

The Oftel review in 2003 [3] describes the six basic ways in which wholesale international voice services are carried. They are

- Direct conveyance;
- Simple transit;
- Refile;
- Switched bypass/international simple resale (ISR);
- Global provider's internal network carriage; and
- Voice over IP ("VoIP") bypass.

A summary of each is set out in Appendix J.

The approach taken in the remainder of this section is to describe the main categories of service provided by the sub-sea network operators and to describe the major service routes.

The major service routes

It is not coincidence that the three major regions of the world connecting with the UK viz: Europe, Americas and Asia all deploy different submarine cable architectures. The three main architectures outlined in section 4.1 have all been created for the different route characteristics, including physical and business factors relating to market forces.

These three major routes carry traffic to all parts of the world and each will carry a mixture of voice, Internet and corporate data traffic. Examples of the systems serving each of the three major routes are given in the following sections. A detailed breakdown of the routes to individual countries is provided in Appendix K. This Appendix also indicates whether a particular operator holds significant market power on each route.

European service routes (Repeaterless systems)

Given the short distance between the UK and Europe most submarine cables are repeaterless. The system examples given in Table 1 show some of the more recent installations and they give an indication of the installed capacity of the systems. Potential capacity on these routes is far in excess of the installed capacity as WDM technology has not been fully deployed on these systems.

For the repeaterless systems, where a number are available to each destination, we have chosen the most recent to each country as the latest equipment will offer the best economic performance and upgrade potential. Fibre has improved a little over the last few years, as have measures to exclude hydrogen which otherwise darkens it, and at least one supplier has recently accepted a contract to deliver 0.174 dB/km on installed cable. High fibre count is undesirable due to the long period of smooth sea required to make a repair, so the key selection parameters in this case are age and landing countries.

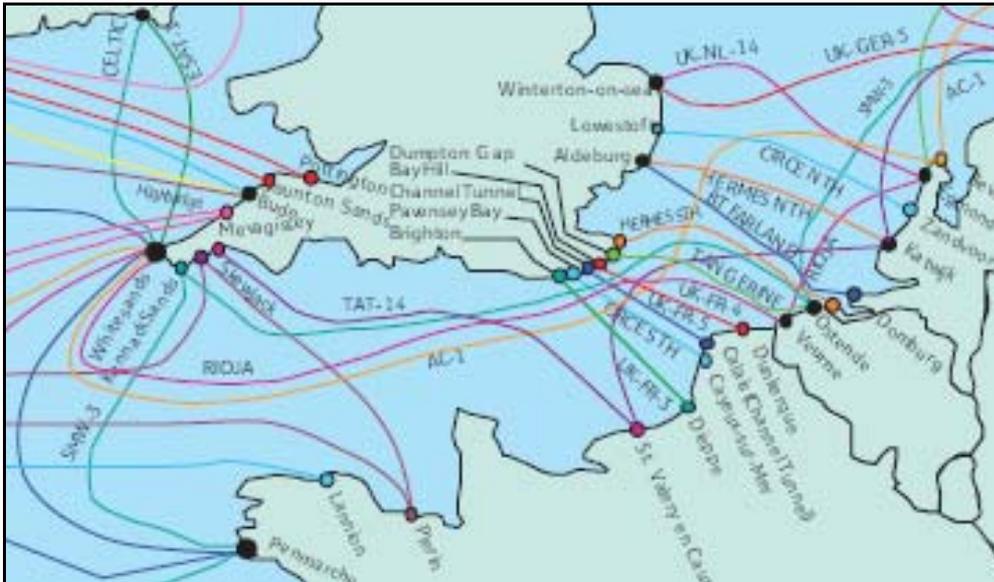


Figure 6 Map of repeaterless cross-Channel cables

Source: <http://www.btglobe.com>

Table 1: Examples of Repeaterless Submarine Cable Systems

Name	Year	Route	Length	Capacity
Concerto N	1999	Sizewell – Zandvoort (Neth)	550km	96 fibres, some lit at 10G
Concerto S	1999	Thorpeness – Zeebrugge (Belg)	total	
CIRCE North	1999	Lowestoft - Zandvoort (Neth)	203km	48 fibres, some lit at 10G
CIRCE South	1999	Pevensey - Cayeux (Fr)	115km	
ESAT 1	1999	Whitesands - Kilmore (Ire)	256km	Many fibres, some lit at 10G
ESAT 2	1999	Southport - Dublin (Ire)	237km	
Sirius N	~1999	Saltcoats - Carrickfergus (NI)	Irish Sea	Many fibres, some lit at 10G
Sirius S	~1999	Blackpool - Dublin (Ire)		
Ulysses 1	1998	St Margarets Bay - Calais (Fr)	49km	48 fibres, some lit at 2.5Gb/s
Ulysses 2	1998	Lowestoft - Katwijk (Neth)	199km	

Asian service routes (branch systems)

There are relatively few branch systems operating now out of the UK. These are mainly on the route to Southeast Asia, Japan and Australasia. Sharing capacity on these routes has allowed capacity to be utilised very efficiently, with branching units providing feeds into many countries. These systems carry a higher proportion of revenue earning traffic than the repeaterless systems. Following the early system installations to Asia the branching architecture has been adopted in some other routes. The examples in Table 2 show some of the major installations, which are not confined to Asian routes. The branch systems are all listed as there are so few.



Fig 7: Map showing a Branched Submarine Cable System

Source: <http://www.apricot.net/apricot97/apll/Presentations/KDDSubmarineFiber/sld019.htm>

Table 2: Examples of Branched Submarine Cable Systems

Name	Year	Route	Length	Capacity
SMW-4	2006	France-Singapore (UK via terrestrial)	~20,000km	Initial 80Gb/s upgrades to 1,280Gb/s
FARICE-1	2004	Iceland -Faroes - Scotland	~1,400km	20Gb/s before upgrades
SMW-3 (backs up SMW4)	1998	Germany via UK to Australia and Japan	~38,000km	In the range 55Gb/s to 160Gb/s
FLAG Europe - Asia	1997	UK - Japan	~27,000km	In the range 10Gb/s to 80Gb/s
CANTAT-3	1994 to 2006	Canada to Europe inc. Iceland and UK	~7,100km	2fp* 2.5Gb/s regenerated

American service routes (ring systems)

Given the perceived market forces for large bandwidth systems to the US, the dotcom expansion at the end of the 1990's fuelled massive investment in high bandwidth and this led to the installation of very high capacity ring systems. In Table 3 only the newest ring systems have been selected because they are the ones that offer the highest ultimate capacity and highest upgrade potential and so are likely to remain in service longest (subject to satisfactory build and cable route standard). We assume that other landings in Europe are not a decisive factor as there are repeaterless and terrestrial alternative routes available. As for the repeaterless systems, only a small proportion of the potential capacity of these systems is used, as can be seen from Table 3. (NB we cannot know the actual fill levels at this point of the study; so the fill figures are indicative only).

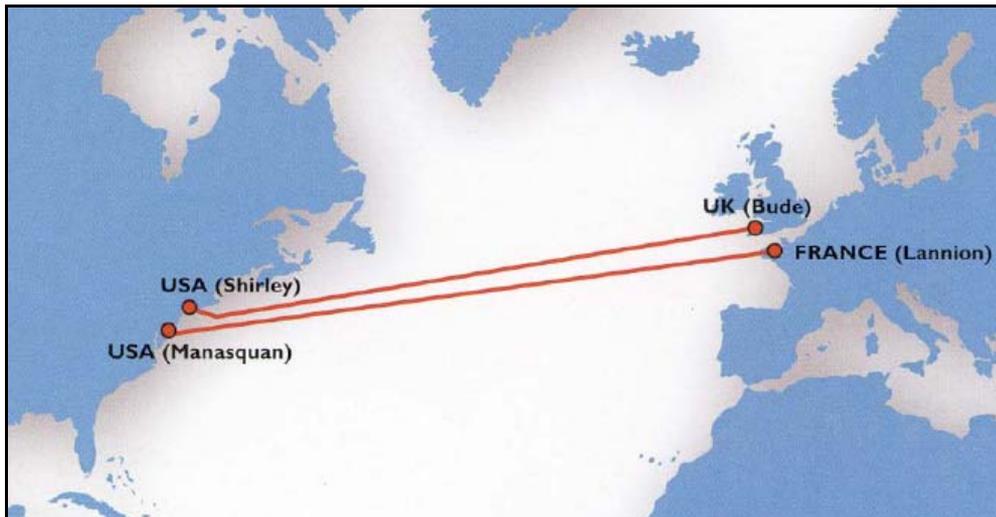


Fig 8 Map showing typical Ring Submarine Cable System

Source: http://www.cw.com/docs/uk/nss/apollo_factsheet.pdf

Table 3: Examples of Ring Submarine Cable Systems

	Year	Route	Length	Capacity
Apollo (ring)	2003	UK and France to USA landings	~12,300km	Approx 80Gb/s upgrades to 3,200Gb/s
VSNL Atlantic (was TGN)	2001	UK to USA ring	~12,900km	Approx 80Gb/s upgrades to 2,560Gb/s
Hibernia Atlantic (was 360N)	2001	Ireland and UK to Canada/USA ring	~12,200km	160Gb/s now upgrades to 1,920Gb/s
FLAG Atlantic 1	2001	London – Paris – New York ring	~12,800km	320Gb/s now upgrades to 2,400Gb/s

Regulatory effects on sub-sea services

Regulation mainly affects pricing structures, particularly where a route is dominated by a Significant Market Player (SMP). Of the 235 (or so) routes terminating in the UK, in 2003 roughly half UK were deemed by Ofcom to be competitive with no single operator dominating. BT was identified as a Significant Market Player in 113 routes and C&W as a significant market player on just 4 routes [2].

