The Trans-Atlantic Cable as World Heritage

Part II: Outstanding Universal Value

Professor Alexander Gillespie, Ph.D

13/7/2016.

This work was completed with the kind support from Intel Ireland and Kerry County Council.

Contents

Paper II: The Valentia Ensemble and the Criteria of Outstanding Universal Value

Dr. Alexander Gillespie.

July 8, 2016.

The collection of sites and associated landscapes which make up the Valentia Ensemble related to the Trans-Atlantic Cable merits being inscribed under the World Heritage Convention. The Valentia Island Ensemble should be inscribed because it is an exemplar of a critical part of telecommunications history which is of Outstanding Universal Value. It has the potential to be inscribed under six different criteria.

Paper I: The Trans-Atlantic Cable as World Heritage

Authenticity, Integrity and Associated Considerations for the ensemble of sites at Valentia Island, County Kerry, Ireland.

Presented at the American Irish Historical Society, New York City, New York
May 2014

SECTION 1. VALENTIA ENSEMBLE & WORLD HERITAGE CRITERIA

SECTION 2. THE INDUSTRIAL PAST AS WORLD HERITAGE: Types, Gaps & Value

SECTION 3. COMMUNICATIONS TECHNOLOGY AS MISSING HERITAGE: Considerations of Value & Location

VALENTIA ENSEMBLE &WORLD HERITAGE CRITERIA

Telecommunications is a sub-type of industrial heritage. Telecommunications is the most under-represented sub-type of industrial heritage, which is also generally under-represented on the World Heritage List. Aside from being an exemplar of a chronically under-represented type of industrial history, the Valentia Ensemble should be inscribed on the World Heritage List because the site possesses Outstanding Universal Value as per six of the criteria which can be used to identify Outstanding Universal Value.

Criterion I: the Valentia Island Ensemble related to the Trans-Atlantic Cable (the 'Valentia Island Ensemble') should be inscribed under Criterion I, as 'a masterpiece of human creative genius'. The reason for inscription under this criterion is because it was the exemplar of the age in terms of achievement. The success of the Trans-Atlantic cable was due to unparalleled advances and cooperation between science, technology and capital, which made possible an achievement which was considered to be impossible by many of the age.

There are no directly comparable telecommunication sites. The closest comparable examples under Criterion I are the Wouda Pumping station in the Netherlands, the copper mining site of Rammelsberg and the historic town of Goslar, and the Iron-Bridge Gorge Ensemble.

Criterion II: The Valentia Island Ensemble should be inscribed under Criterion II as a site which exhibits an important interchange of human values, over a span of time or within a cultural area of the world, on developments in … technology. Here, the advances made at Valentia Island on the Trans-Atlantic cable were not only the dominant technological achievement of the age in telecommunications they were also widely copied and quickly proliferated globally. In addition, considerable care was taken to ensure that the multicultural and educated workforce was well treated and looked after in remote south-west Ireland.

The foremost comparable example under Criterion II is the Grimeton Radio Station in Varberg. However, this site was post World War One, and although important for the development of communication technology, it falls far behind the importance of the Valentia Ensemble in terms of the pure significance of the Trans-Atlantic crossing.

Comparable examples of technological development and global influence include: the Great Copper Mountain at Falun in Sweden; the mines of Rammelsberg; the Cornwall and West Devon Mining Landscape and the Sewell Mining Town in Chile; the Wallonia and the Volklingen iron works; the Rjukan-Notodden site in Norway; the saltpeter Humberstone and Santa Laura works in Chile; Ironbridge Gorge and Pontcysyllte canal in Wales.

Comparable examples for socially progressive approaches to the workforce during industrialisation include Derwent Valley Mills; New Lanark; Saltaire and Crespi d'Adda. For the workforce and creating an interchange of human values Nord-Pas de Calais Mining Basin and the Fray Bentos Industrial Landscape are of comparative value.

Criterion III: The Valentia Island Ensemble should be inscribed under Criterion III as a site possessing a unique, or at least, exceptional testimony to a cultural tradition or to a civilization which has disappeared because although the buildings and relics relating to the Trans-Atlantic cable remain, the entire working population associated with it have gone.

There are no direct telecommunication sites to compare with it. The closest comparable examples are the Falun mine; the Cornwall and West Devon Mining Landscape; the Blaenavon Landscape; the Roros; Zollverein in Essen sites; the Iwami Ginzan Silver Mine in Japan; the Humberstone and Santa Laura works; the Archaeological Zone of Paquime, Casas Grandes, and the Pearling landscape of Bahrain.

Criterion IV: The Valentia Island Ensemble should be inscribed under Criterion IV because it is an outstanding example of a type of technological ensemble or landscape which illustrates a significant stage in human history. The technological experiments, refinements and successes over a ten-year period, coupled to an environment (at the westernmost point of Europe), made this technology and associated landscape impossible to separate.

The foremost comparable examples under Criterion IV are the Grimeton Radio Station in Varberg, which represents technological achievements by the early 1920s, as well as documenting the further developments in this area, over the following three decades. The difference with the Valentia Ensemble is that the Valentia example was the site that pushed telecommunications technology of that age to its furthermost point with the effect that the ability to communicate instantly and accurately transcended national, and even regional, boundaries for the first time in humanity's history

Other comparable examples of technology and landscape under Criterion IV worthy of comparison to the Valentia Ensemble are the: Cornwall and West Devon Mining Landscape; the Blaenavon Industrial Landscape; the Völklingen ironworks; the Engelsberg ironworks; the Roros Mining Town; Japan's Meiji Iron and Steel, Shipbuilding and Coal Mining sites; and Rammelsberg. The Rjukan-Notodden; the Fray Bentos Industrial Landscape of Uruguay; the mercury mine sites of Almadén and Idrija; and Finland's Verla Groundwood and Board Mill are all relevant here.

In terms of purely technological ensembles representing significant stages in human history, the mining sites of Wallonia are of comparative value, as is the Nord-Pas de Calais Mining Basin; the saltpeter Humberstone and Santa Laura site; and Japan's Tomioka Silk Mill. The full 'social' nature of some sites, in terms of places of work, and places for workers, also recognised under criterion IV of comparable value to this application are Derwent Valley, Saltaire and New Lanark.

Criterion V: The Valentia Island Ensemble should be inscribed under Criterion V as 'an outstanding example of a human interaction with the environment especially when it has become vulnerable under the impact of irreversible change'. The technological and scientific advancements at Valentia, as an industry which peaked and disappeared, and at a remote location, are unique considerations.

There are no direct telecommunication sites to compare with. The closest comparative Criterion V examples generally are the: Roros copper mine; Slovakia's Banská Štiavnica; the Japanese site of the Iwami Ginzan Silver mine and its Cultural Landscape, and Crespi d'Adda in Italy, which a rare example of a planned town whose structure has survived, unaltered, despite the threat posed by the evolution of economic and social conditions.

Criterion VI: The Valentia Island Ensemble related to the Trans-Atlantic Cable should be inscribed under Criterion VI as an area to be 'directly associated with events, with ideas, or with beliefs, … of outstanding universal significance', as this is the site where 'globalisation' began.

There are no direct telecommunication sites to compare with Valentia. The closest comparable sites under this criterion, whereby their genesis had spectacular global implications, are: Ironbridge Gorge; New Lanark, the Nord-Pas de Calais Mining Basin; the Champagne Hillsides, Houses and Cellars in north-east France; the Coffee Cultural Landscape of Colombia and the Agave Region of Mexico, all of which saw their product, landscape, and significance reach well beyond their national borders. The globalisation achieved by the telecommunications ensemble at Valentia Island is exactly the same.

THE INDUSTRIAL PAST AS WORLD HERITAGE: TYPES, GAPS AND VALUES

Introduction

This paper is concerned with the recognition of industrial heritage as World Heritage, and the question of how such heritage is valued by the international community. As regards the first question, it will show that, despite the success of the World Heritage regime, some heritage is under-represented. Industrial heritage is one example of such under representation and within this sub-set of World Heritage, further themes are emphasised, and some more than others. Once these industrial sites and sub-themes have been identified, this paper will then move to identify the criteria by which the outstanding universal value of World Heritage is found. This will show that certain values are more commonly ascribed, or denied, to industrial heritage than other types of heritage.

World Heritage

The 'seven wonders of the ancient world' were first mentioned in 130 BCE. Written as a travel guide by the Greek, Antipater of Sidon, the first list of essential must-sees, was created. Today, that list is compiled under the auspices of the 1972 *World Heritage Convention* (WHC). The event that aroused particular international concern and ultimately lead to the WHC was the decision to build the Aswan High Dam in Egypt, which would have flooded the valley containing the Abu Simbel temples, a treasure of ancient Egyptian civilization. In 1959, after an appeal from the governments of Egypt and the Sudan, UNESCO launched an international safeguarding campaign, by which the temples were dismantled, removed to dry ground and reassembled. Its success led to other safeguarding campaigns. Soon after, at the 1965 White House Conference on International Cooperation, it was noted that certain outstanding scenic, historic and national resources, whose survival was a matter of concern to all countries, were under a variety of threats. Accordingly, it was recommended that,

> There be established a Trust for the World Heritage that would be responsible to the world community for the stimulation of international cooperative efforts to identify, establish, develop and manage the world's superb natural and scenic areas and historic sites for the present and future benefit of the entire world citizenry.

This idea was actively supported and publicised throughout the late 1960s, and, in 1971, the United States became its foremost advocate, arguing for the creation of what then President Nixon called 'a new international initiative'. The goal of the initiative was that the nations of the world would 'agree to the principle that there are certain areas of such unique worldwide value that they should be treated as part of a World Heritage Trust'. The countries attending the 1972 Stockholm Conference agreed to this in principle, and soon after, the United States presented a draft convention for the protection of heritage of international importance to the global community for its consideration. This draft was strongly supported by a coalition of international NGOs and international organisations such as UNESCO, which became its repository and thus its ultimate 'owner'. The final version of the *World Heritage Convention* was concluded and adopted on November 16, 1972.

The World Heritage Convention (WHC) is just that – a convention designed to protect the world's heritage, as related to humanity's creative genius in cultural matters, and/or the rich resources of nature. The factor which identifies either cultural or natural heritage as being of global importance is its possession of Outstanding Universal Value (OUV). To quote the *Operational Guidelines*,

> Outstanding Universal Value means cultural and/or natural significance which is so exceptional as to transcend national boundaries and to be of common importance for present and future generations of all humanity. As such, the permanent protection of this heritage is of the highest importance to the international community as a whole.

The emphasis is upon the world's heritage and the Convention works on the principle that every country has a contribution to make. Collectively, the heritage of all nations forms the 'patrimony of humanity'. Such heritage of 'outstanding interest' is 'preserved as part of the world heritage of mankind as a whole' for the benefit of current and future generations. To allow otherwise, whereby the heritage is destroyed, is deemed 'a harmful impoverishment of the heritage of all the nations of the world'. Accordingly, all Parties to the Convention are obliged to 'safeguard this unique and irreplaceable property, to whatever people it may belong'.

The principal difference of the WHC, compared to all other international instruments, is that the WHC seeks only to inscribe sites of Outstanding Universal Value. In practical terms, this means only 'the most outstanding properties from an international point of view' can be inscribed on the List of World Heritage. Roughly, in numbers terms, this suggests that less than 1% of all heritage areas are eligible for the WHC List. Specifically,

> The *Convention* is not intended to ensure the protection of all properties of great interest, importance or value, but only for a select list of the most outstanding of these from an international viewpoint. It is not to be assumed that a property of national and/or regional importance will automatically be inscribed on the World Heritage List.

Although the threshold for inscription is high, as of 2016, there are 1031 sites on the List. Of these, 802 are cultural sites, 197 are natural sites, and 32 are mixed.

The Need for a Balanced, Representative and Credible List

With such high numbers, it is not surprising that the List has been subject to criticism, for being unwieldy, unsystematic and missing important types of heritage, both regionally and thematically. This problem has been long recognised. The *Global Strategy for a Representative, Balanced and Credible Wold Heritage List* was agreed in 1994, and subsequently incorporated into the *Operational Guidelines*. The objective of the *Global Strategy* was (and is) to broaden the definition of World Heritage to better reflect the full spectrum of the world's natural and cultural treasures, and to provide a comprehensive framework and operational methodology for implementing the WHC. To help break away from the previous patterns, the two main advisory bodies, the International Union for the Conservation of Nature (IUCN) and the International Council on Monuments and Sites (ICOMOS), supplemented by numerous Expert meetings, in addition to thematic and comparative studies, have produced a number of studies with the aim of identifying 'gaps' in the World Heritage List. Despite over twenty years progress on this overall topic, significant amounts of work remain to be done.

