O cabo submarino num mar de conetividades

The submarine cable in a sea of connectivity

International Telegraph Cable Map; source: Schneider, 1924

Cover: Buoys and cableship in the landing operation of the SAT-3 system in Sesimbra; FPC, 2001

THE SUBMARINE CABLE IN A SEA OF CONNECTIVITY

The past and the future of communications, and its development over the years, has always involved the seabed and the ocean floor, where, discreetly and unsuspected by most people, submarine cables continue to play a key role.

This exhibition takes us on a fascinating journey through time, giving us insight into a rich past, and into a present constructed from technological development and innovation. It also invites us to take a glimpse into the future of this important transmission system. In particular, the exhibition focuses on:

- Communication in Empires, from the 19th century to the mid-20th century - the telegraph cables and radio-based alternatives.
- Communication between Nations, in the second half of the 20th century - telephone cables and the satellite-based alternatives.
- Communication between people and the development of the Internet, since the late 20th century – optical fibre cables capable of supporting the full range of multimedia communications.
- The current state of research in the optical communications industry, in particular into submarine cables.

The exhibition focuses on the technological, economic and social impact of global communications in the area of information and communication technologies (ICT), highlighting Portugal's geostrategic importance over time, and the global community to which Portugal is linked.

The exhibition has been promoted by Autoridade Nacional de Comunicações (ANACOM), considering the importance of submarine cables in the globalisation of communications, as part of a series of events celebrating the 150th anniversary of the International Telecommunication Union[1] (ITU).

(1) On 17 May 1865, the first International Telegraph Convention was signed in Paris by 20 countries, including Portugal; this led to the establishment of the International Telecommunication Union, a specialist agency of the United Nations for telecommunications and the world's oldest intergovernmental organisation.

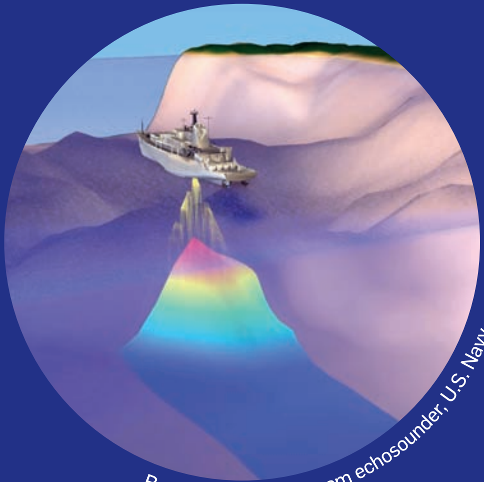
THE SEABED, A NATURAL PLATFORM FOR SUBMARINE CABLES

Setting out to discover the secret world of submarine cables through their historical context, the exhibition's journey through communications and time begins with telegraphic communications and concludes in the modern world of multimedia communications.

Along the way, we also have opportunity to find out about a series of techniques and technologies used to measure ocean depth (bathymetry), providing details of seabed morphology; this is critical when laying submarine cable networks and to their successful maintenance and repair.

From the use of lines with lead weights to determine depth and collect sediment in the era of the first telegraph cables, to multi-beam sonar, satellites and remotely operated vehicles (ROV) equipped with high-definition video cameras, used in current bathymetry to achieve rigorous mapping and in-depth knowledge of marine morphology. This exhibition takes us into a world which resembles a futuristic movie, outlining a fundamental reality for today's communications.

In the exhibition, we can see a map of sea floor of Faial – Pico channel, a sonar equipment and a ROV, property of Instituto Hidrográfico, and a diving equipment, property of the Portuguese Navy Divers School.



Bathymetry – multibeam echosounder, U.S. Navy

Cableship Goliath laying out the telegraph submarine cable in English Channel, Illustrated London News, 07.09.1850

THE SUBMARINE CABLE IN TELEGRAPHIC COMMUNICATION

The epic era of submarine cable operation began in the mid-19th century, more precisely in 1850 with the first international connection between France and England and the first viable and lasting transatlantic link in 1858. From that point onwards, new projects were launched with increasing ambition.

It was a period marked by expanding international trade, particularly for Europe's colonial empires. In the large British Empire, having to wait six weeks for a message sent from England to arrive in India had become untenable.

It is not therefore surprising that, once launched, the maritime communication cable was heralded as the 8th wonder of the world.