Dependencies

Numerous cables terminate in the UK. Each cable carries a range of services and the loss of connectivity caused by a cable system failure affects many services to a particular location. However, on routes where there are multiple cables and where those cables have a low traffic utilisation (e.g. routes to Europe and the Americas), the dependency of each service on that particular cable would be relatively small.

Because the capacity of the branching systems linking the UK and Asia is more heavily utilised, the impact on the service to that part of the world would be greater. On these routes however some traffic is taken via the Atlantic and Pacific cable systems, rather than take the more direct single cable route.

The SMW-4 cable terminates in France. Traffic from the UK to Asia on this cable therefore depends on the France connection.

Network Operations Centres (NOC) are duplicated with many in different countries, therefore the UK sub-cable management can be dependant on another country's NOC and security policies. Also, in branched systems where the sub-sea cable terminates in intermediate countries, the UK sub-cable fibres or channels can be dependent on another country's terminal equipment and associated security policies.

Security and resilience

In sub-sea systems it is the physical security aspect that has traditionally been the main issue. In this section therefore the physical aspects of security are considered as well as the electronic aspects.

Resilience

In the early days of sub-sea systems if a cable failed then traffic would be rerouted over spare capacity in other cables until a repair could be completed. Changeover would be managed at the NOC under manual control with switching taking place at either the landing station or at the International Switching Centre.

This manual process may still take place in some repeaterless and branched systems. Ring systems and repeaterless systems that have been provided in 'pairs' are thought to have automatic changeover. This is possible because the systems are in general lightly loaded and redundant capacity is believed to be available.

On branched systems cable fills are higher and there is less redundant capacity available. It is possible that automatic changeover is carried out by using redundant capacity on other branched systems or on terrestrial systems but it is not clear how changeover mechanisms operate and whether they are automatic or manual.

Physical security

Physical attack on cable

Physical (accidental) attack on the submarine parts of the cable is currently the main cause of service loss although ring systems greatly reduce the direct effect of cable damage on achieved service level statistics. Some cables have been abandoned in the English Channel and Southern North Sea due to the combined effect of poor cable choice for the area, poor installation (burial) and a high level of accidental attack from other seabed users. The types of accidental attack are documented and quantified in the attached Appendix C.

Water depth of about 1000-1500m corresponds generally with the UK continental shelf and it is useful to characterise deployment as 'deep' or 'shallow' compared with this region. In 'shallow' water, it is possible or likely that powerful fishing boats will be pulling heavy gear along the sea floor. It is also possible that large tankers will need to deploy a heavy anchor to retain control in bad weather conditions. A good survey will uncover these risks and a good design will choose an adequately armoured cable and an appropriate burial method. Pressure on the build budget will then force a less than optimal solution and it is the degree of cost-saving that largely determines the unreliability of the cable.

In 'deep' water the manmade hazards are very much reduced however it is still necessary to choose a cable design according to whether there are rock outcrops and sea currents. Cables for 'deep' water deployment can be as small as 15mm in diameter.

Physical attack on land cable and buildings

On leaving the sea, the cable generally crosses a beach before entering a 'beach manhole' where the cable type changes. From there, it runs on a route which can be many kilometres using terrestrial construction techniques until it reaches the shore terminal building. For this part of its route, the cable is as susceptible to digging damage as any other terrestrial cable.

From personal and anecdotal experience, it is clear that many of the shore terminal buildings are relatively poor in terms of physical security. In a number of cases (for example Land's End) the car park is uncontrolled and immediately adjacent to the building – an obvious risk. Access to manned buildings is via a traditional front door backed up with CCTV camera although the security achieved at that level depends on processes and how the station staff handles unexpected visitors.

Once inside the building, any amount of damage could be inflicted by electronic or physical means, for example any of the 'electronic attack' scenarios below could be achieved using the local PCs and control systems. A less technical attack could directly cripple the batteries or power supplies, or just swinging an axe in the equipment rooms could easily stop traffic using no technical knowledge at all. We are aware of a case in Spain where a system was badly damaged by a bomb planted in the terminal station.

The security status of Network Operations Centres (NOCs) is unknown although it would be expected to be a little better than terminal buildings due to the high concentration of equipment controlling multiple areas of the network, and the widespread impact of a security breach at such a network 'hub'. This information is not public-domain.

Electronic security

Management systems

Sub-sea systems management is based on TMN principles, which are described in the sister report [1]. In a sub-sea system usually two or more network operations centres are provided either at different ends of the system or, in the case of branched systems, at some intermediate point. All aspects regarding the status and configuration of the system can be interrogated or changed from the NOCs. Access to management systems must therefore be kept highly secure. The security of management systems is also discussed in [1].

NOCs are not normally co-located with the landing stations and therefore a Data Communications Network (DCN) is needed to link the NOC and the system. The DCN therefore carries all data relating to status and configuration of the system and can be seen as a potential point of attack. The DCN connects to the sub-sea system via any of the relevant shore stations or their backhaul extensions.

The DCN connection may be formed in a variety of ways, such as with private circuits or IP based VPNs. The security is therefore dependent on the security policies and their implementation surrounding these connections, however, authorisation and password protection would be normal on any remote access system. The methods used to provide remote access and the security mechanisms used are likely to vary with the equipment supplier and are not available from open sources.

Communications between the shore station and the undersea amplifiers and regenerators is via supervisory systems. These systems operate over the same fibre as the traffic channels and they allow the network manager to interrogate amplifiers and repeaters along the route and to monitor and adjust parameters such as system gain, power levels and amplifier controls. They also allow power feeds to be switched over to standby or to assist in fault location. Unauthorised access to the DCN therefore could be used to disrupt the operation of a cable system by malicious changes to the managed parameters.

Only the TAT9 (branching) system allows traffic to be switched within the system. Otherwise traffic is switched either at the switching centre or at the landing station

Usually at least two Network Operations Centres (NOCs) are used to manage a system. Usually one of these is in the UK but the others are in other countries. Whilst security can be expected to be high, it may not be easy to verify the level of the security practices in some locations. It is not clear where responsibility and control lies for operating the NOCs, as multiple partners are involved.

Electronic attack

Personal and anecdotal experience indicates that the equipment rooms in terminal stations are electromagnetically screened and built without windows. It could be assumed that this would afford some EMP protection although this has not been verified. A related issue is lightning which has affected the terminals and land cable sections of some systems, requiring repair or replacement of in-station equipment. However, this is not the main focus of this study.

All of the following comments assume equipment architecture as shown in Figures 1 to 3, shown by function (not by box, as this varies) for differing network topologies. In all cases, the terminal adapts incoming SDH traffic on to a specific set of 2.5G or 10G WDM wavelengths, and then makes fine adjustments to power equalisation and chromatic dispersion in order to optimise the submarine portion for operation within very tight optical power budget margins. The margins are good at start of life with only a few channels lit, but become progressively tighter as the effects of ageing combine with a full channel load.

Architectures indicate an external communications link from the NOC to the terminal building. This link could be a private circuit or run over public shared infrastructure using a VPN. Details remain proprietary at present. By intercepting that link, or through the control PC in the terminal building or through the control PC in the NOC, the following attack mechanisms are considered possible:

- Installation of malicious software
- Implementation of unauthorised access privileges;
- Malicious reconfiguration of network elements e.g.
 - Amplifier parameters (gain, compensation etc);
 - Optical transmitter parameters (frequencies, levels etc);
 - SDH switch (redirect traffic, interfere with protection switching etc);
- Malicious reconfiguration of connections
- Isolation of NOC to prevent legitimate access
- Malicious reconfiguration of power feeds (up/down/off)

The main effect of these types of attack would be denial of service, however it is not clear how long it would take to detect these attacks and restore service.