Industrial Heritage

According to the *Nizhny Tagil Charter for Industrial Heritage*,

Industrial heritage consists of the remains of industrial culture which are of historical, technological, social, architectural or scientific value. These remains consist of buildings and machinery, workshops, mills and factories, mines and sites for processing and refining, warehouses and stores, places where energy is generated, transmitted and used, transport and all its infrastructure as well as places used for social activities related to industry, such as housing, religious worship or education.

In broader philosophical terms, industrial heritage is the physical manifestations of the Industrial Revolution. It is from this (on-going) epoch which had Europe (but especially Britain) at its epicentre, building on the knowledge of the Renaissance and the Reformation, the impacts of science and technology, via the social and economic supports of both legal and financial systems, combined to create new industries. These new industries through the adoption and/or utilisation of new types of energy, caused fundamental changes to human civilisation (both positive and negative), which were global in impact, were quickly replicated, and evolved all around the world.

In ideal scenarios, such industrial heritage can be an outstanding resource for contemporary generations to reuse (appropriately), regenerating communities and offering both economic opportunities and cultural identity beyond traditional identities found with comparable heritage, such as churches or castles. To support this potential, the International Committee for the Conservation of Industrial Heritage (TICCIH) and ICOMOS has, since 1994, recommended a large number of sites to be inscribed as World Heritage. About one third of their recommendations have been adopted by the World Heritage Committee.

Despite such historic importance, and there being a clear gap on the World Heritage List, industrial heritage remains 'poorly represented'. Part of the reason that industrial heritage is under-represented is that it is a misunderstood heritage. At worst, it is an urban wasteland, dangerous and polluted, and full of memories of exploited workers toiling in dangerous and underpaid conditions. Alternately, even if it is recognised as having some value, it can be overly romanticised and/or poorly utilised, destroying all of its integrity.

The Industrial Heritage Recognised as World Heritage

The nomenclature of industrial heritage is a difficult area. From the place where significant but isolated events took place, to the creation of entire cities, industrial heritage is frightfully hard to draw clear lines around in terms of what is in, and what is out, as locations, epochs and themes all tend to defy clear boundaries. Accordingly, for the following sections of this paper, it is important to note that the categories often overlap.

Power for Industry

Energy was what made the Industrial Revolution special. Four sources of power are notable for this period. They are hydraulic, wind, water and steam. Of the four, the real source of energy that defined the Industrial Revolution was steam, of which the steam engine as made common by James Watt (who improved the thermal efficiency of the existing steam engines two-three-fold) is the exemplar. Despite steam's critical importance, and although mobile steam engines later make a number of appearances in railways, sites containing stationary steam engines are relatively few in appreciation both generally, and on the World Heritage List. One of the few examples is the Wouda Pumping station in the Netherlands. This 1920s model is the largest and most powerful steam driven installation for hydraulic purposes ever built. It was, and is, a masterpiece of hydrologic engineering and architecture. Another example is the Rjukan-Notodden Industrial Heritage Site in Norway, which comprises hydroelectric power plants, transmission lines, factories, transport systems and associated towns, all in a dramatic landscape of mountains, waterfalls and river valleys.

The use of water for power is not restricted to the Industrial Revolution. This technology dates at least to the time of the Romans. Nonetheless, a number of sites on the World Heritage List are indirectly linked to water power (such as Rammelsburg in Germany and Roros in Norway). It is likely that, in the future, more sites related to the production of power via hydroelectricity will be inscribed on the World Heritage list, as a number of countries have important dam sites on their Tentative List. However, it does not appear that examples of dams from the industrial period, such the great Hoover Dam, will appear on the list in the near future.

Overlapping sites on the World Heritage List that are also important for their use of water as a source of power, and which do date from the period of the Industrial Revolution, are in Derment Valley and New Lanark in Britain. Both of these sites, as a result of the work of Richard Arkwright, were directly related to the development of new technologies and factory systems for the mass manufacture of textiles. The technology originally based on water power (with over half of the 200 Arkwright type mills built in Britain by 1788 were built on the rivers of Lancashire) was eclipsed by steam-powered machinery at the end of the eighteenth century.

Although wind powered locations are notable in some World Heritage sites, their notation is not directly related to the use of this technology. In this regard, there are large gaps relating to the range of wind power sites, ranging from the oldest windmills still working, through to some of the windfarm landscapes of today. The final category of note in the subtheme of the production of energy as a sub-theme of Industrial Heritage is the development and use of hydraulic power, whereby energy is created by releasing forces held in a fluid under pressure. The use of this type of power during the Industrial Revolution is recognised on the World Heritage List, with the Four Lifts on the Canal du Centre.

Extractive Industries

The extraction of different types of rock, metals/minerals and clays from the ground for the benefit of human society has been going on from the Bronze Age at least. The practice was cross-cultural, long-standing, and continuous. From the heritage perspective, mines are now the golden-child of the extractive industry. These areas, rich in technological, social, economic, and environmental history, are unique examples of human achievement. Although reconciling them with the goals of conservation and tourism has not always been easy, their popularity has continued to grow. Deeply historic sites, such as the Neolithic Flint Mines at Spiennes in Belgium, are noticeable on the World Heritage List. A further 20 sites on the Tentative List make reference to quarrying (as a subset of mining). Sites in the Gambia, Palau and north Wales (with regards to slate) are particularly notable.

The first mines (and the first industrial heritage sites) to be recognised for their cultural values under the World Heritage Convention were salt mines. Humanity has been mining salt for thousands of years, although, until the Industrial Revolution, the mining of salt was both dangerous and expensive due to rapid dehydration caused by constant contact. Industrial mining and new techniques made it possible to exploit salt in much greater quantities. The salt mines on the World Heritage List, the Wieliczka and Bochnia salt mines in Poland, and the Royal Saltworks of Arc-et-Senans in France, both helped by their architectural brilliance, were inscribed at the same time in 1982. Although both have historic roots that predate the 1700s, they were strongly linked to scientific and technological developments associated with the Industrial Revolution.

The second (and most common) type of mine on the World Heritage List is the copper mine.. Copper has also been valued by humanity for millennia. Over four thousand years ago it was used for decorations, coinage and weapons. In antiquity, breakthroughs in smelting and alloying expanded the production and utility of copper. These techniques were then used in related types of metal including bronze (where tin was added) and brass (where zinc was added). In the eighteenth century, the newly discovered qualities of copper (electrical and thermal conductivity, strength, formability and resistance to corrosion) meant that it became highly sought for ship bottoms, and later, for its usage in telegraphic cables and the transmission of electricity. Most of the copper mines that are World Heritage sites reflect this deep history. The Falun mine in Sweden dates to the 9th century, Rammelsberg in Germany, dates to the 11th century; and Roros in Norway which dates to the middle of the 17th century. Although the Cornwall and West Devon Mining Landscape also has long historical roots, it has been recognised for its 18th and 19th century industrialised non-ferrous hard-rock mining for copper and tin. The copper mine site in Sewell in Chile comes from the same period.

The third and final type of mining focus on the World Heritage List is related to the extraction of precious metals. Humanity has been mining for such valuables as gold and silver for thousands of years. Today, there are half a dozen sites on the Tentative List related to the mining of precious metals, including the silver mines of Pulacayo in Bolivia, Tarnowskie in Poland, and the Sado Gold Mines of Japan. In terms of those already inscribed, four mining related sites involving precious metals are particularly notable. These are the Iwami Ginzan Silver Mine in Japan (which was working from the 16th century); Slovakia's Banská Štiavnica (with roots to the late Bronze age, but peaking between the 16th and 18th centuries); Ouro Preto (Black Gold) in Brazil (which peaked in the 18th and 19th centuries); and Mexico's Guanajuato (which began in the 16th, but peaked in the 18th century). The last site overlaps with the Camino Real de Tierra Adentro, the road that linked many of the silver mines to important points throughout the region (with both domestic and international destinations). Other mines involved in the extraction of economically valuable metals are the Almaden (Spain) and Idrija (Solvenia) mercury mines. These sites, operating from the year 1500 onwards, facilitated the working of gold and silver mines, globally, via the provision of mercury.

Coal Mines and the Iron and Steel Industries

Humanity has been using coal as an energy source for over four thousand years. However, it has only been in recent centuries that chemistry allowed us to understand why coal was a better source of energy than wood. When this energy source could be produced cheaper and more effectively than the alternatives, coal – and its industrialised scale of production - for both the generation of power (thermal coal) and steel (metallurgical coal) became a key part of the Industrial Revolution. This critical role increased as technology developed ways to dig mines into increasingly difficult areas, solving the problems of drainage, ventilation, haulage and coal preparation. To date, four coal mining sites with strong links to the Industrial Revolution are already inscribed. These are Wallonia in Belgium, the Zollverein in Essen, Germany, the Nord-Pas de Calais Mining Basin, and Japan's Meiji Iron, Steel and Coal sites. In addition, at least three coal mining sites on the Tentative List (for Spain, Indonesia and the Czech Republic), are currently proposed in this sub-theme.

The difficulty with the information contained in the above paragraph is that it is a little artificial as coal mines are often directly linked to ensembles of iron and steel industries. Iron, which was a critical component of the Industrial Revolution, is well recognised in a number of sites on the World Heritage List. The foremost example of this is the Ironbridge Gorge landscape and associated technological sites, which is the birthplace of the Industrial Revolution. This area contained all of the elements needed for the revolution, from the mines to the blast furnaces. The first ever place to smelt iron from coke, was Coalbrookdale in England. Abraham Darby I discovered the production technique of smelting iron using coke instead of charcoal in 1709, and then went on to produce the actual 1779 bridge of this fabulously strong new material– Ironbridge. A second example from Britain involves the area around Blaenavon. This inscription reflected its pre-eminence as the world's major producer of iron and coal in the late 18th and 19th centuries, encompassing everything from coal and ore mines, quarries, railway systems, furnaces, workers' homes, and associated social infrastructure. From the same period, the Engelsberg Ironworks in central Sweden are also considered to be an outstanding example of an influential European industrial complex which produced superior grades of iron during the 17th to 19th centuries. The final example in this category is the Völklingen Ironworks in Germany. Völklingen Ironworks operated over the 19th and 20th centuries and it was also influential globally, producing important technological innovations in the industrial scale production of pig-iron.

Factories

The Latin word *factorium* means ‘a place of making’. Factories are included in over 60 inscribed sites on the World Heritage List and over a dozen are included on the Tentative List. Although the idea of places dedicated to mass manufacture can be traced to some of the stone axe quarries or flint mines of the Neolithic Period (and are to be found on the World Heritage List) and although places of manufacture are common in most cultures before the 18th century (and are also evident in World Heritage sites), the modern world associates the term factory to the Industrial Revolution.

In the Industrial Revolution, integrated works, including all aspects of production from the actual place of work, to supporting industries, through to housing for the workers, came into being. The foremost example of this development is with textile production. Although textile production is a process which goes back thousands of years, the most well-known factories of the Industrial Revolution are related to textile production when mechanisation, either by the power of water or steam came into being. It was such textile mills which drove the exponential growth in productivity and profit in Britain between 1780 and 1860. The World Heritage List recognises the key sites related to the three key textile related sites in Britain. The most notable is the Derwent Valley Mills. This site contains a series of 18th and 19th century cotton mills and an industrial landscape of high historical and technological significance, all of which are centered around the brilliance of Richard Arkwright’s water-powered spinning mill, from which an entire community of work places and workers’ housing developed in an integrated landscape.

Other examples of factories that made the List include the Verla Groundwood and Board Mill of Finland, which was a small-scale rural industrial settlement associated with pulp and paper production, that flourished at the end of the 19th century, Japan’s Tomioka Silk Mill and Related Sites, which involved Japanese technology improving silk worm production, French technology for manufacture, and mass production of high quality silk to a global market. La Chaux-de-Fonds/Le Locle was also recognised as small artisanal communities moved to the planned watch making towns of Switzerland. Globally, later factories evolved into bigger, much more complex, areas and covered industries ranging from plants that made cars, to those that made aeroplanes. These massive factories from the 20th century, despite their monumental changes in production output and method, which are often now rusting and unwanted, are omitted from the World Heritage List.

Many of the changes to production noted above had social consequences. From the Luddites to Marxism, or as Frederick Engels suggested in 1844, ‘the history of the working class in England begins with the discovery of the steam engine and of the machines for the manufacture of cotton’, the social implications of the Industrial Revolution, especially for the workers at the forefront of the changes, is very important. Although there is room for improvement in the World Heritage List on this question, the inclusion of sites with positive social considerations within industrial developments was clearly evident with a number of early efforts of this period after industrialists, entrepreneurs and philanthropists became aware of the need to also house associated working populations in ways via which both productivity and social progress could be reconciled. The form that this type of development took was often industry specific. From small cottages, to terraced housing, through to stand-alone buildings for the bosses, evolution is clear in this area from the end of 17th century onwards, as some sought to humanise the Industrial Revolution.