On 8 June 1870, the first submarine telegraph cable entered into service, linking Portugal (Carcavelos) to England. Upon its inauguration the first messages were exchanged between King D. Luís I of Portugal and Queen Victoria.

Over the following decades, Portugal, and especially the islands of Madeira, the Azores and Cape Verde, attracted a number of British, American, German and Italian submarine cable companies seeking to fulfil the communications requirements of their colonial empires, particularly the immense British Empire. The limitations of the technology available at that time meant that relay points were needed; as a result, Portuguese territories were made primarily important as transit and interconnection points for transatlantic communications (north/south and east/west).

Taking advantage of this situation, Portugal became part of a constantly evolving global network and thus created solutions to meet the growing needs of the traffic routed to their colonial territories as well as the international terminal traffic.

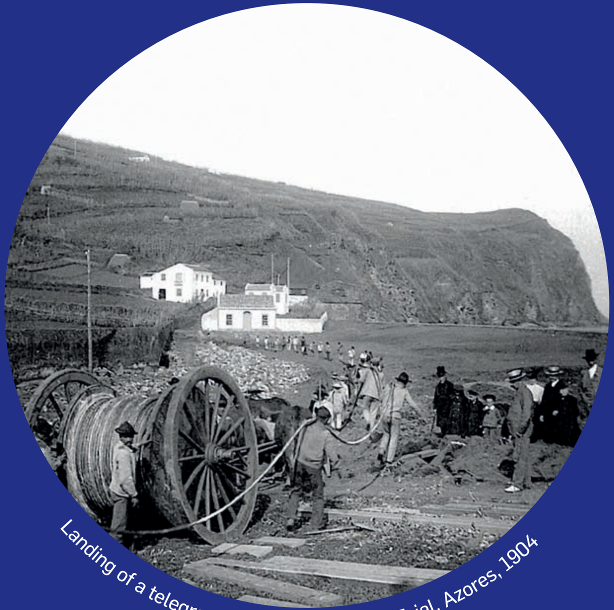
Portugal's main international submarine cable stations were located at Carcavelos, Azores - Horta, Madeira - Funchal and Cape Verde - São Vicente. Due to its location - in the mid-Atlantic, halfway between North America and Europe – Horta had a key position in the international submarine telegraph network, with a total of 15 international cables landed on Faial's island.

From the early 20th century, a strong competitor emerged to face the submarine cable in international telegraph communications: wireless telegraphy and the first telephone communications via radio.

The importance of submarine telegraph cables declined over the course of the century and they were replaced by coaxial submarine cables with signal amplification provided by submarine repeaters. Offering increased communications capability, these cables enabled not only the transmission of telegraph messages, but crucially the transmission of expanding volumes of telephone communications. Finally, in the early 1970s, use of telegraph cables was abandoned.

From this period it is possible to see in the exhibition some devices used at that time and documents, emphasizing the great heritage of the Azores, in Faial Island, illustrating the period of the international telegraph submarine cable by its technological components, but also the social, political and strategic impacts for Portugal and the world.

Royal Family at Carcavelos station – Inauguration of the submarine cable to Azores, 1893



Landing of a telegraph submarine cable in Faial, Azores, 1904

Siphon recorder and cable key, Museu da Horta collection

THE COAXIAL SUBMARINE CABLE IN THE TELEPHONE COMMUNICATION

Although submarine cables were first used for telephone communications in 1891, it wasn't until the mid-twentieth century that they could be used for transporting voice communications under the oceans. Until then intercontinental voice communications had been transmitted by radio.

As opposed to land-based cables, the signal level transmitted along existing submarine cables weakened rapidly, mainly as a result of the cable's high capacitance, with the cable and the sea acting like electrodes in a capacitor. Therefore, without any means of amplifying the signals to compensate for their attenuation in longer cables, nothing was received at the other end.

As a result, in the first half of the 20th century, submarine cables were only viable for the transmission of voice communications over short distances, not much beyond a few tens of kilometres and only through shallow water. These cables were mostly made up of wire pairs, one pair per voice circuit, of the type used for terrestrial cable. It wasn't until 1921 that voice could be transmitted over medium distances (around 200 km) and at medium depths, based on similar morphology to that used in current coaxial cables.