Intuitively it is felt that the branched sub-cable architecture on routes to SE Asia would be the most vulnerable to these types of attack, simply because these cables terminate in many countries en route where the security of the landing station, terminal equipment and management control may be less easily verified and controlled. It is interesting to note that it is these routes which have less redundancy than the other two major service routes.

Conclusions and recommendations

This report has examined the sub-sea fibre optic infrastructure terminating in the UK and considered its importance in terms of supporting critical national infrastructure and its vulnerability to electronic attack. Open source material and expert opinion were used to create this report and it was found that all the sources focussed on physical resilience and security. No previous studies into electronic attack against sub-sea systems were identified. The comments relating to electronic attack in this report are therefore derived from a number of brainstorming sessions with experts in submarine cable systems.

It was concluded that fibre optic sub-sea systems now predominately use SDH and SDH/WDM systems which offer better resilience and improved management characteristics. From an analysis of the cables terminating in the UK, three main system architectures corresponding to three major routes were identified:

1. Repeaterless – used between UK and Europe
2. Branching – used between UK and SE Asia and terminating on route in a number of countries;
3. Ring – used between UK and the Americas across the Atlantic.

Using this breakdown it was possible to categorise the most important cables in terms of the most recent installations which offer the largest capacity and upgrade potential, and therefore those cables upon which the UK CNI will be most dependent.

It was found that only a small proportion of international traffic is carried by satellite radio and therefore without sub-sea cable systems, global telecom services at the level we know today would be impossible. The UK CNI is therefore dependent on sub-sea cable systems for global telecom services. Given that the capacity of the branching systems linking the UK and Asia is more heavily utilised than other routes, it is concluded the impact of a service failure would be greater and therefore the dependency on these cables is greater than those cables serving the other major service routes.

In terms of services it is concluded that sub-sea systems carry the same types of end user services as the UK SDH and fibre optic network. Although a detailed breakdown of the service volumes has not been identified for the sub-sea systems, it seems likely that the proportion of voice, Internet and corporate data is comparable to the UK traffic, although it is possible that the proportion of mobile voice calls may be lower. So just as optical fibre technologies provide reliable, high capacity, network connections for UK telecommunications services, the international connectivity for those same services is provided very largely by sub-sea SDH and optical fibre systems.

These services may be carried via either via international private circuits or by one of several 'dial up' models. The arrangements take account of the fact that three different operators are involved: a national operator at each end of the system and the cable system operator.

BT has been identified as a Significant Market Provider (SMP) on almost half of the 235 (or so) routes to other countries terminating in the UK. Cable and Wireless are SMP on about 4 of the routes while the remainder are deemed to be competitive with no single provider dominating the route.

Sub-sea systems are designed to have very high resilience against failure with the most common reason for failure through physical cable damage from shipping. Newer ring systems and paired cable systems have adequate redundant capacity and employ automatic protection switching in the event of failure, however details of these mechanisms could not be found from open source.

In terms of security, it is concluded that there are potential opportunities for compromise if an attacker were to gain access to the data communications network or management systems in the Network Operating Centres or shore stations. Unauthorised access to network or element managers could lead to major service disruption and some of these attack mechanisms have been identified in the report. However, providing that security policies are carefully implemented it is thought the disruption could be contained. This conclusion is not based on a vulnerability analysis of specific service offerings but on the technology and management systems in general and mirrors the findings from the sister report [1].

One important difference between sub-sea cables and UK terrestrial infrastructure is access and control where, as you would expect, sub-sea cable and equipment access points are dispersed in different countries and controlled by different partners. This is of particular note in the Branching sub-sea cables to Asia which terminate in several countries on route. Note: this is the same major service route where the impact of failure was deemed the greatest.

Due to the open source nature of this report, not all aspects could be studied. Therefore the following recommendations are made for future investigation if thought necessary:

1. Further study using open source and expert opinion could be conducted on the different Branching sub-sea cables to better understand the risks and dependencies, including how automatic changeover is implemented;
2. Discussions with BT, given that they are the Significant Market Provider on almost half of the routes terminating in the UK, could provide a greater insight into the security issues and best practice solutions surrounding sub-sea cables;
3. To better understand the effectiveness of the attack mechanisms identified in the report a study could be instigated with an owner/operator who has R&D facilities;
4. Depending on the results of 1 and 2, owners and operators of the highest risk Branching sub-sea cables could be approached to assess the security policies and environment in which these cables are operated. This should include the NOCs and the DCNs;
5. A sub-sea cable owner/operator from each of the three different major service routes could be approached to understand how the security features are deployed and how effective they are against electronic attack;
6. Dependent on the results of the previous points, a good practice guide could be produced outlining how best to secure sub-cable systems against electronic attack.

Appendix A: Equipment providers

Company	Alcatel Submarine Systems
Contact	Christchurch Way, Greenwich, London, SE10 0AG Tel: +44 (0) 208293 2380 Fax: +44 (0) 208293 2690
Ownership	Alcatel, Paris, France

Company	Tyco
Contact	Tyco Telecommunications Global Headquarters 60 Columbia Road Morristown, NJ 07960 USA Tel: +1 973.656.8000 Fax: +1 973.656.8131
Location	USA
Ownership	Tyco

Company	Fujitsu
Contact	Fujitsu Telecommunications Europe Ltd Solihull Parkway Birmingham Business Park Birmingham B37 7YU Tel: 0121 717 6033
Ownership	Fujitsu, Japan

Company	MPB Communications Inc
Contact	MPB Communications Inc. Head Office 147 Hymus Boulevard Montreal, Quebec H9R 1E9 Canada Tel: +1 514 694-8751 Fax: +1 514 694-6869
Ownership	Canada

Appendix B: Sub-sea cable operators/owners

Company	Apollo
Contact	Surrey Quays 9–63 Croft Street London SE8 5DW Tel: +44 (0) 20 7379 8795 E-mail: appollonoc@cwmsg.cwplc.com
Ownership	Cable and Wireless?

Company	Hibernia
Contact	Clonsaugh Industrial Estate Dublin 17 Ireland Tel. +353 1 867 3600 Fax +353 1 867 3601 info@hiberniaatlantic.com
Location	Ireland

Company	TYCO/VSNL
Contact	Tyco Telecommunications 5th Floor 30-34 Moorgate East London, EC2R 6PJ Tel: 0207 374 5200 Fax: 0207 374 5201
Location	Basingstoke
Ownership	Tyco Telecommunications Global HQ, USA

Company	FLAG/Reliance
Contact	FLAG Telecom Ltd 9 South Street London W1K 2XA Tel: 0 207 317 0800 Fax: 0 207 317 0808
Location	Flag London, Reliance India.
Ownership	FLAG Telecom Ltd

Company	BT
Contact	BT Subsea Operations 18-20 Millbrook Rd East Southampton SO15 1HY Tel: 023 8082 9806 Fax: 023 8022 9981
Location	Corporate HQ, London
Ownership	BT

Appendix C: Submarine cable fault statistics

The submarine cable industry has collected a large volume of data concerning the causes of faults in submarine cable networks. Whilst the specific case-by-case details remain proprietary and commercially sensitive, the repair industry has released the following amalgamated analysis for the period 1997-2000 on a global basis, in a paper [4] presented at the prestigious Sub-Optic 2001 conference which took place in Kyoto in 2001. Recognising that this will not apply directly to any specific area or region, it is still useful to have a flavour of the overall mix of fault causes worldwide.