This type of social progress can be seen in a number of World Heritage sites. In particular, New Lanark was a purpose-built 18th century mill village set in a picturesque Scottish landscape near the Falls of Clyde, where the Utopian idealist Robert Owen inspired a model industrial community based on textile production with mechanised factories and a benevolent paternalism for the workers. His goal was a Utopian vision of a society without crime, poverty, and misery via supporting workers with well-designed and equipped housing and public buildings. This model for humane working practices within capitalism became a landmark example of global importance. Subsequent examples such as the industrial village of Saltaire of the mid-19th century also had a profound influence on developments in industrial social welfare and urban planning in the United Kingdom and beyond. A non-English site which also displays the enlightened responses by industrialists of the age is the ‘company town’ of Crespi d’Adda in Italy.

Other World Heritage factory sites are inscribed for their progressive designs of the places of work (as opposed to their associated sites to support the workers). Of note, the Fagus Factory (dating from 1910) in Germany, which was inscribed because of its architectural values and importance to design (and the Bauhaus school) in terms of the functionality of the industrial complex and the humanisation of the working environment. Similarly, the Van Nellefabriek site in the Netherlands, which was built in the1920s, was inscribed for being one of the icons of 20th century industrial architecture, comprising a complex of factories, with façades consisting of steel and glass. It was conceived as an ‘ideal factory’, open to the outside world, and in which daylight was used to provide pleasant working conditions.

Transport: Canals, Railways, Bridges and Aqueducts

Canals, as in human engineered waterways, are monumental works in which technology, design and landscape come together at particular epochs of time, producing unique examples of cultural landscapes. From canals which dissect countries for the purposes of international transit, through to those which created transit systems for earlier times, canals are special. Their uniqueness is so great that canals are the only specific type of transport related heritage which is explicitly recognised in the *Operational Guidelines*. Accordingly,

A canal … may be of Outstanding Universal Value from the point of view of history or technology, either intrinsically or as an exceptional example representative of this category of cultural property. The canal may be a monumental work, the defining feature of a linear cultural landscape, or an integral component of a complex cultural landscape.

With such importance, canals and their heritage potential are a focus of domestic, regional and international attention. However, the greatest canals of the Industrial Revolution (the 193 kilometer Suez Canal, which took ten years to construct and was opened in 1869, and the 77 kilometer Panama Canal, that was begun in 1881 by France, but completed in 1914 by the United States) are not inscribed on the World Heritage List, nor are they proposed as tentative options. Despite these omissions, as of the middle of 2016, there are 109 sites on the World Heritage List which include canals. Some of these sites, such as Venice and its Lagoon, are literally built around mosaics of canals (Giudecca, St Mark's and the Great Canal), but these are all secondary, supporting considerations to the extraordinary architectural masterpiece that is, overall, Venice. Similarly, with the Amsterdam Canal District, canals were only part of the larger collection of considerations that make Amsterdam an exemplary hydraulic and urban planning homogenous and cultural masterpiece from the 16th and 17th century. The Grand Canal of China, is also overshadowed by its cultural (and opposed to technological) significance, and is excluded from Industrial Revolution considerations, as this masterpiece was begun in the 7th century.

Conversely, with four other sites, it is the canals and their link to the Industrial Revolution which are the primary focus of Outstanding Universal Value. The first of these, built between 1667 and 1694, is the 360 kilometer network of navigable waterways that is the Canal du Midi.

This canal network links the Mediterranean and the Atlantic through 328 structures (locks, aqueducts, bridges and tunnels) and is considered one of the most remarkable feats of civil engineering and landscape design of its time. The Pontcysyllte Canal, which was built in the second half of the eighteenth century in Wales, is valued as a highly innovative monumental masterpiece of civil engineering structure. It was built using metal arches supported by high, slender masonry piers, designed for the transport of heavy cargo transport in order to further the Industrial Revolution. The Rideau Canal, was recognised for, *inter alia,* being one of the first canals to be designed specifically for steam-powered vessels and demonstrating the use of European slack-water technology in North America on a large scale. The Four Lifts on the Canal du Centre and their Environs La Louvière and Le Roeulx (Hainaut) were another 19th century development that were part of a program to open up a rich industrial area and help with the transport of coal. The boat lifts alone represented the apogee of engineering technology to the construction of canals for this period.

Railways are clear examples of technology from the Industrial Revolution, as steam powered transport simply did not exist before this period. Thereafter, mechanically worked railways evolved and were intimately connected with the history of industrialisation. Technology, commerce, labour, speed and reliability of transport, associated terminals (some of which are of independent World Heritage value) and landscape all combined to create a product which spanned the world. They have a high heritage appeal to enthusiasts and non-enthusiasts alike. Although guidance has been offered on the topic by the TICCIH and ICOMOS, the genre is relatively undeveloped on the World Heritage List and major sites such as the Trans-Siberian, and Trans-Continental, are not inscribed nor tentatively noted. Nonetheless, three notable railway sites exist in this category. That is, although railways are acknowledged as a consideration within over 70 World Heritage sites that are already inscribed, the actual railways are only the foremost consideration of their Outstanding Universal Value in three of them, and all of these, are related to mountain railways. First, the Semmering Railway, is considered one of the greatest feats of civil engineering within a spectacular landscape, built over 41 kilometres of high mountains in the middle of the nineteenth century, spanning sixteen major viaducts with 118 smaller arched stone bridges and 11 iron bridges. The Rhaetian Railway, in the Albula/Bernina Landscape, is also considered to be an exemplary railway development which opened up the Central Alps, as achieved at the beginning of the 20th century. Finally, the Mountain Railway of India represents bold and ingenious engineering solutions to the problem of establishing an effective rail link across a mountainous terrain of great beauty.

Bridging rivers, gorges, narrows and other impediments has always been an important goal of

human settlement. Over 100 sites on the World Heritage List have bridges mentioned as part of their value. A further 120 sites on the Tentative List also note the importance of bridges to their nomination. Bridges are popular because they are visible testimony to the skills of engineers, in which design, span, materials and purpose all combine to achieve their goals. Advances in bridges in the Industrial Revolution are evident when revolutionary leaps in technology and materials allowed bridges that were stronger, malleable and fire-resistant to be constructed. On the World Heritage List, the most obvious bridge of relevance is the actual bridge in the Ironbridge Gorge ensemble, as this was the world's first iron bridge, made of a material and processes that was at the very heart of the Industrial Revolution. Two other bridges of note here are the Vizcaya bridge in Spain, and the Forth bridge in Britain, both of which were constructed at the end of the nineteenth century. However, other iconic bridges such as the Brooklyn bridge, which were also firsts and entirely unique types and of great national significance to the United States, are not inscribed, nor even on the Tentative List.
Aqueducts are also marvels of engineering whereby humans have worked out ways to convey water from one location to another. The Romans were the pioneers and exemplars of this technology, moving water throughout their empire, from distant sources into cities and towns for sanitation, households, public areas, and irrigation into the countryside, as well as for mining and milling operations. With such value, it is no surprise that aqueducts are found in at least 29 World Heritage sites. However, only three World Heritage sites feature them as the primary attraction of an area. Two of these are Roman, namely the Pont du Gard in France (a three level, fifty-meter-high, 275-meter-long architectural and engineering masterpiece) which is part of a Roman aqueduct, and the Old Town of Segovia and its Aqueduct (with two tiers of arches, 813 meters long, 28 meters high). The third Aqueduct system is that of the Padre Tembleque Hydraulic System. Although it predates the Industrial Revolution in Europe, this is a 16th century aqueduct on the Central Mexican Plateau, in which Roman, European and indigenous technology created a system that incorporates the highest single level arcade (nearly 50 kilometres long) ever built in an aqueduct. Accordingly, aqueducts from the Industrial Revolution are not an obvious feature on the World Heritage List.

Agriculture

Changes in agricultural production were critical to the success of the Industrial Revolution. Increased efficiency and enhanced levels of output via new methods of production and land improvement allowed expanding human populations to be sustained and to avoid the Malthusian trap. Despite this importance, heritage sites concerned with the advances in agriculture from this period do not feature prominently on the World Heritage List, although there are certainly pockets of interest in particular sub-themes. This interest is evident in three areas.

First, in terms of the sites related to land-drainage, water management and pumping plants, (all connected to efforts to manage water-logged lands), the World Heritage List is widely spread. At one end, the List has two historic sites which deal with water management (Kuk in Papua New Guinea, and the Aflaj irrigation system in Oman). At the other end are two sites, both in the Netherlands, the mill network at Kinderdijk-Elshout (from the Middle Ages) and Beemster Polder, dating from the early 17th century. Both Dutch sites are exceptional examples of hydraulic works handling water with an elaborate system of dykes, reservoirs, pumping stations, and iconic windmills, all involved in reclaiming land, where technology and landscape planning come together perfectly. It appears that future inscription on the Tentative List will follow this trend, with a widening gap between sites listed for historical management of water, and those related to revolutionary developments during the industrial age, of which only one site stands out.

Second, in terms of exemplars of agricultural buildings and related mechanization, such as those related to dovecots, milling processes, as well as examples relating to the specific sections of the industry (such as important sites relating to meat processing, through to bakers and/or biscuit manufacturers), the World Heritage List has been, traditionally, light. However, in contemporary times, there has been progress made in this area. For example, the Humberstone and Santa Laura works in Chile was the dominant natural source of sodium nitrate, which was used for fertiliser (and explosives), which transformed agricultural lands globally since the second half of the nineteenth century. A number of sites related to production of specific commodities have also been inscribed. For example, the Fray Bentos Industrial Landscape of Uruguay of 2015 is important as an exemplar of an industry that began in the mid 19th century and dealt with all aspects of the meat production and trade. Two nineteenth century coffee plantation sites in Colombia and Cuba are also noticeable. This focus upon commodity related industries related to exports, especially in former colonies, can be expected to expand as the Tentative Lists reveal a considerable degree of interest in the industrial archaeology related to sugar (Barbados and the Dominican Republic), bananas (Colombia) and chocolate (with the proposed French site of the Old Menier Chocolate Factory in Noisiel).

The third area of industrial heritage and agriculture is related to the production of alcoholic beverages. In terms of non-wine related sites, the tequila site in the Agave Region of Mexico, which has a legacy of 250 years, stands out, as does the Alto Douro Wine Region in Portugal, from where port wine is most famous. Although there are a few sites on the Tentative List for such areas, the overall result is that the List is relatively empty with different types of alcohol production, where the science and technologies of the Industrial Revolution really did make a difference to production, such as with malt houses, breweries and distilleries.

In contrast, vineyards, as an agriculturally related theme, dominate the World Heritage List. This type of heritage is a very strong subset of areas representing long standing cultural traditions blended into cultural landscapes in specific geological areas. There are currently at least 25 sites on the World Heritage List noting their possession of vineyards as important considerations within their boundaries. There are a further fourteen on the Tentative List. However, only a few sites place vineyards at the core of their application. These are the area around Dijon in France, where grape cultivation and wine production associated with the Burgundy Climats wine region is located; the Champagne Hillsides, Houses and Cellars in north-east France; Italy’s vineyards at Piedmont; the Lavaux vineyard in Switzerland; the Tokaj wine region in Hungary; and the wine producing region of the Pico Island in the Azores. All of these examples, despite the evolution of their technology, are only distantly related to developments of the Industrial Revolution.

Communications

As I have discussed in detail elsewhere, the most under-represented type of industrial heritage on the World Heritage List relates to telecommunications. According to the 1992 *Constitution of the International Telecommunication Union*, Telecommunication means, ‘Any transmission, emission or reception of signs, signals, writing, images and sounds or intelligence of any nature by wire, radio, optical or other electromagnetic systems’. It is this definition that divides discussions of communications to both before, and after, the Industrial Revolution. It was the developments in this period, and thereafter, that saw revolutionary discoveries in terms of the telegraph, the trans-Atlantic cable, the telephone, and then the wireless/radio that allowed humanity to safely and accurately communicate information over distances that came to encompass the entire planet. Subsequent developments from the computer age, of which email is the exemplar, have only continued this progress

Despite the contemporary importance and evolution of this technology which has fundamentally reconfigured human society, and despite being the one technology from the Industrial Revolution that did not cause mass pollution, unemployment or make working conditions intolerable, it is largely invisible from studies of heritage. Indeed, only one site on the World Heritage List, relates to communications. This site is the Varberg Radio Station in Sweden, which was built between 1922 and 1924. This is a well preserved monument to wireless trans-Atlantic communication, which retains both its original equipment and aerial, and exists as an exemplar of post First World War communications technology.