The development of terrestrial telephone networks, with increasing numbers of users, and the need for quality intercontinental communication that was less dependent on weather conditions led to important developments at the end of the first half of the century. One of the most important developments was the introduction of the coaxial cable coupled with the use of polyethylene, an artificial thermoplastic polymer insulator to replace gutta-percha, and also the amplification of signals using submarine repeaters inserted into the cable itself at intervals of around 50km.

As such, the first transatlantic cable, TAT-1, came into service in 1956 - a large investment made by a specially formed joint venture between American Telephone and Telegraph (AT&T), Britain's General Post Office and Canada's Canadian Overseas Telecommunications Corporation. This cable connected Scotland to Newfoundland in Canada, with repeaters that used valves (pentodes). In service until 1978, it could transmit 34 voice communications simultaneously, a channel for 24 telegraph communications and a channel for service communications.

Portugal's telecom utility, CPRM - Companhia Portuguesa Rádio Marconi, began to use international telephone cables with the simultaneous landing of two cables in Sesimbra: one to South Africa (SAT-1) and another to England (Portugal - United Kingdom 1).

Over the following two decades, CPRM invested in 5 further coaxial systems terminated at stations in Portugal, four international systems and one domestic system (linking the mainland to Madeira), and as party in eleven other international submarine systems.

Although by the end of the 1980s, the pace of submarine cable installation had become intense, submarine cables still did not dominate the panorama of intercontinental communications – satellites carried the majority of intercontinental telephone traffic, given their ubiquity in terms of geographic access, greater available transmission bandwidth and lower operating costs.

From this period, the exhibition displays equipment from the former coaxial submarine cables landed in Portugal, including a repeater and station equipment such as a line terminal equipment, monitoring equipment, Wheatstone bridge and a submarine cable power feed system. In addition to the equipment on display, various documents, photos and films seek to provide an accurate portrayal of the activity and the technological environment in which this activity was conducted and developed.

Terminal equipment in cable station in Sesimbra, FPC, 70's

Cableship John Mackay landing the SAT-1 submarine cable in Sal, Cape Verde, FPC, 1968

Inaugural medal of the TAT-5 / MAT-1, FPC, 1970

THE OPTICAL SUBMARINE CABLE IN MULTIMEDIA COMMUNICATION

The first half of the 20th century saw the emergence of applications in various fields which entailed the transmission of light guided along glass tubes and later glass fibres.

When light is transmitted by fibre, regardless of the material used or the application, the light beam, given the optical characteristics of the carrying medium (fibre), is propagated by successive internal reflection. The fibre acts as a waveguide, transmitting light end-to-end.

Charles Kao and George Hockham, of Standard Telephones and Cables (STC) Laboratories in the United Kingdom, published an article in 1964 demonstrating, in theory, that the loss of light in existing glass fibres could be reduced drastically, if impurities could be removed. Research and laboratory testing was carried out over subsequent years and, in 1973, Bell Laboratories developed a process to inject chemical vapours and oxygen which, when heated, made the glass ultra-transparent and enabled the mass production of optical fibre providing for reduced loss of light. This process remains the standard in the manufacture of optical fibre cables today.

Lasers (light amplification by stimulated emission of radiation) had already been introduced in 1958 as an efficient light source and at the beginning of the 1960s, the LED (light emitting diode) was invented and the production was initiated.

As such, the two main elements necessary for optical communication had been developed: a light source, powerful photon emitter such as a laser and/or LED, converting electrical impulses (bits) representing digital binary values (0 and 1) in pulses of light and a means of carrying and guiding light within the infrared radiation window, glass (silica) or plastic.

In the mid-1970s, optical fibre began to be used for terrestrial telephone communications between major cities and, in the early 1980s, the infrastructure of a large number of operators already included many kilometres of optical fibre network.

In 1988, at a time when communications were still essentially telephone-based, with data communications primarily limited to the largest companies and the Internet confined to the scientific community, the first transatlantic optical submarine cable came into service. This cable, in addition to providing a ten-fold increase over the capacity of a coaxial cable, enabling 40,000 simultaneous communications, had a multipoint configuration type, allowing interconnection among different terminal stations with the use of branching units, a situation that was only made possible by the extremely thin fibres, as well as provides a greater return on investment and wider use. By making it possible for investment to be shared among a larger number of countries and by providing greater ubiquity and flexibility in access, this solution brought added economic value.