Fig.C1 - Submarine Cable Fault Causes - Worldwide

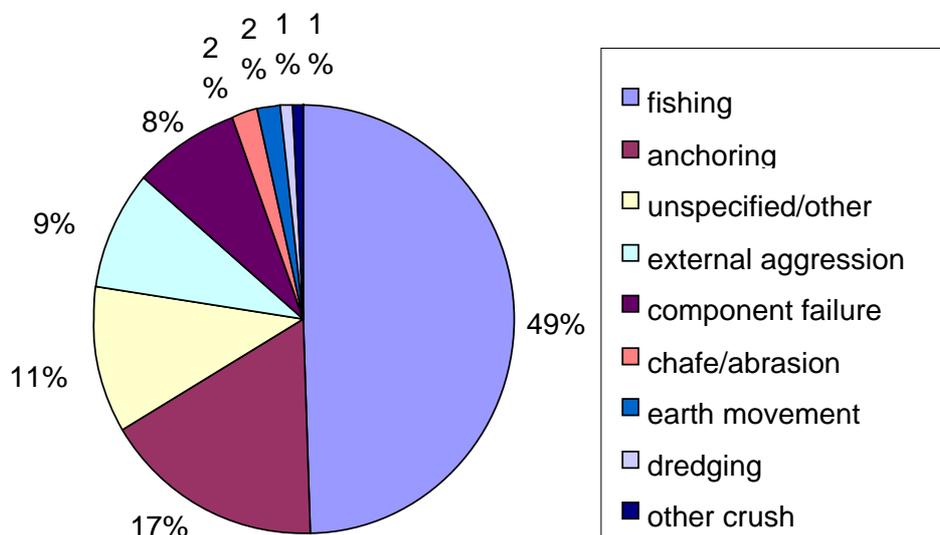


Fig. C1 above shows the relative proportions of all classes of fault in decreasing order of frequency, including external aggression, component failure, earth movement and other/unknown. The dominance of external aggression type faults is clear, with fishing accounting for about half of all observed faults, and anchor damage following closely behind. The process of cable engineering should consider all fault mechanisms at the location in question, and then specify an appropriate cable design and protection technique.

Given the dominance of man-made external aggression faults, it might be expected that most external aggression faults would occur in relatively shallow water, where the human activities mostly take place. The analysis shows that in recent years, the distribution of faults does indeed fit that profile as shown in Table C1:

Table C1: Distribution by depth of external aggression faults

Water depth - range	% of External Aggression Faults in depth range
0m - 100m	64%
100m - 200m	13%
200m - 1000m	16%
Deeper than 1000m	7%

The above information shows percentages, and it may be useful to introduce some indications about the true absolute level of the fault risk. The study indicates two key results in this regard, normalised for cable length as shown in Table C2 below:

Table C2: Distribution of normalised faults (all causes) by water depth

Water depth – range	Faults per 1000km per year
0m – 1000m	0.8 to 1.8
Deeper than 1000m	0.05 to 0.2

Concerning trends with time, the increased power of fishing vessels has been largely balanced by improved cable protection techniques, for a largely stable rate of normalised fishing faults in recent years. The improved protection techniques are yielding small improvements with time in resisting other types of external aggression. In some limited areas where fishing has moved beyond 1000m depth, and where such fishing was not expected, a handful of faults are occurring annually.

Cable in less than 1000m of water also experiences anchoring damage at a rate of about 0.2 faults per 1000km per year, and that figure is slowly reducing with time as deeper burial comes together with increased cable awareness. In a wider sense, cable networks in all areas experience fewer faults as the existence of the cable becomes known to the shipping and fishing communities. There is some evidence that, for example, a ten year old cable would experience external aggression faults at about half the rate of an equivalent newly-laid cable.

To conclude, the vast majority of faults occur due to external aggression from human causes. Failures due to chafe and component failure have reduced due to improved system designs. A focus on protection against fishing, both in route engineering and installation, and also in offshore liaison with other seabed users, offers the greatest potential for further improvements in fault rates. [4]

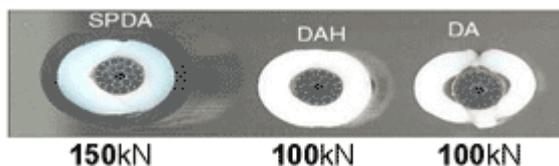
Appendix D: Information on Apollo

Design Basics

- Performance designed to better than relevant ITU-T specification throughout system life
- The interface card specification is S-64.2b and can reach approximately 40 km when used at 1550nm on G.652 fibre
- Equipment protection channel on a 16+1 basis
- Remote Management via 1353SH Network Management System
- Signal is optically amplified by submerged repeaters spaced at approximately 42 km
- North 160 repeaters, South 175 repeaters
- System design considered control of gain, non-linear effects and chromatic dispersion



Enhanced Cable Design OALC-4 SPDA, DAH and SAH



- Three types of enhanced cable specially designed for Apollo based on proven technology
- Used on both European and US continental shelf
- Best protection against armour wire penetration
- Good optical performance
- 10 tonne improvement (200%) in crush resistance for SPDA
- 5 tonne improvement (100%) in crush resistance for DAH and SAH

Strength Through Diversity

- Full diversity
 - Two separate marine routes
 - Four separate landing stations
 - Three separate countries

Popular southern landing direct into Continental Europe - US East Coast Landing Points

- Optimum solution selected for both marine and backhaul requirements

UK Northern Leg Landing Point

- Route designed in conjunction with the local fishing industry

French Southern Leg Landing Point

- Avoids heavily fished areas and the marine approach was designed with local fishing industry input

Cable Landing Stations

- Modular site layout designed for co-location and third party access
- Separate co-location rooms
- Diverse duct entrances into each co-location room

Features of Apollo

- Apollo North links Bude, UK with Shirley, New York, USA
- Apollo South links Lannion, France with Manasquan, New Jersey, USA
- Apollo comprises two fully diverse submarine legs, each leg containing four fibre pairs
- Each fibre pair can be upgraded to a minimum of 80 10Gbit/s wavelengths
- Each submarine leg has a capacity of 3.2 Tbit/s
- The southern leg connects France and Washington D.C., avoiding heavily congested areas in the UK and New York

Greater Resilience

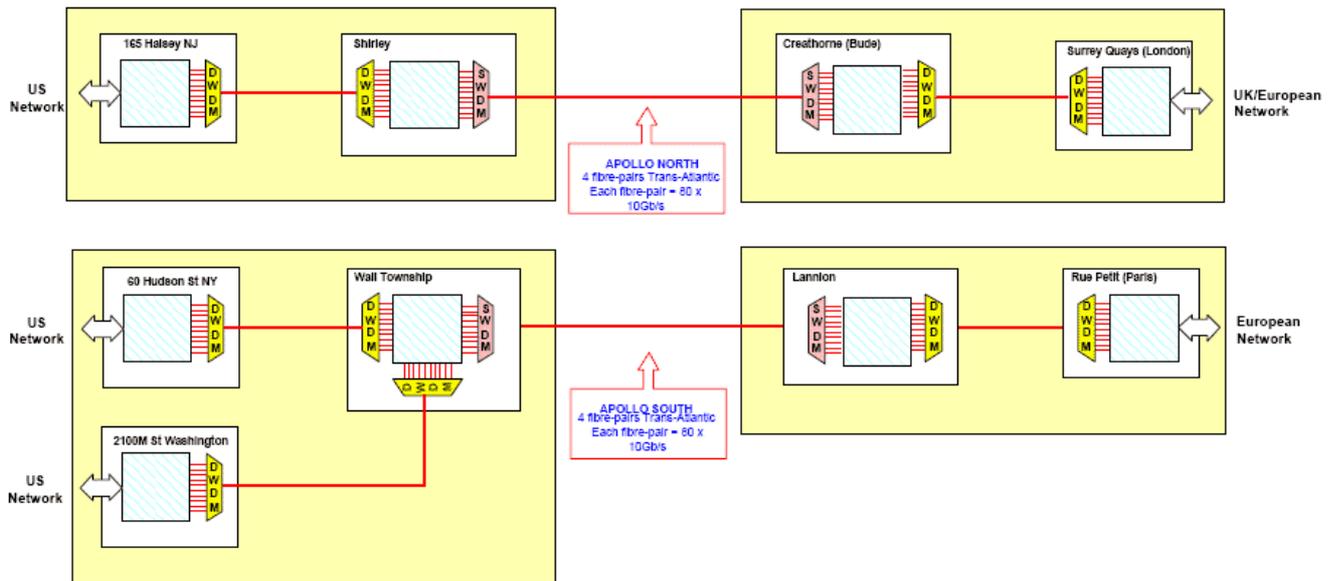
- Latest survey methods for burial assessment used
- First to use Alcatel Submarine Networks' enhanced cable protection design - driven by the Apollo project
- Submarine cables installed using latest plough burial techniques to ensure enhanced resilience and security

Fully Flexible Upgrades

- Two lit fibres already equipped and ready to be upgraded
- Wet segment line equipment designed to allow upgrades to be in service and non-traffic affecting
- Upgrades can be tailored according to customer traffic requirements
- Customers can install their own chosen network protection topologies
- There are two "dark fibres" available

Apollo Strengths

- Seamless city-to-city service
- Wavelength Division Multiplexing (WDM)
- Superior network protection
- Dedicated 24 hour network management and control to ensure optimum service levels
- Emphasis on cable protection
- Exceeds all relevant ITU standards



- Dedicated operation within the Cable & Wireless Global Transmission NOC
- Cable engineers experienced in the operation of submarine cables
- Management of network from city-to-city

Fully Diverse Operation Ensures Continuity of Operations

- Duplicated servers - London and Birmingham
- Fully managed Data Communication Network (DCN)
- 24/7 operations at both sites



Submarine Cable Management

Cable monitoring performed at all landing stations controlled by the Apollo NOC

Activations

- Pre-provisioned capacity for rapid activation
- Dedicated provisioning team
- City-to-city test and commission

Contact points

E-mail: ApolloNOC@cwmsg.cwplc.com

Tel: +44 (0)121 629 5864

Appendix E: Information on Hibernia

(Hibernia Atlantic. Commissioned in 2000, RFS 2001)

Ownership background

Hibernia Atlantic was established by CVC – Columbia Ventures Corporation – to acquire the Trans-Atlantic cable network system that was originally constructed by 360Networks in 2001 at a cost then in excess of Euro900M. The Company '360 Networks' was founded in 1987 as the telecom construction division of Leducor Industries. In 1998, 360Networks entered the service provider business and began building a global network. The company went public in 2000, but filed for bankruptcy in 2001.