Outstanding Universal Value and World Heritage

As noted above, Outstanding Universal Value is the prism through which all World Heritage is recognised. The idea is OUV is divided into ten different criteria. Four of these are purely related to natural sites and of no possible application to industrial heritage areas. The other six criteria, however, are of possible applicability, with which all of the sites noted above have been inscribed under one or more the criteria.

Criterion I

Criterion I for the recognition of Outstanding Universal Value is that a site represents, 'a masterpiece of human creative genius'.

In a few rare instances, entire cities linked to mercantile trade histories (such as Riga, Medina of Essaouira, and La Lonja de la Seda de Valencia) have been recognised, but the recognition has not been because of considerations related to the Industrial Revolution. However, when dealing with more specific parts of the Industrial Revolution, the recognition of a site representing a masterpiece of human creative genius has been achieved a number of times with sites related to extraction, transport and agriculture. Conversely, it has not been recognised with factory related sites, and only in one site (the Wouda Pumping station in the Netherlands, the largest and most powerful steam driven installation for hydraulic purposes ever built) related to the creation of energy (which although spectacular, was not at the forefront of the Industrial Revolution).

In terms of extraction related sites, the Royal Saltworks of Arc-et-Senans in France, as the first architectural complex of a type where a factory was built with the same care and concern for architectural quality as a palace or an important religious building, was recognised as a masterpiece. Of the four World Heritage sites involved in the mining of precious metals, the Historic Town of Ouro Preto (Black Gold) in Brazil due to its aesthetic quality of the vernacular and erudite architecture and irregular urban pattern was found to make it a masterpiece of human genius. Similarly, Mexico's town of Guanajuato and adjacent silver mines was valued for some of the most beautiful examples of Baroque architecture in the New World. Finally, the copper mining site of Rammelsberg and the historic town of Goslar were recognised as outstanding examples in the fields of mining techniques and industrial water-management.

Transport related sites of bridges, aqueducts and canals are often considered masterpieces of human genius. The Vizcaya Bridge in Spain made this grade of recognised creative human genius because of the way aesthetics, technology, functionality, and landscape were successfully weaved together. The Forth Bridge was inscribed for very similar values. The aqueduct bridge of Tepeyahualco is considered a masterpiece, due to its integrating of the highest single-level arcade ever built in aqueducts from Roman times until the middle of the 16th century, via an ingenious and supplementary use of local technology and materials. In terms of being 'a first' the actual Iron Bridge, at the Ironbridge Gorge, as humanity's first known metal bridge, reflected obvious genius.

The Grand Canal of China from the seventh century was recognised as a masterpiece of human creative genius include due to its hydraulic engineering, scale, and continuous development. Rideau Canal was valued as genius for being a perfect example of a slackwater canal system; whilst the Pontcysyllte Canal in Wales was recognised as a highly innovative civil engineering structure of metal and wood. Canal du Midi met this criterion as an exemplar of a designed landscape; whilst the brilliance of the hydraulic and urban planning for the Amsterdam Canal District from the 16th and 17th century, satisfied the same value.

In terms of sites related to improving the output of the land, the Kinderdijk-Elshout site was identified as genius because its ingenuity and fortitude for over nearly a millennium in draining and protecting an area by the development and application of hydraulic technology. Beemster Polder, was similarly recognised as a masterpiece of creative planning, in which the ideals of antiquity and the Renaissance were applied to the design of a reclaimed landscape. No other sites related to agriculture, in terms of specific industries or food types, have been this value.

Criterion II

Outstanding Universal Value under Criterion II is whereby a site exhibits an important interchange of human values, over a span of time or within a cultural area of the world, on developments in architecture or technology, monumental arts, town-planning or landscape design.

In the broadest sense, some mercantile cities or ports have been inscribed under this value. Most of these, such as Riga; Hoi an in Vietnam; Melaka and George Town on the Straits of Malacca; Luang Prabang in Lao, and Jeddah, were all recognised for their interchange of human values, often in multicultural communities linked to commercial exchanges. The city that went beyond these considerations under criterion II and was linked to the Industrial Revolution was Liverpool, for its innovative technologies and dock construction and port management, which went on to have large implications for international maritime practices. The only other site that came close to this type of achievement is the Amsterdam Canal District, which was valued for being a leader in a series of technical, maritime, cultural, philosophical, and economic fields that made it the capital of the world economy in its day.

There are no sites recognised under Criterion II for their contributions of power to industry. However, all of the other sub-categories are recognised here. In terms of extraction based enterprises, Criterion II values are well located when significant changes in technology and globalisation were recorded. These considerations were found at the Great Copper Mountain at Falun in Sweden due to the German technology that allowed it to become a major producer of copper in the 17th century and to go on to influencing mining technology globally. The mines of Rammelsberg were valued as an important interchange of human values in the field of mining and water management techniques from the Renaissance forwards. The Cornwall and West Devon Mining Landscape was valued here for its technology and infrastructure, particularly the innovative use of the high-pressure steam beam engine which led to the evolution of an industrialised production of copper and tin, which then dominated world supply and influenced mining practice internationally. Similarly, the Sewell Mining Town in Chile is an outstanding example of the global phenomenon of company towns, established in remote parts of the world through a fusion of local labour to mine resources for global markets.

The same themes of technological breakthrough and influence over global trends were also recognised at the mining sites of Wallonia and the Volklingen iron works. This same logic was applied to the inscription of the Wouda Pumping station because it produced the most advanced, and never surpassed, steam pumping station in the world, from which all others followed. The Rjukan-Notodden site in Norway was valued for manifesting an exceptional combination of technology and industry used to manufacture artificial fertiliser from which a global industry followed. The saltpeter Humberstone and Santa Laura works in Chile, and the mercury mines in Spain and Slovenia, again, had the mix of technology and global influence. Japan's Meiji Iron and Steel, Shipbuilding and Coal Mining sites, whereby Japan took technology from the West and then leapfrogged to become a global leader, were also valued under Criterion II. Mexico's town of Guanajuato and adjacent silver mines was inscribed here due to its technological developments and regional influences, as was the associated Camino Real de Tierra Adentro, the road that linked many of the silver mines to important points throughout the region.

The link between technological breakthrough and global influence is also well recognised with many of the bridges on the World Heritage List. Spain's Vizcaya bridge is notable here. Ironbridge Gorge, both in terms of the Coalbrookdale blast furnace and the actual Iron Bridge itself, and their impact, was monumental. Similarly, Pontcysyllte canal in Wales is an excellent example of technical interchanges and decisive progress in the design and construction of artificial waterways, which went on to be well copied internationally. The Grimeton Radio Station in Varberg was valued under Criterion II, as an outstanding monument representing the process of development of communication technology in the period following the First World War.

All of the important factory related sites on the World Heritage List are recognised for their Criterion II values. Derwent Valley Mills in England was the birthplace of the modern factory system and went on to change the world. New Lanark was valued as the model of communities based around the principle that industrialisation and social progress could be achieved at the same time. Saltaire followed this thinking, as a planned industrial town, which sought to link industrial achievement and social welfare. Similarly, the 'company town' of Crespi d'Adda in Italy displays the enlightened responses by industrialists at the turn of the 20th century. Model factories/work sites whereby breakthroughs in design, as linked to better working conditions, such as the Fagus Factory in Germany; the Van Nellefabriek site in the Netherlands; the Zollverein Coal Mine Industrial Complex in Essen, Germany, and the Royal Saltworks of Arc-et-Senans in France were all valued here, under Criterion II. So too, the Tomioka Silk Mill in Japan, for the developments of technology related to silk farming, from refined indigenous production of the worms, to the importation of the factory machinery from France, through to becoming dominant in the global silk market at the beginning of the 20th century.

Technology, global influence and the mixing of different cultures thereby creating an interchange of human values was found under Criterion II with the Nord-Pas de Calais Mining

Basin. Likewise, the interchange of migrant workers and evolving technologies was noted with the Fray Bentos Industrial Landscape, which created social, cultural and economic change. The aqueduct Padre Tembleque in Mexico was noted here, as it exhibited Roman, European, Arab-Andalusian and pre-Hispanic indigenous tradition, as well as Mesoamerican technology and goals. The interchange of human values, overlapping with local technologies and ultimately global markets, was also found with the Agave Region of Mexico where tequila was/is produced (with the fusion of pre-Hispanic traditions of fermenting mescal juice with the European distillation processes and of local and imported technologies); and the coffee plantations in the Southeast of Cuba due to their fusion of local and foreign technology. Similarly, with the Iwami Ginzan Silver Mine in Japan, its linkages to significant commercial and cultural exchanges between Japan and the trading countries of East Asia and Europe, merited it to also be included under Criterion II.

The last option under Criterion II, of developments in technology and landscape design, is also recognised with windmill technology and the Kinderdijk-Elshout and Beemster Polder sites of The Netherlands; and Canal du Midi, as a perfect example of a designed landscape. Finally, the technological achievements that are the designed landscapes of the mountain railways sites are well recognised here. This was the case with the Semmering Railway, as an outstanding technological solution to a major physical problem in the construction of early railways. Similar recognitions were linked with the Rhaetian Railway in the Albula/Bernina Landscape, and the Mountain Railways of India, as outstanding examples of the interchange of values on developments in technology, and the impact of an innovative transportation system on the social and economic development of a multicultural region, which was to serve as a model for similar developments in many parts of the world.

Criterion III

The possibility for Outstanding Universal Value under Criterion III is where a site possesses a unique or, at least, an exceptional testimony to a cultural tradition or to a civilization which is living or which has disappeared.

This criterion of traditions which are living, or disappeared, is found with a number of mercantile cities or ports, often at the outermost points of globalisation, with a strong emphasis upon the traditions they once held. Liverpool, Bridgetown in the Bahamas; Valparaiso; Melaka and George Town on the Straits of Malacca are all important here. In terms of other cultural traditions that are ongoing and long-standing, and have gone on to have global importance, the vineyards are particularly notable. This subset of agricultural related sites having traditions going back between 500 years (Pico Island in the Azores) and thousands of years (the Alto Douro Region). In between, the Lavaux vineyard in Switzerland, the Tokaj wine region in Hungary, the area of around Dijon in France, with the Burgundy Climats wine region; the Champagne Hillsides, Houses and Cellars; and Italy's vineyards at Piedmont, all have hundreds of years of legacy, helping to foster thriving, ongoing, living cultures. The other on-going site of cultural importance recognised under Criterion III is the Grand Canal of China, dating to the seventh century, which was valued due to the various dynasties and their successive populations that came to rely, preserve, and expand it.

In terms of the civilisations that have disappeared, the Archaeological Zone of Paquime, Casas Grandes, which reached its apogee in the 14th and 15th centuries, linking what is now southern United States and northern Mexico for its inter-cultural evolution and exchange, is notable. So too, the Pearling landscape of Bahrain, which had a rich cultural tradition which dominated the Persian Gulf between the 2nd and early 20th centuries, but is now completely gone.

Disappeared traditions, of which either full, or parts, of the original sites (either intact, or as relics) continue to exist, are found with many mining sites and associated landscapes. The Falun mine which worked from the 9th century to the 20th century is notable here. So too, in Britain, are the Cornwall and West Devon Mining Landscape and the Blaenavon Landscape as exceptional illustrations of the social and economic structure of a long gone, 19th century industry. Zollverein in Essen ticks the same box because the technological and other structures of Zollverein are representative of a crucial period in the development of traditional heavy industries in Europe which are now gone. This growth of technology, and the disappearance of associated communities, is also evident with the Iwami Ginzan Silver Mine in Japan; and Roros in Norway, with the additional flavour of its international community of German, Danish, Swedish immigrants, and Norwegian nationals. Similarly, the Humberstone and Santa Laura works hosted a now lost culture that involved its own language, organisation, customs, and creative expressions, as well as displaying technical entrepreneurship. So too, the Historic Town of Ouro Preto, in which European and Brazilian technology, markets and cultures came together, and went, leaving behind a syncretised artistic tradition of two cultures.

Criterion IV

Criterion IV is the most common inscription for industrial related heritage, ranging from cities, to complete ensembles through to relics, and the landscapes they occur within. This common listing is because Criterion IV is very wide. Specifically, it covers sites which are an outstanding example of a type of building, architectural or technological ensemble or landscape which illustrates a significant stage in human history. Although it is not easy to recognise, this criterion was originally designed for industrial heritage. It was meant to cover important engineering structures, that were not buildings in the usual sense, such as bridges, tunnels, canals, etc. However, the word 'structure' was lost in the drafting process, to eventually be replaced with 'technological ensemble'.