The first optical submarine cable was landed in Portugal in 1992. Named as Eurafrica, the system was a multipoint configuration terminated on mainland Portugal, Madeira, Morocco and France.

New developments followed at a rapid pace, with ever improving performance and increased fibre transmission capacity spanning six generations of technological advancement to date.

A current optical submarine system with 40 Terabit transmission capacity, supports 10 billion simultaneous telephone conversations or the download of the content of 5 million books per second.

Nowadays, more than half a million kilometres of optical submarine cable cross the 5 oceans and there are 12 landings of international optical submarine systems in Portugal. As one of the main cable landing points, Portugal is still the only country in the world directly linked by a direct submarine cable with every continent except Antarctica.

Sample of optic submarine cable

Laying out a branching unit – System ACE, 2011

This enormous growth in the laying of submarine cables and the massive increase in capacity has one phenomenon behind it: the Internet. With its various applications, Internet is now the “glue” technology that connects people, businesses and public organisations to each other and to the world of services and applications, through computers, advanced mobile phones or other devices, in work, leisure, commerce, citizenship and, in general, bringing societies and nations closer to each other.

The Internet, as we know it today, requires high speeds and capabilities that are only possible with optical transmission, with submarine cables acting as enormous global highways of communications. They carry 99% of inter-continental Internet traffic – voice, data, images, videos, messages, games, information and applications. All this traffic, digitally converted, is carried over the current network of optical submarine cables.

As the speed of a signal through optical fibre is approximately 200,000 km per second, it takes 5 milliseconds to travel one thousand kilometres. Therefore, the transmission of an email or execution of a complex financial transaction between Lisbon and New York, 6000 kilometres apart, only takes 30 milliseconds.

No more than a brief moment is needed to do everything, or almost everything. This marks the speed of today's world – a world where "time is money" and where the delivery of information, here or anywhere in the world, is demanded instantly.

Taking us through this era of global multimedia communication, based on optical submarine systems, the exhibition displays some of its main references from the evolution of this technology, as well as a repeater from the first optical submarine cable terminated in Portugal.

TECHNOLOGICAL PRINCIPLES AND TECHNICAL INFORMATION

In a space dedicated to various topics related to submarine cables and techniques of submarine cable installation, operation and maintenance, visitors can see a range of films and information in electronic format.

Visitors can select videos to watch on a selection of topics, including on the main principles of optical communication, the manufacture of optical fibre and of a submarine cable, loading cable onto ships, the laying of deep sea cable, landing and repairing a submarine cable, as well as sharing use of the seabed and dangers for the submarine cable and activities in the cable laying ship.

Optical repeater, NEC

Technical page and credits
Promoter: Autoridade Nacional de Comunicações (ANACOM)
General coordination: Fundação Portuguesa das Comunicações (FPC)
Institutional support: Governo Regional dos Açores, Marinha Portuguesa, Fundação para a Ciência e a Tecnologia, PT Portugal, CTT - Correios de Portugal
Commissary: José Morais de Oliveira
Scientific and technical coordination, content selection and production: Henrique Melo Barreiros, John Ross, José Almeida Mota, Vasco de Sá
Multimedia conception and audiovisual direction: Joel de Almeida
Historical research, document selection and museological heritage: FPC
Multimedia systems and applications: Subvertice
Architecture: Rui Órfão
Graphic design: Arne Kaiser
Contributions and acknowledgments: Alcatel-Lucent, Associação dos Antigos Alunos do Liceu da Horta, Carlos Moreira, Corning, Escola de Mergulhadores da Armada, Geodienst - University of Groningen, Huawei, Instituto Hidrográfico, International Cable Protection Committee – ICPC, Museu da Horta, NEC, Science Museum of London, University Oxford - Professor Mark Graham and Dr. Stefano de Sabbata of Oxford Internet Institute, TE Subcom, Telegraph Museum Porthcurno, Xtera.

The Museum – part of the Fundação Portuguesa das Comunicações, which has the Autoridade Nacional de Comunicações (ANACOM), Correios de Portugal (CTT), and PT Portugal as founders – is a cultural asset, deeply committed to the sharing of knowledge of communications and high tech.

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Monday to Friday from 10 am to 6 pm
Saturday from 2 pm to 6 pm
Last Thursdays of the month open till 10 pm
(free entrance between 6 pm and 10 pm)

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