CVC completed the acquisition of this network (formerly 360atlantic) in April 2003 for \$17.2M.

Hibernia Atlantic UK operations are situated in Southport giving the North West Region direct access onto the North American telecom networks through major interconnecting 'market place' exchanges in New York, Boston & Canada. There are also direct links into the Irish Telecommunications network through their International Exchange in Dublin.

Architecture

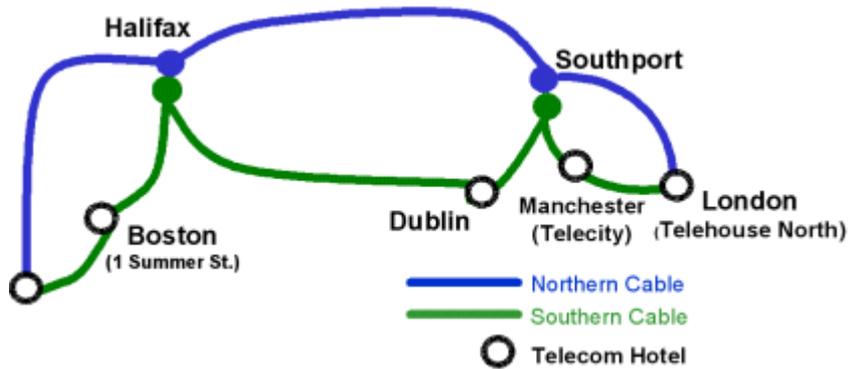
The network is configured as a self-healing ring on diverse paths, with cable landing stations in Dublin; Boston (USA); Halifax, (Nova Scotia); and Liverpool (UK). The Hibernia Atlantic system also includes a fully protected terrestrial ring that links the Boston and Halifax stations via New York City in North America. The system also includes a fully protected terrestrial ring that links the Southport station, (near Liverpool) with Telehouse North in London, while also providing fully protected breakout capability at Manchester-Telecity.

The system offers secure and resilient bandwidth services utilizing recent DWDM, SONET/SDH and optical switching technologies. The system has immediate capacity up to 160 gigabits per second on each path. The system can be upgraded to handle a protected capacity of 1.9 terabits per second, or more than 10 times the current lit capacity.

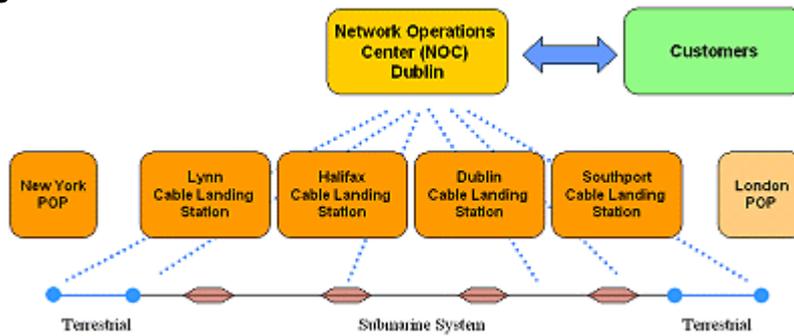
Each cable contains four fibre pairs, with each pair capable of carrying 48 x 10 Gb/s wavelengths, resulting in a total capacity of 1.92 Tb/s (protected).

The system is configured in a ring topology and is capable of delivering protected SDH circuits at STM-1, 4, and 16, in addition to straight 10 Gb/s (STM-64's) wavelengths. The technology deployed is state of the art and is capable of delivering very high performance (low latency) connectivity between Ireland and the United States. As an example, the round trip delay from Dublin to New York is 63ms (31.5 ms each way).

The spacious cable landing stations in the four countries were purpose-built with redundant power and communications equipment to minimize the potential of any service disruptions. The back up generators at its Dublin International Exchange Centre for example have enough capacity to power a medium sized Irish town.



Network Management



NOC Resilience



LARGEST OWNERS

100.0% Columbia Ventures

COMMENTS

Hibernia Atlantic (formerly 360atlantic) forms a self healing ring across the Atlantic, linking the U.S., Canada, Ireland, and the U.K. The system is the first submarine cable to provide a direct fiber-optic connection between North America and Ireland.

In April 2003, Columbia Ventures Corporation completed its acquisition of the 360atlantic cable and renamed it Hibernia Atlantic.

READY FOR SERVICE DATE (RFS)

April 2001

CABLE CAPACITY

Total

Fiber Wavelengths Gb/s per Capacity

Pairs per Fiber Pair Wavelength (Gb/s)

Year-end 2004 2 8 10.0 160

Fully upgraded 4 48 10.0 1,920

CABLE LENGTH

12,200 km

SERVICE OFFERINGS

Bandwidth products

- E-1/T-1
- E-3/DS-3
- STM-1/OC-3
- STM-4/OC-12
- STM-16/OC-48
- STM-64/OC-192
- Unprotected SDH/SONET

Wavelengths

- 2.5 Gb/s Wavelength
- 10 Gb/s Wavelength
- Unprotected Wavelength

Appendix F: Information on FLAG

(Flag Atlantic: commissioned in 1999, RFS 2000)

Ownership

At the time the system was commissioned and granted a licence by the USA FCC, FLAG Atlantic was a joint venture company organized and existing under the laws of Bermuda. Two Bermuda holding companies, FLAG Atlantic Holdings Limited (FAH) and GTS TransAtlantic Holdings, Ltd. (GTS TransAtlantic), each holding 50% of FLAG Atlantic. FAH is a direct wholly owned subsidiary of FLAG Telecom Holdings Limited, a Bermuda holding company. GTS TransAtlantic is an indirect wholly-owned subsidiary of Global TeleSystems Group, Inc., a publicly-traded Delaware corporation.

About 2002, Flag Telecom filed for Ch11 (i.e. USA bankruptcy protection). After Ch11 the Bond holders were effectively the owners and sold out to, I believe, a company named 'Distressed Assts Ltd' (or some similar name). On 12 Jan 2004 FLAG Telecom became a member of the Reliance Group who bought it for an alleged US\$ 160M (Flag Atlantic probably cost > \$2000M.)

Indian owned Reliance Infocomm Ltd. is an Anil Dhirubhai Ambani Enterprises group company.

(The Reliance Group was founded by Shri Dhirubhai Ambani, Anil is one of his 2 sons)

System

FLAG Atlantic is a loop system consisting of three undersea segments. Segment N is the whole of the submarine cable system provided between and including the system interfaces at the cable stations on the north shore of Long Island, New York and at Cornwall, England.

Segment S is the whole of the submarine cable system provided between and including the system interfaces at the cable stations on the south shore of Long Island and at Brittany, France. Segment E (also known as Flag Interlink) is the whole of the submarine cable system between and including the system interfaces at the cable stations at Cornwall, England and Brittany, France. Segments N and S have four optical fibre pairs, Segment E has six.

The system is based on SDH and uses DWDM multiplexing and has been constructed as a self-healing ring. The total capacity of the system is 1.28 Tbit/s. Initially, Flag expected the system to have a capacity (i.e. carry) of 160 Gb/s, with upgrade potential in 160 Gb/s (or multiples thereof) increments as demand warrants.

At the time of writing present demand would suggest that no more than 2-3 fibres are so far lit.

UK backhaul

The backhaul route is owned by Reliance and is independent from any other carrier. The UK section was constructed by Hermes (one of the 2 JV companies) between the landing station and the London PoP. From there it runs through the channel tunnel (to PoP at St Beieec) and then to Brittany to complete the loop. The shore terminal stations are maintained for Flag by C & W.

Flag therefore has its own network as first line of restoration.