In addition, the word 'landscape' was added, to help match the 'combined works of nature and of man' as designated in Article 1 of the Convention. According to the Annex III of *Operational Guidelines*, landscapes may come into three parts. These are Designed Landscapes (such as garden or created parks); Evolved/Vernacular Landscapes (which may be relics but the significant parts are still visible, having come to an end, or a Continuing Landscape, whereby the evolutionary process is ongoing); or an Associated Cultural Landscape. This is one where the landscape is significant due to the powerful cultural (religious, artistic, historical or scientific) associations of the natural element, rather than material cultural evidence which may be significant or even absent.

With built heritage, the importance of landscape setting is long standing, for as the foundational, 1964 *Venice Charter for the Conservation and Restoration of Monuments and Sites* stated, 'the concept of a historic monument embraces not only the single architectural work but also the urban or rural setting in which is found the evidence of a particular civilization, a significant development or a historic event.' Nearly forty years later, the 2005 *Vienna Memorandum on Managing the Historic Urban Landscape* emphasised that, 'the broader territorial and landscape context' are important in understanding, contexualising, and recognising the built heritage. The 2008 ICOMOS Quebec Declaration on the Preservation of the Spirit of Place added to this area, emphasising the importance of connecting ideas of intangible heritage with non-tangible concepts of material place, such as genius loci, under the concept of spirit of place. These considerations of landscape have a particularly strong influence in the area of industrial heritage. This is because each location was chosen for a particular reason and placed in a specific location. That facilitated the goals of the industry.

In terms of designed landscapes which overlap strongly with technology, the two sites in The Netherlands at Kinderdijk-Elshout and Beemster Polder were both recognised here as outstanding human-made landscapes in which technology and aesthetic design came together. Similar considerations applied to the Amsterdam Canal District and Canal du Midi, with the latter being an absolute exemplar of a designed landscape. So too, the Rideau Canal, the Pontcysyllte Canal, the Grand Canal of China and the Four Lifts on the Canal du Centre and their Environs. Each one of these canals was linked to a particular period of history. Britain's Forth Bridge was recognised here to be an extraordinary and impressive milestone in the evolution of bridge design and construction during the period when railways came to dominate long-distance land travel, innovative in its concept, its use of mild steel, and its enormous scale. All three of the primary railways sites, Semmering, Rhaetian, and the Mountain Railway of India are also recognised for, *inter alia*, spectacular landscapes which were opened up by carefully planned human technology.

Planned landscapes also included the Lavaux vineyard in Switzerland and the Champagne Hillsides, Houses and Cellars of north-east France, both of which possess long standing industry carefully blended into the landscape. Similarly, the cultural landscape in the Agave Region of Mexico, where architectural complexes illustrate the fusion of technologies and cultures of over 250 years in the production of tequila, are valued. Likewise, with the Alto Douro Region, a cultural landscape was created which included the full range of activities associated with winemaking, such as terraces, villages, chapels and roads. The coffee plantations in the Southeast of Cuba are also seen as a unique cultural landscape, illustrating a significant stage in the development of this form of agriculture and commodity production.

The technological ensembles clearly linked to the Evolved or Associated Landscapes that marked a significant stage in human history include the Ironbridge Gorge as an industrial region, including transformation industries, manufacturing plants, workers' quarters, and transport networks that made up a coherent ensemble. Dermwent Valley, Saltaire and New Lanark were all recognised under such considerations, although their supplementary work on quality housing and social conditions for their workers were particularly drawn out.

The Cornwall and West Devon Mining Landscape matched this with its characteristic engine houses and beam engines as a technological ensemble in a landscape that went on to have global dominance. The components of the Blaenavon Industrial Landscape fulfill the same considerations, as did the Völklingen ironworks; the Engelsberg ironworks; the Roros Mining Town; Japan's Meiji Iron and Steel, Shipbuilding and Coal Mining sites; and Rammelsberg, with the latter, known for its comprehensive technological ensemble in the fields of management, mining techniques, non-ferrous metallurgy and the management of water for drainage and power, with roots going back to the Renaissance period, and evolving as a clear part of the landscape. The Rjukan-Notodden site in Norway was inscribed under Criterion IV for including everything from dams to power plants, to factory areas, company towns, and transport systems, located in a unique landscape where the natural topography enabled hydroelectricity to be generated. Similarly, the Fray Bentos Industrial Landscape of Uruguay, with the ensemble of cattle pasture and handling facilities, industrial buildings, mechanical facilities, port facilities, residential fabric and green areas, stands out as an example of early 20th century industrial development.

The focus on technological ensembles representing significant stages in human history also covers the Wieliczka and Bochnia salt mines of Poland for illustrating the historic stages of the development of mining techniques in Europe, from the 13th to the 20th centuries, within an overall socio-technical system. The Royal Saltworks of Arc-et-Senans in France are recognised, for their provision of an outstanding technical ensemble for the extraction and production of salt by pumping based on a technique of tapping sources of salt deep underground. The mining sites of Wallonia are recognised as an eminent and complete example of industrial mining in continental Europe (for technological, urban, architectural and social values) at various stages of the Industrial Revolution. The Nord-Pas de Calais Mining Basin was recognised because of the large-scale development of coal mining landscape in the 19th and 20th centuries, by large industrial companies and their considerable workforce. The saltpeter Humberstone and Santa Laura mines in the north of Chile together became the largest producers of natural saltpeter in the world, transforming the Pampa and indirectly the agricultural lands that benefited from the fertilisers the works produced. Japan’s Tomioka Silk Mill, with its indigenous plant design, importation of foreign technology, and global domination in terms of both product, and spread of manufacturing method, was also found to be a Criterion VI exemplar. The final example here of a technological ensemble is the Grimeton Radio Sation in Varberg, Sweden, for representing the technological achievements, by the early 1920s, of telecommunications, as well as documenting the further developments in this area over the following three decades.

Of the mining towns related to precious metals, Slovakia’s Banská Štiavnica was inscribed under Criterion IV as an outstanding and distinctive example of a medieval mining centre of economic importance that continued into the modern period. The mercury mine sites of Almadén and Idrija were inscribed as they illustrate the various industrial, territorial, urban and social elements of a specific socio-technical system in the mining and metal production industries. Finland's Verla Groundwood and Board Mill are an excellent example of the small-scale rural industrial settlements associated with pulp, paper and board production that flourished in northern Europe and North America in the 19th and early 20th centuries, was also valued here.

Sometimes under Criterion IV, the considerations of architectural (as opposed to technological) ensemble spill over in the industrial space. For example, Mexico's town of Guanajuato and adjacent silver mines were found to be an architectural ensemble that incorporates the industrial and economic aspects of a mining operation. In addition, the Camino Real de Tierra Adentro, that linked many of the silver mines with many examples of buildings and technology, illustrating a significant stage of human history, was also recognised as Criterion IV. Likewise, the La Chaux-de-Fonds/Le Locle watch making towns in Switzerland were valued under Criterion IV as a unique and highly planned urban and architectural ensemble, wholly dedicated to the manufacture of watchmaking from the 18th century until the present day. The aqueduct of Padre Tembleque was held to represent an outstanding example of hydraulic water architecture, based on in-depth knowledge of Roman and Renaissance hydraulic engineering which was integrated with local Mesoamerican construction knowledge. Finally, the factories at the beginning of the twentieth century, namely the Fagus Factory in Germany (as a pivotal piece of modern architecture, in terms of design and function) and the Van Nellefabriek site in the Netherlands (for design that captured the environment, and made the workplace both more functional and pleasant to work in) were valued here.

Criterion V

Criterion V is for sites that are 'an outstanding example of a traditional human settlement, land-use, or sea-use which is representative of a culture (or cultures), or human interaction with the environment especially when it has become vulnerable under the impact of irreversible change'.

The foremost example of sites related to technology under criterion V are those related to alcohol. Specifically, the wine producing region of the Pico Island in the Azores was noted here due to its extraordinary human-made landscape of small, stone walled fields (designed to protect the crops, built on near soil-less areas, from salt and spray) and associated infrastructure (warehouses, churches), which allowed sustainable living and a high valued product, to be made in a hostile environment. Similarly, the long-standing wine regions, woven into the surrounding countryside around Dijon in France, the Burgundy Climats wine region; the Alto Douro Wine Region in Portugal; the Tokaj wine region in Hungary; Italy's vineyards at Piedmont and the the Lavaux vineyard in Switzerland. The cultural landscape in the Agave Region of Mexico exemplified the continuous link between ancient Mesoamerican culture of the Agave and today, as well as the continuous process of cultivation, technology and social support, since the 17th century when large scale plantations were created and distilleries first started production of tequila. Likewise, the Coffee Cultural Landscape of Colombia is a multigenerational, culturally distinctive area involved in coffee production in challenging geographical conditions.

Other forms of human interaction with the environment especially when it has become vulnerable under the impact of irreversible change, include the Roros copper mine which is considered as a cultural landscape that provides a picture of how the mine and the mining town functioned as a complex that verged on the limits of what was possible in an inhospitable environment with a harsh climate. Slovakia's Banská Štiavnica was recognised here as an outstanding example of mining area which has become vulnerable to the potential erosion of its character and urban fabric, following the cessation of mining activities as well as the removal of the Mining Academy. Finally, the Japanese site of the Iwami Ginzan Silver mine and its Cultural Landscape, that survived virtually intact but are now concealed by the mountain forests, was found to bear dramatic witness to historic land-uses of outstanding universal value.

A final example under Criterion V involves traditional human settlement which was representative of a culture. The 'company town' of Crespi d'Adda in Italy is a rare example of a planned town which structure has survived, unaltered, despite the threat posed by the evolution of economic and social conditions.

Criterion VI

Criterion VI requires an area to be 'directly or tangibly associated with events or living traditions, with ideas, or with beliefs, with artistic and literary works of outstanding universal significance'. In the area of industrial heritage, it is the ideas and beliefs associated with an industrial site that are pivotal.

At the forefront of such considerations, Ironbridge Gorge achieved a Criterion VI inscription, as the symbol of the Industrial Revolution. New Lanark meets Criterion VI for being synonymous with the work of Robert Owen and his social philosophy in matters such as progressive education, factory reform, humane working practices, international cooperation, and garden cities, which was to have a profound influence on social developments throughout the 19th century and beyond. The Nord-Pas de Calais Mining Basin was valued under this criterion because of the social, technical and cultural events associated with the history of the site had international repercussions, especially in terms the history of its major disasters. It was also valued because of the evolution of the social and technical conditions of coal extraction, making it a major symbolic place of the workers' conditions and their solidarity, as testimony to the ideals of worker unionism and socialism.

The Champagne Hillsides, Houses and Cellars in north-east France were valued under criterion VI as the unique and world-renowned image of Champagne as a symbol of the French art of living, of festiveness and celebration. The Coffee Cultural Landscape of Colombia was valued as the most representative symbol of national cultural identity in Colombia. The Grand Canal of China met Criterion VI for being a powerful symbol of economic, social and political unification operating for over 1,300 years in China. The Agave Region of Mexico was inscribed for the Tequila landscape, and its cultural significance, within and beyond Mexico. Finally, and also with Mexico, the town of Guanajuato and adjacent silver mines were inscribed under criterion VI, for being directly and tangibly associated with world economic history, particularly that of the 18th century.

Conclusion

There are over 1,000 sites on the World Heritage List. Despite this large number, the List is unbalanced and unrepresentative in certain themes. One clear area which is under-represented is industrial heritage, and its seven sub-themes.

Of the sub-themes, the area of power production for industry is reasonably well covered, but the exemplars of early to mid-20th century structures (such as the Hoover Dam) and evolutions of the 21st century (such as large-scale wind-farms) are omissions. In terms of extractive industries, mining for salt, copper, coal and precious metals is well represented, as is the Iron and Steel industry. Factories are reasonably well designated, with good foundation work on both original sources from the Industrial Revolution and afterwards, in terms of importance in production, design and social considerations. Where the List fails is in terms of the large scale plants of the 20th century. The List is variable in relation to transport, with its canals, railways, bridges and aqueducts. Whilst many good examples of canals have been listed, world changing canals (such as the Panama Canal and the Suez) are missing; as are exemplars of the most famous railways and bridges. The listings of agricultural sites related to the Industrial Revolution are not consistent, although progress is being made filling this sub-theme in terms of commodities, from an international perspective. The most dominant part of this sub-theme, those sites related to alcohol, do not really touch on the developments in breweries and distilleries during the Industrial Revolution. The largest gap in all of the sub-themes is with telecommunications. Here, only one site has been inscribed on the World Heritage List. Despite the vital contribution of this area to the Industrial Revolution and the modern world, the critical sites related to the telegraph, the submarine cable (and especially the Trans-Atlantic cable), the telephone and the wireless, are almost completely under represented.

In terms of the Outstanding Universal Value of World Heritage, six possible values are available to remedy the under presentation of these aspects of industrial heritage.