Note:

Reliance are planning to move all their activities to India and that will involve closing their office near Heathrow and moving their London Network Operations Centre to Mumbai (to use local staff).

Appendix G: Information on VSNL

Note from Press announcement of 3rd May 2005:

Videsh Sanchar Nigam Limited (VSNL) (NYSE: VSL), --- today announced that the Federal Communications Commission (FCC) in the United States approved its application on April 29, 2005 to transfer the Tyco Global Network (TGN) landing station licenses from Tyco to VSNL. The FCC's approval culminates a nearly six-month process that included a formal review by the Committee on Foreign Investment in the United States (CFIUS) as well as the Department of Homeland Security (DHS), the Department of Defense (DOD), the Department of Justice (DOJ), the Federal Bureau of Investigation (FBI) and other agencies to ensure the transaction would not pose competition, law enforcement, national security or public safety concerns. All agencies agreed it would not.

Appendix H: Summary of all submarine cables serving UK

Note: Cables listed by In-Service date

IN SERVICE CABLES	
<p>UK-Ireland 1 <i>(Updated 8 August 2000)</i></p>	<p><i>In-Service: 1988</i> Holyhead, UK - Portmarnock, Ireland - 126 km at 6 x 140 Mb/s <i>Maintenance Authorities: British Telecom, Eircom</i></p>
<p>Scotland-Northern Ireland 1 <i>(Updated 29 September 2004, BT)</i></p>	<p><i>In-Service: 1989</i> Portpatrick, Scotland - Donaghadee, Northern Ireland - 35 km at 6 x 560 Mb/s <i>Maintenance Authorities: British Telecom</i></p>
<p>UK-Channel Isles 7 <i>(Updated 14 Sep. 2000, C & W Guernsey)</i></p>	<p><i>In-Service: 1989</i> Dartmouth, UK – Lancrese Bay, Guernsey, - 124 km at 2.5Gb/s <i>Maintenance Authorities: British Telecom, C & W Guernsey</i></p>
<p>UK-France 3 <i>(Updated 23 May 2002)</i></p>	<p><i>In-Service: 1989</i> Brighton, UK - Dieppe, France - 155 km (143km) at 6 x 140 Mb/s <i>Maintenance Authorities: BT, C&W, France Telecom</i></p>
<p>UK-Isle of Man</p>	<p><i>In-Service: 1990</i> Millom, UK - Douglas, Isle of Man - 155 km at 6 x 140 Mb/s <i>Maintenance Authorities: British Telecom, MTL</i></p>
<p>TAT 10 (Segment D) <i>(Updated 8 August 2000)</i></p>	<p><i>In-Service: 1992</i> Norden, Germany, Alkmaar, Netherlands - 314 km at 3x565 Mb/s <i>Maintenance Authorities: KPN, DTAG</i></p>
<p>Denmark-Germany 1 <i>(Updated 25 October 2005, TDC)</i></p>	<p><i>In-Service: 1992</i> Maade, Denmark – Norden, Germany - 293 km at 2x565 Mb/s <i>Maintenance Authorities: DTAG, TDC</i></p>
<p>LANIS <i>(Updated 8 August 2000, C&W)</i></p>	<p><i>In-Service: 1992</i> Blackpool, Isle Of Man, N. Ireland, Scotland - 293 km at 6x565 Mb/s <i>Maintenance Authorities: C&W</i></p>

<p>Scotland-Northern Ireland 2 <i>(Updated 29 September 2004, BT)</i></p>	<p><i>In-Service: 1993</i> Girvan, Scotland, Larne, NI - 83 km at 565 Mb/s <i>Maintenance Authorities: BT</i></p>
<p>UK-Channel Isles 8 <i>(Updated 4 August 2000, Jersey Telecoms)</i></p>	<p><i>In-Service: 1994</i> Goonhilly, UK – St Ouens Bay, Jersey, Channel Isles - 237 km at 155 Mb/s, 12 fibre. <i>Maintenance Authorities: British Telecom, Jersey Telecoms</i></p>
<p>Guernsey-Jersey 4 <i>(Updated 4 August 2000, Jersey Telecoms)</i></p>	<p><i>In-Service: 1994</i> Saints Bay, Guernsey – Greve de Lecq, Jersey - 37 km at 155 Mb/s, 12 fibre. <i>Maintenance Authorities: C & W Guernsey, Jersey Telecoms.</i></p>
<p>CANTAT 3 <i>(Updated 25 October 2005, TDC)</i></p>	<p><i>In-Service: 1994</i> Pennant Point, Canada – Europe 6,450 km at 3x2.5 Gb/s <i>Maintenance Authorities: Teleglobe Canada, Iceland Telecom, BT, TDC, DTAG</i></p>
<p>Celtic <i>(Updated 29 September 2004, BT)</i></p>	<p><i>In-Service: 1994</i> Sennen Cove, UK, Kilmore Quay, Ireland - 263 km at 2.5 Gb/s <i>Maintenance Authorities: BT, Telecom Eireann</i></p>
<p>RIOJA (2B/3B) <i>(Updated 23 May 2002)</i></p>	<p><i>In-Service: 1995</i> Santander, Spain, Goonhilly, UK, Veurne, Belgium, Alkmaar, Netherlands - 1737 km at 2x2.4 Gb/s <i>Maintenance Authorities: Telefonica, BT, Belgacom, KPN</i></p>
<p>UK-Netherlands 14 <i>(Updated 26 October 2005, KPN)</i></p>	<p><i>In-Service: 1997 (Planned to be out-of-service 1 Jan 2006)</i> UK - Netherlands - 206 km <i>Maintenance Authorities: C&W, KPN, C&W, BT</i></p>
<p>HER-1 <i>(Updated 4 August 2000, GTS Network)</i></p>	<p><i>In-Service: Oct. 1997</i> 24 fibres, 204 km (BMH-BMH) at 2.5 Gb/s per fiber-pair <i>Maintenance Authorities: Global TeleSystems Inc, GTS Network Services</i></p>
<p>HER-2 <i>(Updated 4 August 2000, GTS Network)</i></p>	<p><i>In-Service: Oct. 1997</i> 24 fibres, 133 km (BMH-BMH) at 100 Gb/s per fiber-pair <i>Maintenance Authorities: Global TeleSystems Inc, GTS Network Services</i></p>
<p>Ulysses 1 <i>(Updated 25 October 2005 MCI)</i></p>	<p><i>In-Service: 1998</i> 48 fibres, 49 km at 2.5 Gb/s <i>Maintenance Authority: MCI</i></p>

<p>AC-1 (Updated 25 October 2005, TDC)</p>	<p><i>In-Service: 1998</i> Brookhaven,US - Whitesands,UK, Beverwijk, Netherlands, Westerland, Germany - 2472 km at 4x20 Gbs <i>Maintenance Authority: Global Crossing</i></p>
<p>Ulysses 2 (Updated 25 October 2005 MCI)</p>	<p><i>In-Service: 1998</i> 48 fibres, 199 km at 2.5 Gb/s <i>Maintenance Authority: MCI</i></p>
<p>UK-Germany 6 (Updated 29 September 2004, BT)</p>	<p><i>In-Service: 1998</i> Norden, Germany, Scarborough, UK - 557 km at 8 X 2.5 Gb/s <i>Maintenance Authorities: BT, C&W & TSI</i></p>
<p>FARLAND (Updated 29 September 2004, BT)</p>	<p><i>In-Service: 1998</i> Aldeburgh , UK, Domburg, Holland - 148 km at 10 Gb/s <i>Maintenance Authorities: BT/NTL</i></p>
<p>SOLAS (Updated 8 August 2000, C&W)</p>	<p><i>In Service: ??</i> Kilmore Quay, Ireland, Oxwich Bay, UK, Porthcurno, UK - 140 Km at 2xSTM-16 <i>Maintenance Authorities: C&W, Eircom</i></p>
<p>SIRIUS (Updated 8 August 2000)</p>	<p><i>In-Service: ??</i> ?? UK, ?? N. Ireland, ?? Ireland <i>Maintenance Authorities: NTL</i></p>
<p>CIRCE North (Entered 2 September 2000, Viatel)</p>	<p><i>In-Service: February 1999</i> Lowestoft, UK to Zandvoort, Netherlands, 48 Fibres, 203km at 10 Gbit/s <i>Maintenance Authority: Viatel</i></p>
<p>ESAT 1 (Updated 29 September 2004, BT)</p>	<p><i>In-Service: 1999</i> Whitesands , UK, Kilmore Quay, Ireland - 256 km at 2.5 Gb/s <i>Maintenance Authorities: BT/ESAT</i></p>
<p>ESAT 2 (Updated 29 September 2004, BT)</p>	<p><i>In-Service: 1999</i> Southport , UK, Dublin, Ireland - 237 km at 10 Gb/s <i>Maintenance Authorities: BT/ESAT</i></p>
<p>CIRCE South (Entered 2 September 2000, Viatel)</p>	<p><i>In-Service February 1999</i> Pevensey Bay, UK to Cayeux-sur-Mer, France, 48 Fibres 115km at 10Gbit/s <i>Maintenance Authority: Viatel</i></p>
<p>Concerto #1 (Entered 18 December 2000, Flute)</p>	<p><i>In-Service: March 1999</i> Sizewell, UK, - Zandvoort, Netherlands, - Zeebrugge, Belgium – Thorpeness, UK, 550 km self-healing ring configuration, 96 fibre cable (Dark fibre). Connectivity to London, Amsterdam and</p>