Criterion I: A site is only rarely recognised for representing a masterpiece of human creative genius when it comes to industrial heritage. The only possibility for meeting this criterion is when the technology or its application is truly special and is an absolute breakthrough. Some cases relating to transport (such as bridges), extraction and agriculture have been inscribed, but most do not. Factories do not meet this criterion, and it is very rare for sites related to power production.

Criterion II: Sites that demonstrate developments in technology related to power production have not met this criterion's requirement of representing an important interchange of human values, over a span of time or within a particular area. Criterion II is commonly found for extraction based industries and all other sites where a clear development in technology which went on to have a global impact.

Criterion III: Sites which developed clear cultural traditions, which are living or disappeared, as was common for agricultural related sites (especially alcohol production) for long standing practices are valued under this criterion. So too, sites which are now relics of a time past. In this last set of relics, old mining or industrial sites are particularly notable.

Criterion IV: this is the most commonly recognised value for industrial heritage as it relates technological ensembles that represent a significant stage in human history. The overlap with landscape is also important here. Landscapes and industrial heritage are commonly linked together. Technological ensembles are well represented here in all sub-themes from extraction industries to factories. Notably, social focused sites linked to industrialisation are also evident here.

Criterion V: this criterion, which stems from the recognition of areas of human settlement linked to the environment, is mostly used for sites related to agriculture. However a few examples exist of some industries which were intimately connected to their environmental context.

Criterion VI: Sites, whereby a place is identified for an idea or tradition of outstanding universal significance, are rarely used for industrial heritage. The exception is where a site can be linked to something which had true international ramifications. This can be seen in terms of either the product they created (for example, tequila or champagne) or the philosophy (such as social responsibility for industry) had universal implications.

COMMUNICATIONS TECHNOLOGY AS MISSING HERITAGE: CONSIDERATIONS OF VALUE AND LOCATION.

1. Introduction

As soon as written communications existed, the need to move these documents accurately from one location to another, as fast and securely as possible, became obvious. This requirement, which has been with humanity for over four thousand years, saw revolutionary developments in technology with the Industrial Revolution and its aftermath. The quest to receive accurate, secure, suitable and instant communications remains a constant drive in the 21st century.[1] Indeed, in early 2016, it was announced that a new 300 million (USD) cable was being laid down in order to shave 5 milliseconds off communications between New York and London.[2]

The contemporary importance and evolution of this communications technology has fundamentally reconfigured human society. It is the one technology from the Industrial Revolution that did not cause mass pollution, unemployment or make working conditions intolerable. However, communications technology is largely invisible from studies of heritage. Indeed, of the more than 1,000 sites which are recognised as World Heritage by the World Heritage Committee, only one site relates to communications. This paper seeks to provide an outline of where the other critical sites of historical importance that should also be recognised as heritage of global importance, can be located.

NOTE: this paper is primarily concerned with the communications technologies that developed before the First World War. The one site for telecommunications that exists on the World Heritage List, Varberg Radio Station, was built in 1922, and came after all of the important developments in this area. This is not to deny the obvious importance of contemporary computer and/or smart phone communications technologies that have also changed the world, of which email is the exemplar.[3] The work on industrial heritage in the

---

[1] Cady, S (2015) 'From Smoke Signals to the Cloud: A Review and Analysis of Distance Media for Control, Coordination and Collaboration'. *Organisation Development Journal* 33 (1): 41-57; Fisher, D (2002) 'From Smoke Signals to Cell Phones: Tracing how Technologies Evolve'. *The Technology Teacher* 61 (7): 12-22; Lucky, R (2000) 'The Quickening of Science Communication'. *Science* 489 (5477): 259-279.

[2] Anon (2016) 'Under the Sea'. *New Scientist* June 4. 6.

[3] Blum, A (2012) *Tubes: A Journey to the Center of the Internet*. (Harper, NYC). 34-56; Partridge, D (2008) 'The Technical Development of Internet Email'. *IEEE Annals of the History of Computing* 30 (2): 3-29; Oslin, G (1992) *The Story of Telecommunications* (Mercer UP, Georgia). 359-386.

computer age, which began during the Second World War, is a much larger topic that is outside of the scope of this paper.

2. Communication

The Egyptians are believed to be the first people to have had systems to move written communications around their empire. Over a thousand years later, the Greek historian Herodotus recorded the Royal Road of Persia which their king, Darius the Great, had built in the 5th century BCE to facilitate rapid communication throughout his empire. Similar roads existed in the comparable empires in China and India. In theory, a succession of fresh riders and fresh horses, taking a message in relay, could cover hundreds of miles per day. Herodotus recorded that, 'there is nothing in the world that travels faster than these Persian couriers. Neither snow nor rain nor heat nor gloom of night stays these couriers from the swift completion of their appointed rounds'.[4]

The Greeks attempted similar systems, in addition to systems of flags, torches and even homing pigeons to carry messages. The Romans, in addition to using carrier pigeons, flags and torches, developed an imperial post system comprised of riders on fast horses, who could travel, in ideal conditions, fifty miles per day. A supplementary service for non-governmental mail was slightly slower. The time added by ocean crossings could be substantial, so that imperial edicts could take up to four months to travel between Rome and the further most points of the Empire.[5] This system barely changed for the following 1500 years, although additional tools of fire, smoke and flags were used. Accordingly, despite revolutionary technologies such as the printing press which transformed the way that the written word could be recorded, the speed at which such words or messages could be transported accurately over distance remained determined by the speed of horses, the routes to be traversed and/or the reliability of the pigeons to which the communications were attached. Accordingly, when Benjamin Franklin dispatched writers throughout the territories in America on July 4th with copies of the *Declaration of Independence*, the *Declaration* did not reach the furthermost point of Georgia until July 22nd.[6]

---

4 Herodotus *Histories* (trans, Joseph, P, Penguin, London). V: 52-53, viii.98. See also Calder, W (1925) 'The Royal Road in Herodotus'. *The Classical Review* 39 (1): 7-11.

5 Moatti, C (2006) 'Translation, Migration and Communication in the Roman Empire'. *Classical Antiquity* 25 91): 109-140; Eliot, C (1955) 'New Evidence for the Speed of the Roman Imperial Post'. *Phoenix* 9 (2): 76-80.

6 Dittmar, J (2011) 'Information Technology and Economic Change: The Impact of the Printing Press'. *The Quarterly Journal of Economics* 126 (3): 1133-1172.

3. The Optical Semaphore

The Industrial Revolution changed communication. Whilst some new developments, such as optical semaphore systems (where signals were reproduced down a line of towers with mechanical arms, allowing a signal to go from Paris to Calais in four minutes), offered some promise, they were limited to how far, how fast, how accurately, and how much information they could carry.[7] Similar limitations also applied to other developments of the Industrial Revolution, such as railways. Although they made the delivery of conventional post faster, they were always tied to the speed and distribution networks of locomotives.[8] Despite these restrictions, the optical semaphore, of which a few pieces still remain, represents the last significant development before instantaneous communications technology eclipsed everything in its path. Remaining examples which could be linked together in regional heritage initiatives include, inter alia, the restored 1848 semaphore tower in Malta,[9] the Cologne station from 1812,[10] and possibly the oldest, largely original semaphore, from the end of the 18th century at Castelnaudary, near Toulouse.[11]



[7] Field, J (1994) 'Optical Telegraphy, 1793-1855'. *Technology and Culture* 35 (2): 315-340.
[8] Beyrer, K (2006) 'The Mail Coach Revolution'. *German History* 24 (3): 133-154.
[9] This picture is sourced from *https://vassallohistory.wordpress.com/**semaphore**-towers/*
[10] This picture was sourced from https://en.wikipedia.org/wiki/Prussian_semaphore_system#/media/File:Telegraf-flittard.jpg
[11] This picture was sourced from http://www.johnhearfield.com/Radar/Chappe.htm

4. The Birth of Telecommunication: Electricity

According to the 1992 Constitution of the International Telecommunication Union, telecommunication means, 'Any transmission, emission or reception of signs, signals, writing, images and sounds or intelligence of any nature by wire, radio, optical or other electromagnetic systems'.[12] It is this definition that divides discussions of communications to both before, and after, the Industrial Revolution, as one key ingredient made all of the new technologies possible (that the old technologies did not have). The key ingredient that allowed the break from the past was the discovery of the one medium which promised to provide instantaneous communication over great distances. That medium was electricity. Although electricity is commonly attributed to the so-called 'second stage' of the Industrial Revolution (with the electrification of industry and communities after the 1880s), its impact goes back much further. This is because the technological application of electricity to telegraphy made distant communication possible, pushing all other forms of communication to one side.[13]

5. The Telegraph

The development of the telegraph is excellent proof that the ideal of a sole inventor is a myth. All great ideas stand on the shoulders of others, and this is especially the case in communications technology.[14] This story began in the mid 16th century when Otto von Guericke found electricity in his globe of sulfur. In 1729, Benjamin Franklin sent a spark of electricity across the Schuylkill River, near Philadelphia, but no-one knew what to do with the experiment. Over a decade later in the 1740s, as Franklin tried to capture bolts of lightning with a kite, John Graham showed that electric current could also be passed along a wire, and not just a wet string. A Scottish doctor writing in 1753 envisaged an electric telegraph, although this speculation, could not be advanced until the technology evolved.[15]

The Italian physicist, Alessandro Volta, provided the next piece of the puzzle when he discovered that electricity could be contained in a battery and its current could be regulated.

[12] Annex 1 to the 1992 Constitution of the International Telecommunication Union. This is found on page 54 of the ITU's (2011) Collection of the Basic Tests of the International Telecommunications Union. (Geneva, ITU).

[13] Ross, T (2011) 'Did the Telegraph Lead Electrification ? Industry and Science in American Innovation'. *Business and Economic History* 9: 1-34; Behringer, W (2006) 'Communications Revolutions: A Historiographical Concept'. *German History* 24 (3): 333-375.

[14] Lemley, M (2012) 'The Myth of the Sole Inventor'. *Michigan Law Review* 110 (5) 709-760; Khan, Z (2004) 'Institutions and Democratic Inventions in the 19th Century: Evidence from the Great Inventors, 1790-1930'. *The American Economic Review*. 94 (2): 395-401.

[15] Niedermeyer, E (2003) 'Benjamin Franklin and Static Electricity: Considerations of Past, Present and Future'. *American Journal of Eletroneurodiagnostic Technology* 43 (1): 26-29; Anon (1799) 'An Essay Tending to Improve Intelligible Signals and to Discover an Universal Language'. *Transactions of the American Philosophical Society* 4 (1): 162-173.

The idea of trying to control this output through differentiated wire transmissions excited the imaginations of Samuel von Sommering and Fancisco Campillo, who came to understand the magnetic field and the impact that an electric current held on a compass needle. Their work overlapped with the work of Johann Schweigger, who invented the galvanometer, with a coil of wire around a compass, which could be used as a sensitive indicator for an electric current. The first working, and very rudimentary, system of 8 miles of wire laid underground, insulated in glass tubes and using a static charge, was built by the English inventor, Francis Reynolds in 1816, but no-one could see its value. Undeterred, the science continued. The German, Hans Christian Oersted, cracked the secret of electromagnetism in 1819, realising that a wire carrying a current exerted a magnetic force. Andre-Marie Ampere recognised that telegraphy could be done by a system of galvanometers in 1821. The Englishman, William Sturgeon, and the American, Joseph Henry, refined these inventions over the following years, before the German diplomat, Pavel Schilling began to put all of the pieces together, controlling the electrical current and linking galvanometers with magnetic needles via silk thread, in the early 1830s. When the work of the English scientist, Michael Faraday, on electromagnetic field theory was added to the equation, and the importance of copper as the primary conductor, the opportunities for telegraphic cables opened up even further.[16]

All of this work culminated in the mid 1830s when the German mathematician Carl Gauss (below left) and scientist Wilhelm Weber (below right)[17] adopted and refined all of the existing theory and practice. They operated the first working telegraph system, in Gottingen in 1833, communicating at a speed of 6 words per minute, across a distance of three kilometers. Although some of the original sites related to this achievement have disappeared, it is possible that some, at the University, are still in existence.[18]

---

[16] Schiffer, M (2008) 'A Cognitive Analysis of Component Stimulated Invention: The Electromagnet and the Telegraph'. *Technology and Culture* 49 (2) 376-398; James, F (2008) 'Michael Faraday in the Twentieth Century'. *British Journal for the History of Science* 41 94): 477-516; Poole, W (2006) 'Nuncius Inanimatus: Seventeenth Century Telegraphy: The Schemes of Francis Godwin and Henry Reynolds'. *Seventeenth Century* 21 (1): 45-60; Steinle, F (2002) 'Experiments in History and Philosophy of Science'. *Perspectives on Science* 10 (4): 408-432; Schroder, W (2001) 'Geomagnetic Research in the 19th Century: A Case Study of the German Contribution'. *Journal of Atmospheric and Solar Terrestrial Physics* 63 (15): 1649-1665; Other, A (1999) 'Alessandro Volta's Electric Pile'. *Journal of Electroanalytical Chemistry* 460 (1): 345-356.