	<p>Brussels. Maintenance Authority: Interoute/Flute Limited</p>
<p>SEA-ME-WE 3 (Segment 10) <i>(Updated 25 October 2005, TDC)</i></p>	<p><i>In-Service: April 1999</i> Penmarc'h, France, - Goonhilly, UK, - Ostende, Belgium - Norden, Germany, 1258km at 4 x 2.5Gb/s (Upgradeable to 8 x 2.5Gb/s). Maintenance Authorities: BT, Deutsche Telekom AG, TDC</p>
<p>Tangerine <i>(Updated 10 December 2002, Level 3)</i></p>	<p><i>In-Service September 2000</i> Broadstairs, UK to Ostend, Belgium. 112km, 4 x 48 fibres (192 fibres). Maintenance Authority: Level 3</p>
<p>Ingrid System (Nos 1-6) <i>(Entered 30 August 2000, CIEG)</i></p>	<p><i>In Service Sept 2000</i> Havelet Bay, Guernsey to Greve de Lecq, Jersey 37.1km at , 3 x 24 fibres; Archirondel, Jersey to St Remy de Landes , France 1x 24 + 2 x 48 fibres Maintenance Authority CIEG</p>
<p>PEC <i>(Entered 22 September 2000, Global Marine Systems Limited)</i></p>	<p><i>In-Service:</i> Dumpton Gap (UK)-Bredene (Belg) 117km at Maintenance Authorities:</p>
<p>Manx-Northern Ireland <i>(Entered 18 October 2002, BT)</i></p>	<p><i>In-service: September 2000</i> Peel (Isle of Man)-Ballyhornan (Northern Ireland) 59 km at 12 x 40 Gb/s Maintenance Authority: BT</p>
<p>Hibernia Atlantic <i>(Updated 27 October 2005, Hibernia Atlantic)</i></p>	<p><i>In-service: June 2001</i> Dublin, Eire - Halifax, Nova Scotia, Canada - Boston, USA - Southport, UK. Maintenance Authority: Hibernia Atlantic</p>
<p>TAT-14 Segments H, I, J, N & K1S <i>(Updated 27 October 2005, TeliaSonera)</i></p>	<p><i>In-Service: December 2001</i> Mevagissey, UK St. Valery en Caux, France; Katwijk, Netherlands; Norden, Germany; Blaabjerg, Denmark – Total TAT-14 length 15,428 km at 16 x 10 gbit/s SDH. Maintenance Authorities: AT&T, BT, France Telecom, TeliaSonera, Deutsche Telecom, KPN</p>
<p>VSNL Northern Europe <i>(Updated 17 November 2005, Tyco)</i></p>	<p><i>In-Service: January 2002</i> Hunmanby, UK - Eemshaven, The Netherlands (578km) Maximum capacity of 3.84 Tb/s.</p>

	<i>Maintenance Authority: VSNL</i>
<u>FARICE-1</u> <i>(Entered 6 February 2004, FARICE hf)</i>	<i>In-service: January 2004</i> Capacity: 2 x 10 Gbit/s. Seydisfjordur, Iceland - Funningsfjordur, The Faroe Islands - Dunnet Bay, Scotland. Total Length:1407 km <i>Maintenance Authorities: Farice Ltd, Iceland Telecom Ltd</i>
OUT OF SERVICE CABLES	
UK-Denmark 4 <i>(Updated 25 October 2005, TDC)</i>	<i>In-Service: 1988; Out-of-Service 1 September 2004</i> Scarborough, UK - Blaabjerg, Denmark - 635 km at 2 x 280 Mb/s <i>Maintenance Authorities: BT, TDC</i>
UK-Belgium 5 <i>(Updated 7 January 2005, BT)</i>	<i>In-Service: 1987; Out-of-Service 1 January 2005</i> Broadstairs, UK - Oostende, Belgium - 58 km at 560 Mb/s <i>Maintenance Authorities: BT, Belgacom</i>
UK-Netherlands 12 <i>(Updated 7 January 2005, BT)</i>	<i>In-Service: 1989; Out-of-Service 1 January 2005</i> Aldeburgh, UK - Domburg, Netherlands - 152 km at 560 Mb/s <i>Maintenance Authorities: BT, C&W, KPN</i>
TAT 10 (Segment B) <i>(Updated 24 October 2005 AT&T)</i>	<i>In-Service: 1992; Out of Service 7 July 2003</i> Greenhill, USA, Norden, Germany - 6934 km at 3x565 Mb/s <i>Maintenance Authorities: AT&T, DTAG</i>
UK-NSO <i>(Updated 24 November 2005, BT)</i>	<i>In-Service: 1988; Out of Service: 2005</i> Weybourne, UK -- North Sea Platform - 142 km at 2 Mb/s <i>Maintenance Authority: BT</i>
UK-France 4 <i>(Updated 24 November 2005, BT)</i>	<i>In-Service: 1991; Out of Service: 1 January 2006</i> Dunkerque, France - Bay Hill, UK - 93 km (57km) at 6 x 560 Mb/s <i>Maintenance Authorities: France Telecom, C&W, BT</i>
UK-Belgium 6 <i>(Updated 24 November 2005, BT)</i>	<i>In Service 1991; Out of Service: 1 January 2006</i> St Margarets Bay, UK – Veurne, Belgium - 100 km at 2 x 2,5 Gbps + 2 x 565 Mb/s <i>Maintenance Authorities, BT, C&W, Belgacom</i>
UK-Germany 5 <i>(Updated 24 November 2005, BT)</i>	<i>In-Service: 1991; Out of Service: 1 January 2006</i> Norden, Germany, Winterton, UK - 465 km at 2 X 140 Mb/s <i>Maintenance Authorities: BT & TSI</i>

Source - International Cable Protection Committee website

Appendix I: Present/future demand on trans-Atlantic cables

According to TeleGeography's Bandwidth Pricing Report, a consortium consisting of major European and North American carriers is rumoured to be seeking to make a bulk trans-Atlantic capacity purchase by the end of 2005. This consortium is requesting detailed information from trans-Atlantic submarine cable operators about their network architectures, operating and maintenance costs, and future costs of upgrade. With an anticipated combined requirement of more than 1 Tbps of capacity over the next three years, this move aims to lock in current market prices with long-term IRU purchases and provide these carriers with a hedge against possible future price increases. Likely respondents to this request include Apollo, FLAG (FA-1), Hibernia Atlantic, and VSNL (Tyco Trans-Atlantic). Each system not only has existing lit inventory but also plenty of spare upgradeable capacity.

This rumoured mass capacity purchase clearly would be the most important event to occur in the trans-Atlantic submarine cable market in recent years. The response to this proposal will likely help determine which cable systems survive and which cables could potentially be forced into bankruptcy or perhaps even shut down. Carriers with trans-Atlantic capacity and investors with interest in the sector should monitor this situation closely. Anticipated levels of trans-Atlantic demand, as well as current and historical trans-Atlantic bandwidth pricing data, are available in TeleGeography's website.

Appendix J: Market operation

The Ofcom document [2] describes the six basic ways in which wholesale international services are carried. They are:

- Direct conveyance;
- Simple transit;
- Refile;
- Switched bypass/international simple resale (ISR);
- Global provider's internal network carriage; and
- Voice over IP ("VoIP") bypass.

The following explains the operation of each of these services.

Direct conveyance

- 1. The customer dials an international number.*
- 2. The originating provider routes the call over its international facilities to a correspondent provider in the destination country.*
- 3. The correspondent provider receives a settlement payment from the originating provider and terminates the call.*

In this case, an agreement exists between the originating provider and its correspondent provider in the destination country. The agreement between providers for direct conveyance is often referred to as a "correspondent agreement" or a "bilateral agreement" and the route to which these agreements relate is often referred to as a "bilateral route".