[17] This image is from http://www.thefamouspeople.com/profiles/wilhelm-weber-551.php

[18] Hentschel, K (1999) 'Some Historical Points of Interest in Gottingen'. *Physics in Perspective* 1 (1): 110-117.

The chances of economic reward stemming from the profits that could be made by patenting the new technologies excited the imaginations of many.[19] The first patent on the electric telegraph with multi-needle instruments, following further refinements, was given in Britain in 1837, to Charles Wheatstone (below, on the left)[20] and William Cooke[21] (on the right).

The first commercial telegraph in Britain was opened a year later, in 1838. Unfortunately, although one of the original factories in which telegraph machinery was made remains, much of the original infrastructure involved with telegraphy in England from this period has disappeared, with some of the key pieces being destroyed in the Blitz in 1940.[22]

Across the Atlantic, following the work of David Alter, and then further refinement on technology and code by Stephen Vail and Samuel Morse[23] between 1836 and 1838 (in the

---

[19] Trainer, M (2007) 'The Role of Patents in Establishing Global Telecommunications'. *World Patent Information* 29: 352-362; Nonnenmacher, T (1997) 'Emerging Technology, Market Structure and the Development of the Telegraph Industry, 1838-1868'. *The Journal of Economic History* 57 (2): 488-513.

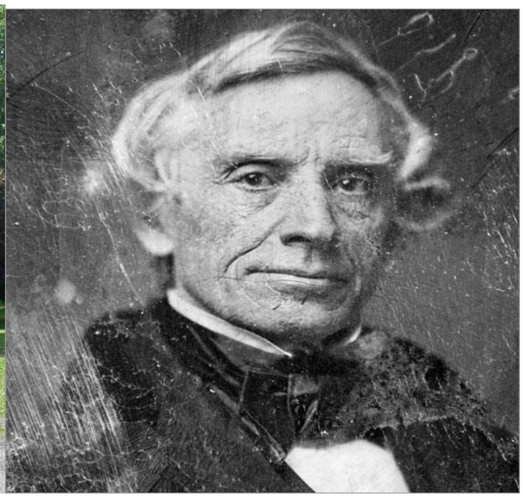
[20] The picture of Wheatstone is by Samuel Laurence from 1868. It can be found at https://en.wikipedia.org/wiki/Charles_Wheatstone

[21] This picture of Cooke is available at http://www.connected-earth.com/Peopleandpioneers/Pioneers/C/Cooke/index.htm

[22] See Liffen, J (2013) 'Telegraphy and Telephones'. *Industrial Archaeology Review* 35 (1): 22-39.

[23] The image of Morse is from http://www.wired.com/2010/04/0427samuel-fb-morse-born/

building of Old Speedwell Iron Works at Morristown New Jersey[24] which still exists, below), the concept of telegraphy caught hold.[25]



When the Senate (narrowly) agreed to fund his proposal to build a a telegraph line between Washington and Baltimore, Samuel Morse dramatically opened this telegraph line in 1844 with the phrase from the Book of Numbers,[26] 'What hath God wrought'.[27] When the American physicist Joseph Henry devised a way to boost the impulses and defeat fading signals, all of the States east of the Mississippi became connected.[28] Paris, Vienna and Berlin were all communicating by telegraph by 1849, and by 1850, all of the main towns of Britain were linked into the telegraph network.[29]

a. The Impact of the Telegraph

As the below painting by Christian Schussele, *Men of Progress*[30] shows that of all the great achievements and inventors of the age, it was Samuel Morse (centre of the painting, to the right) and his telegraph, which was deemed the most important of them all.

---

[24] This image is from https://en.wikipedia.org/wiki/Speedwell_Ironworks
[25] Fishlock, T (2004) *Conquerors of Time*. (Murray, London). 236.
[26] Numbers 23:23.
[27] Lowe, D (2007) What Hath God Wrought: The Transformation of America, 1815-1848. (Oxford UP, Oxford). Silverman, K (2003) Lightning Man: The Accursed Life of Samuel F.B. Morse. (Knopf, NYC).
[28] See Littman, M (2011) 'A New Understanding of the First Electromagnetic Machine: Joseph Henry's Vibrating Motor'. American Journal of Physics 79 (2): 172-181.
[29] Metz, D (2015) 'The Scientific Instruments of Charles Wheatstone and the Blending of Art, Science and Culture'. Interchange 46 (1): 19-29; Liffen, J (2010) 'The Introduction of the Electric Telegraph in Britain: A Reconsideration of Cooke and Wheaton'. International Journal for the History of Engineering and Technology 80 (2): 26-298; Cavicchi, E (2009) 'Earth Grounds and Heavenly Spires: Lightning Rod Men, Patent Inventors and Telegraphers'. Transactions of the American Philosophical Society 99: 181-199; Bektas, Y (2001) 'Displaying the American Genius: The Electromagnetic Telegraph in the Wider World'. British Journal for the History of Science 34: 199-220.
[30] http://www.artbabble.org/video/npg/samuel-morse-portrait-minute

The reason that Morse and his telegraph became so well recognised was because once his technology entered the mainstream, there was almost universal enthusiasm for it in all of the countries in which it operated. Commentators predicted that it would bring everything from economic prosperity to spiritual enlightenment,[31] through to world peace.[32] In reality, it brought neither peace nor nirvana but it did radically transform society at all other levels.[33] This was especially the case in Britain and the United States.[34] Most noticeably, as Karl Marx correctly predicted in 1855, the telegraph would 'transform the whole of Europe into one single stock exchange'.[35] The proof of his assertion was found with the added value that the telegraph gave to financial markets[36] and businesses.[37] The media also quickly recognised the benefits

[31] Noakes, R (1999) 'Telegraphy is an Occult Art'. *The British Society for the History of Science* 32 (4): 421-459.
[32] Angell, N (1911) *The Great Illusion: A Study of the Relation of Military Power in Nations to their Economic and Social Advantage* (Putnam, NYC). 184-185.
[33] Lubrano, A (1997) *The Telegraph: How Technology Innovation Caused Social Change* (Garland, NYC).
[34] Hochfelder, D (2012) *The Telegraph in America, 1832-1920.* (Knopf, NYC); Standage, T (1999) *The Victorian Internet: The Remarkable Story of the Telegraph and the Nineteenth Century's Online Pioneers*. (Collins, London).
[35] Marx, as in Carey, J (2009). *Communication and Culture: The Case of the Telegraph*. (Taylor and Francis, London). 157.
[36] Du Boff, R (1980) 'Business Demand and the Development of the Telegraph in the United States, 1844-1860'. *The Business History Review* 54 (4): 459; Tarr, J (1987) 'The City and the Telegraph'. *Journal of Urban History* 14 (1): 38-80.
[37] Morus, I (1996) 'The Electric Ariel: Telegraphy and Commercial Culture in Early Victorian England'. *Victorian Studies* 39 (3): 339-353; Tarr, J (1987) 'The City and the Telegraph: Urban Telecommunications in a Pre Telephone Era'. *Journal of Urban History* 14 (1) 303-325.

of the national telegraph to their businesses. Paul Julius Reuter[38] made his fortune and founded a commercial empire based upon the collection of news from distant sources.[39]

The military recognised the value of having the type of accurate and instantaneous information provided by telegraphs at their disposal.[40] Police forces, also, discovered they had the tool of near instant communications, which could be used to trap quick moving criminals.[41] The technology's multiple values led governments to try to regulate it,[42] while consumers became accustomed to it, as both a luxury for communication at a distance when speed was required. Citizens also became accustomed to the telegraph as a tool whereby information could be transmitted quickly for the public good and no longer hidden.[43]

6. The Submarine Telegraph and its Limits

The difference between land and sea telegraphs was striking. By the early 1850s, overland telegraphy had achieved a high degree of sophistication. Signals could be transmitted more or less automatically and at high speeds. This was not the case when cables had to traverse through water. Although some scientists had recognised that some form of insulation for the cable was essential, and experimented with some materials, their success was limited. Nonetheless, all countries recognised that if the full potential of telegraphs was to be released, the technology had to be able to cross the oceans that divided countries.[44]

---

[38] The painting of Paul Reuter, as by Rudolf Lehmann in 1869. The source is https://en.wikipedia.org/wiki/Paul_Reuter#/media/File:Paul_Julius_Reuter_1869.jpg.

[39] Barton, R (2010) 'The Birth of Telegraphic News in Britain, 1847-68'. *Media History* 16 (4): 189-203; Kiebowicz, R (1987) 'News Gathering By Mail in the Age of the Telegraph: Adapting to a New Technology'. *Technology and Culture* 28 (1) 77-89.

[40] Showalter, D (2004) 'Information Capabilities and Military Revolutions: The Nineteenth Century Experience'. *The Journal of Strategic Studies*. 27 (2): 220-242; Pound, R (1936) 'The Military Telegraph in the Civil War'. *Proceedings of the Massachusetts Historical Society* 66: 185-203.

[41] Moorhead, S (2014) 'Telegraphy and the Downfall of the Kelly Gang: And Other Vignettes from the Telegraph Society of Victoria'. *Australian Journal of Telecommunications and the Digital Economy*. 2 (3): 78-89.

[42] Nonnenmacher, T (2001) 'State Promotion and Regulation of the Telegraph Industry, 1845-1860'. *The Journal of Economic History* 61 (1): 50-64.

[43] Phillips, R (2000) 'Digital Technology and Institutional Change from the Gilded Age to Modern Times: The Impact of the Telegraph and the Internet'. *Journal of Economic Issues* 34 (2): 1-19; Fairclough, M (2013) 'The Telegraph: Radical Transmission in the 1790s'. *Eighteenth Century Life* 37 (2): 26-52.

[44] See Spear, B (2003) 'Submarine Telegraph Cables, Patents and Electromagnetic Field Theory'. *World Patent Information* 25 (3): 203-209.

Scientists, inventors and enthusiasts were all exploring the options in this area from the turn of the 19th century, with the chemist Edward Davey noting, in 1837, that, ‘communications may be effected through, or under, the water by enclosing the conductor in rope well coated or soaked, in an insulating and protecting varnish’.[45] The leading figures associated with the land telegraph in both the United States (Samuel Morse) and Britain (Charles Wheatstone) were also at the forefront of submarine telegraphy.

The most notable attempts to transmit signals under water from this period included the 1845 cable which stretched for 12 miles down the Hudson river in New York. In the same year, a 25 mile cable was laid between Dover and Calais. Both of these worked for a short period. The cable that linked France and England was covered with cotton soaked in a rubber solution and it was encased in a very thick lead tube. The cable worked for a only a few hours and it transmitted just a few successful signals, including one from Napoleon III, before it became apparent that the cable was broken. A second attempt to cross the English Channel in 1850 had more success. Progress was advanced when a core of four copper wires was insulated with the natural rubber of gutta percha, and weaved tight by steel wire. The new link to France was a success, as were attempts to link to Ireland, and then England, to Belgium. Each instance was a mixture of failure and success, and the longest of these lines was only 100 miles in length.[46]

Increased distance and depth multiplied the difficulties. The distances were problematic because the signals became harder to transmit because the cables were poorly constructed, and badly insulated, resulting in signals that were weaker and harder to read. The depths of the ocean to be crossed added to the problems, as did the unknown nature of the ocean floor. Accordingly, two cables, the Spezia-Corsica cable (70 nautical miles and 325 fathoms) and Sardinia-Bona cable (130 nautical miles and 800 fathoms) ran into substantial difficulties as depths turned out to be more than double what was expected.[47]

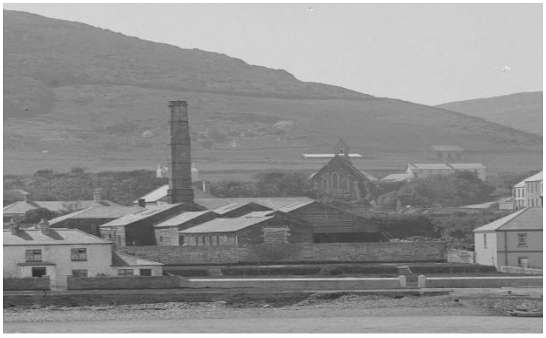
Problems such as these led Samuel Morse to believe, initially, that the idea of a submarine cable between the United States and Europe was, ‘a brilliant but impracticable, or rather, unresolved conception’.[48] It was as unreal, said Morse, as air travel. The difficulties that Morse recognised were questions of whether an electric charge could be propelled over a distance as wide as the Atlantic; such as, a lack of knowledge about the ocean bed; difficulties in laying