Simple transit

- 1. The customer dials an international number.*
- 2. The originating provider routes the call over international facilities to a correspondent provider in the transit country.*
- 3. The transit provider routes the traffic to the destination country.*
- 4. The transit provider declares this traffic as transit traffic to the destination.*

In this case, a three party agreement exists between the originating, transit and terminating providers for settlement purposes.

Refile

- 1. The customer dials an international number*
- 2. The originating provider sends the call to a hub country via the PSTN or over a private leased line.*
- 3. The refile provider re-originates the call over the PSTN.*
- 4. The call is delivered to the final destination via the refile provider, which pays the settlement charge to the terminating provider.*

International refile exploits the fact that international accounting rates, which are the rates at which international providers account to each other for the calls they originate and terminate, are negotiated on a bilateral basis between countries, and can therefore differ significantly depending on the partner.

For example, the combined accounting rate between country A and country B, and country B and country C can be less than the single accounting rate between country A and country C. In this case, providers would have a financial incentive to route – or refile – country A to country C traffic through country B.

Switched bypass/international simple resale (ISR)

- 1. The customer dials an international number.*
- 2. The call is routed over a private leased line to a switch in the destination country (but not usually to the incumbent provider e.g. to an alternate fixed provider or a mobile provider).*
- 3. The call is re-routed to the incumbent provider's network and completed as a local call on the PSTN.*
- 4. The originating provider pays no international settlements.*

Switched bypass exploits the fact that in a number of cases international accounting rates are well above the cost of local termination in the destination country. Depending on the telecommunications legislation in the destination country, this practice may be prohibited in that country.

Global provider's internal network

- 1. The customer dials an international number.*
- 2. The call is routed over the originating provider's international network to the destination country.*
- 3. The call is terminated in the destination country.*

Many providers in the global international services marketplace have a presence in more than one country. In the case of each of these overseas operations, there exists a market for delivery of international services traffic.

Each of the overseas operations will be able to buy and sell international services delivery. In such circumstances a provider may choose to route traffic originating in country A to its presence in country B (a transit country) in order to buy call termination to the final destination.

- 1. The customer dials an international number.*
- 2. The call is routed over the originating provider's international network to a transit country.*
- 3. The call termination to the destination country is then bought in the "local market" in the intermediary country.*
- 4. The call is delivered to the destination country either using its facilities in the transit country (or via a transit provider) via its correspondent delivery method or by other means.*

Even in the absence of an internal network, carriers may route traffic via an international private line to a third country to buy international services delivery in that third country. This is similar to “Switched bypass” above, but the destination country is not limited to that in which the private line terminates.

VoIP bypass

1. *The customer dials an international number.*
2. *The call is routed over the PSTN to gateway computer.*
3. *The call is converted from analogue voice to IP and sent over a data network such as the Internet to a gateway in the terminating country.*
4. *The call is converted back from IP to analogue voice.*
5. *The call is completed as a local call on the PSTN.*
6. *The originating provider pays no international settlements.*

VoIP bypass relies on IP backbone networks not being used to their full capacity and so allowing providers to carry voice traffic at lower rates than could be achieved over switched networks. Additionally in destination countries where international termination rates are high and national termination rates are lower, as the voice traffic re-enters the PSTN at a national switch rather than an international switch, the provider is able to avoid the high international termination charge paying only the national charge.

In some countries VoIP bypass is prohibited as it avoids the international accounting rate mechanism (though its use is often very hard to detect). VoIP bypass is often of particular importance for the introduction of competitive international services conveyance to such countries despite being prohibited. In certain countries, it has expedited the liberalisation of that country’s international telecommunications market.

Trading Exchanges

1. *The customer dials an international number.*
2. *The call is routed to a trading exchange where delivery to the destination is purchased via the exchange’s trading mechanisms. (This is usually via an ‘anonymous’ transaction between the buyer and seller managed by the trading exchange.)*
3. *The “seller” delivers the call to the destination however it chooses.*

Examples of trading exchanges are Arbinet and Band-X.

Whilst the trading exchanges have a physical presence in a country (i.e. their switch), the markets in which they operate effectively transcend national boundaries as providers from many countries will be connected to the exchanges via international private lines for both buying and selling.

As some trading exchanges are perceived by some providers to offer lower call quality than that offered by other carriage methods, they may not be perceived as attractive conveyance methods in certain circumstances. Although the trading exchanges are believed to be small currently, they provide evidence of a wider competitive market operating above and beyond national boundaries.

Appendix K: Assessment of significant market power for wholesale international markets

The data in this annex is extracted from an Ofcom Explanatory Note 'Wholesale international services markets' published 26 August 2003 [3]. It was part of an initial market analysis carried out by Ofcom in accordance with the requirements of the European 'Framework Directive' for electronic communications networks and services which came into force in the UK on 25 July 2003.

The Explanatory Note was part of a consultation activity which identified the UK wholesale international services markets and analysed them to show whether individual routes were competitive, or whether one operator held significant market power. It should be noted that the review covered both satellite and sub-sea traffic. However the sub-sea dominates the provision of capacity.

The tables are reproduced below. The data will have been used to determine whether regulatory actions need to be taken and if so, what form they should take. Following these further negotiations the status of some markets may have changed so this table should be taken as indicative only.

Competitive routes	Markets for which the Director proposes that BT has SMP	Markets for which the Director proposes that C&W has SMP
118	113	4
Andorra Antigua and Barbuda Argentina Australia Austria Azerbaijan Bahamas Bahrain Bangladesh Barbados Belarus Belgium Belize Bermuda Bolivia Botswana Brazil Brunei Darussalam Bulgaria Canada Cayman Islands Chile China Colombia Costa Rica Croatia Cyprus Czech Republic Denmark Dominica Dominican Republic Ecuador Egypt El Salvador Estonia Falkland Islands Finland	Afghanistan Albania Algeria American Samoa Angola Anguilla Antarctica Australian Territory Armenia Aruba Benin Bhutan Bosnia and Herzegovina Burkina Faso Burundi Cambodia Cameroon Cape Verde Central African Republic Chad Comoros Congo Congo, DR Cook Islands Côte d'Ivoire Cuba Djibouti East Timor Equatorial Guinea Eritrea Ethiopia Faroe Islands Fiji French Guiana French Polynesia Gabon Georgia Gibraltar	Ascension Island Diego Garcia Montserrat Turks & Caicos

Competitive routes	Markets for which the Director proposes that BT has SMP	Markets for which the Director proposes that C&W has SMP
France Gambia Germany Ghana Greece Grenada Guatemala Guyana Hong Kong Hungary Iceland India Indonesia Iran Ireland Israel Italy Jamaica Japan Jordan Kazakhstan Kenya Korea (South) Kuwait Laos Latvia Luxembourg Macau Malaysia Maldives Malta Mexico Monaco Mongolia Morocco Nepal Netherlands Netherlands Antilles New Zealand Nicaragua Nigeria Norway Oman Pakistan	Greenland Guadeloupe Guam Guinea Guinea Bissau Haiti Honduras Iraq Kiribati Korea, PDR Kirgizstan Lebanon Lesotho Liberia Libya Liechtenstein Lithuania Macedonia Madagascar Malawi Mali Marshall Islands Martinique Mauritania Mauritius Mayotte Micronesia Midway Islands Moldova Mozambique Myanmar Namibia Nauru New Caledonia Niger Niue Norfolk Island Northern Marianas Palau Papua New Guinea Puerto Rico Reunion Rodriguez Islands Romania	

Competitive routes	Markets for which the Director proposes that BT has SMP	Markets for which the Director proposes that C&W has SMP
Panama Paraguay Peru Philippines Poland Portugal Qatar Russian Federation Saint Helena Saint Lucia Saint Vincent & the Grenadines Saudi Arabia Singapore Slovak Republic Slovenia South Africa Spain Sri Lanka Sweden Switzerland Syria Taiwan Tanzania Thailand Tunisia Turkey Ukraine United Arab Emirates Uruguay USA Venezuela Vietnam Virgin Islands (UK) Yemen Yugoslavia Zambia Zimbabwe	Rwanda Saint Kitts & Nevis Saint Pierre & Miquelon Samoa San Marino Sao Tome and Principe Senegal Seychelles Sierra Leone Solomon Islands Somalia Sudan Suriname Swaziland Tajikistan Togo Tokelau Tonga Trinidad & Tobago Tristan Da Cunha Turkmenistan Tuvalu Uganda Uzbekistan Vanuatu Virgin Islands (US) Wake Island Wallis & Futuna Emsat Inmarsat Iridium Thuraya	

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International Cable Protection Committee –

<http://www.iscpc.org>

History

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