[45] Davey, as noted in Wallace, G (2000) ‘Laying the Foundation’. *Marine Technology Society Journal* 34 (3): 1-5.
[46] Mead, J (2002) ‘Insulation Materials for Wire and Cable Applications’. *Rubber Chemistry and Technology* 75 (4): 701-730.
[47] Cookson, G (2006) *The Cable* (Tempus, Gloucestershire) 51.
[48] Morse, as noted in Cookson, G (2006) *The Cable* (Tempus, Gloucestershire) 9.

out the cable; and the sheer economic cost of such a project. He concluded, 'the world is simply not ready for such a project'.[49] Others, such as the eminent scientist Professor Airy, the Astronomer-Royal, forcibly stated that it would be impossible to deposit a submarine cable at the depths of the Atlantic ocean and that, in any case, it was mathematically impossible to transmit electrical signals through such a length.[50] Such concerns followed the work of the physicist Michael Faraday, who identified 'the capacitance effect' in 1838, a theory that explained how underwater signals had the capacity to grow increasingly weak over prolonged distances. Accordingly, even the men who went on to be critical in solving the problems in years to come, such as William Thomson (later Lord Kelvin) had doubts about the ultimate feasibility of a cable stretched across the Atlantic.[51]

a. The Five Challenges

Multiple attempts were made to stretch a working telegraphic cable between New Foundland in Canada and Valentia Island in Ireland. The location, integrity and authenticity of where this achievement took place in Ireland has been detailed in a further paper[52] but the most significant point that is to be taken from the research is that the site where the original 1858 message was received continues to exist, albeit in a distressed state (the top two pictures, below, as it was and as it is) whereas the following site exists as a relic (bottom left), but the third, and final site built in 1868 (bottom right), is in very good condition.



[49] Morse, as noted in Cookson, G (2006) *The Cable* (Tempus, Gloucestershire) 11.
[50] See Homes, C (2009) 'The Astronomer Royal, the Hydrographer and the Time Ball: Collaborations in Time Signalling'. *The British Journal for the History of Science* 42 (3): 381-406.
[51] Lange, M (2009) 'Must the Fundamental Laws of Physics by Complete ?' Philosophical and Phenomenological Research 78 (2): 312-345; Thomson, W (1854) 'On the Theory of the Electric Telegraph'. Proceedings of the Royal Society of London 7: 382-399.
[52] See Gillespie, A (forthcoming) 'Authenticity and Integrity in World Heritage Sites: The Case of the Atlantic Cable and Valentia Island, Ireland'.

17.9 The remains of the original Atlantic cable relay station at Foilhommerum, Valentia Island.

The attempt in 1857 was a complete failure. The 1858 attempt worked, but only for a short period. This first telegraph exchange beneath the waters of the Atlantic took place but it took a painfully slow 16 hours to transmit. This telegraph expressed, in the words attributed to Queen Victoria, the bond of 'friendship founded upon common interest and reciprocal esteem' between Britain and the United States. The American President concurred, looking forward to what other examples of 'science, skill and indomitable energy of the two countries' would produce.[53] The words of the American President could not have been more correct, as there was great despair due to the short-lived nature of the 1858 cable, whilst the 1865 cable failed to reach its goal.[54] It was only with the success of the 1866 attempt that people would regain faith in the venture. Thereafter, progress in these conventional cables did not stop until the entire world was connected, with New Zealand, being the last to join the system two years after the turn of the 20th century.[55]

Although the global outreach was achieved within 40 years of crossing the Atlantic, the significance of that achievement should not be underestimated, for, as Samuel Morse correctly recognised, there were five substantive challenges that had to be overcome.

The first challenge that had to be dealt with was how to better insulate cables. Earlier submarine cables which had experimented with different types of insulation, such as hemp and tar, lasted only a short time in the water before they failed. This problem was bypassed by the discovery of gutta percha, which was heralded as the 19th century's wonder material. This

[53] The First Transatlantic Telegram, as noted in Oslin, G (1992) *The Story of Telecommunications* (Mercer UP, Georgia). 170.

[54] de Cogan, D (1985) 'Dr Whitehouse and the 1858 Trans-Atlantic Cable'. *History of Technology* 10: 1-15; de Cogan, D (2011) 'Numerical Analysis of Some Measurements on the First Trans-Atlantic Telegraph Cable'. *IET Scientific Measurements and Technology* 5 (4): 117-124.

[55] Beauchamap, K (2001) *History of Telegraphy* (Institute of Electrical Engineers, London). 174-180.

product created a natural type of insulating rubber. It came from Malaysia and made its way to both England and the United States in the mid 1840s. In 1847, the German scientist and industrialist, Ernst Werner von Siemens (below left),[56] developed a heat machine that eliminated leaky seams in insulation once gutta percha was applied. This was the first critical breakthrough that allowed a submarine cable to be laid across the Atlantic to be crossed a few years later.[57]

The second challenge was how to overcome the rudimentary knowledge of the ocean floor. Early submarine telegraph cables, such as that attempted between India and Egypt in 1858, failed because the Red Sea had not been adequately surveyed and there was not sufficient slack for the cable, which became necessary because of the unforeseen depths that needed to be crossed.[58] Such problems were only overcome when the scientific understanding of the ocean floor evolved rapidly, especially with the work of Matthew Fontaine Maury (above, right),[59] who was a Lieutenant in the American navy in the mid19th century. Here, science and technology combined to produce new understandings of something that had remained fundamentally unexplored until the 1850s. The new science not only managed to gauge the

56 This picture of Siemens is found at http://alchetron.com/Werner-von-Siemens-1139903-W

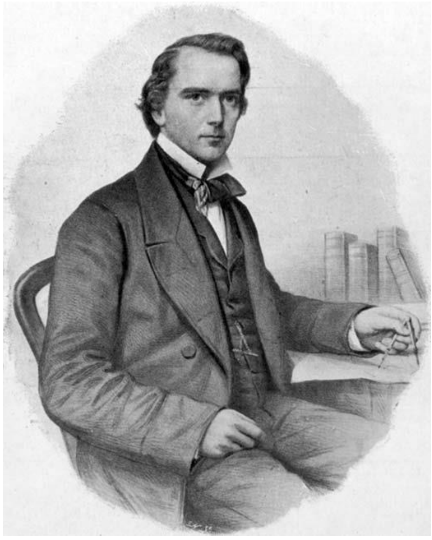
57 Tully, J (2011) *The Devil's Milk: A Social History of Rubber*. (Monthly Press, NYC). Chapter 2; Godfrey, H (2013) 'Pulled By Wire, Pushed by Desire: Submarine Telegraphy and the Gutta Percha Trade of the Nineteenth Century'. *Borneo Research Bulletin* 44: 150-177; Tully, J (2009) 'A Victorian Ecological Disaster: Imperialism, the Telegraph and Gutta Percha'. *Journal of World History* 20 (4): 12-27.

58 See Choudhury, H (2000) 'O'Shaughnessy and the Telegraph to India, 1835-1856'. *The Indian Economic and Social History Review* 37 (3): 42-81.

59 This picture of Fontaine Maury is by Ella Sophonisba Hergesheimer, done in 1923. It can be found at https://americangallery.wordpress.com/category/hergesheimer-ella-s/

depths of the ocean floor, but it also managed to show (wrongly as it turned out) that the route between Newfoundland and Ireland was a relatively stable plateau (between 1700 and 2,400 fathoms). Nonetheless, even at this depth, the cable was going to be laid at more than double that of previous submarine cables.[60]

The third challenge was the distance to be covered. Although the depth of the Atlantic was not insurmountable, the distance was. The distance of a planned 2,500 nautical miles (the final connection was just over 2,000 nautical miles) was completely unprecedented. Even at the most basic level, vessels did not exist that were large enough to carry the amount of cable required and lay it out from end to end. This meant that the first attempts at the Atlantic Cable involved a spliced cable that came from two different directions on two different ships. It was not until the 1865 and 1866 cables, which were laid with the largest vessel ever made at that point – *the Great Eastern* (itself, one of the wonders of the Industrial World, able to carry 2,500 miles of cable in its entirety, as well as room for 500 men) – that real success in laying out the cable was possible. This was due to both the steady nature of the vessel, the cable being laid end to end (without a splice), and greatly improved paying out machinery. The work of Charles Bright, (left),[61] who was knighted for his technical and electrical work, which contributed to the initial success of the cable, was very notable.[62]



[60] Priede, I (2013) 'Biogeography of the Oceans: A Review of Development of Knowledge of Currents, Fronts and Regional Boundaries from Sailing Ships in the Sixteenth Century to Satellite Remote Sensing'. *Pure and Applied Geophysics* 171 (6) 1013-1027; Lanzerotti, L (2010) 'Using the Guide of History'. *Space Weather* 8 (3): 1-9; Rozwadowski, H (2008) *Fathoming the Ocean: The Discovery and Exploration of the Deep Sea* (Oxford UP, Oxford). Chapter 2; Rozwadowski, H (2001) 'Technology and Ocean-Scape: Defining the Deep Sea in Mid Nineteenth Century'. *History and Technology* 17 (3): 217-247.

[61] The picture of Bright can be found at https://en.wikipedia.org/wiki/Charles_Tilston_Bright#/media/File:Charles_Tilston_Bright.jpg

[62] Hearn, C (2004) *Circuits in the Sea: The Men, the Ships and the Atlantic Cable*. (Praeger, NYC) 63-65.

The fourth challenge that had to be surmounted was that the science and its application needed to be improved. This was evident in a number of areas. First, the scientific understandings of currents and measurements had to evolve to a point that they were reliable.[63] Second, the cable design, both in terms of its core (and the movement to purity of copper) and the surrounding combination of insulation and weaved wire had to advance.[64] As this picture above shows, the progression between the cable of 1857 and 1866 was vast.

A further area that needed to be improved quickly was the ability to read the electric signals which were very weak after being projected over such long distances. In this regard, the work of the famous Irish physicist William Thomson (later Lord Kelvin,[65] who was knighted for his work in helping to successfully lay the 1865 and 1866 cables)[66] came to prominence. Kelvin replaced Wildman Whitehouse, who was blamed for the failures of the 1858 cable, which ceased to work after 732 messages.[67] As it was, the scientific work of Lord Kelvin on the cable is remarkable.

---

[63] Klassen, S (2007) 'The Application of Historical Narrative in Science Learning: The Atlantic Cable Story'. *Science and Eduction* 16: 335-352; Noakes, R (2014) 'Industrial Research at the Eastern Telegraph Company, 1872-1929'. *British Journal for the History of Science* 47 (1): 119-146. Hunt, B (1994) 'The Ohm is Where the Art Is: British Telegraph Engineers and the Development of Electrical Standards'. *Osiris* 9: 48-63; Jayson, J (2014) 'The Banill Cell, Ohm's Law and The Emergence of the International System of Units'. *American Journal of Physics* 82: 60-72.

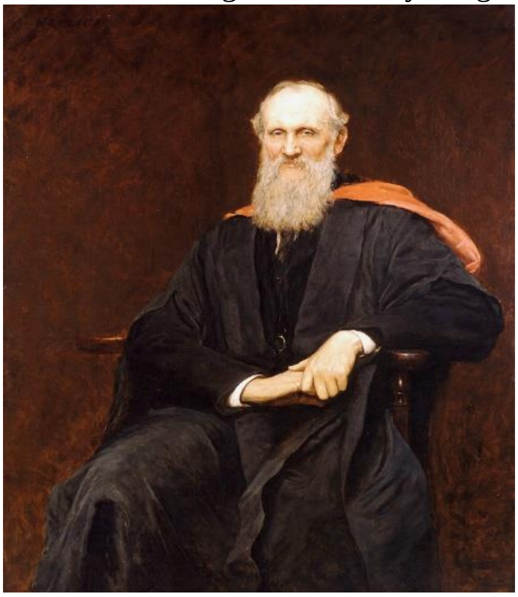
[64] Bright, C (1898) *Submarine Telegraphs: Their History, Construction and Working*. (1974 reprint, Arno Press, NYC). 52, 55, 80-85.

[65] The picture of William Thomson, Baron Kelvin, can be found at http://www.thefamouspeople.com/profiles/william-thomson-1st-baron-kelvin-6412.php

[66] See Erlichson, H (2006) 'Kelvin and the Trans-Atlantic Cable'. *The Physics Teacher* 44: 426-432; Flood, R (2008) *Kelvin, Life, Labours and Legacy*. (Oxford UP, Oxford). 48-65.

[67] Green, A (2012) 'Dr Wildman Whitehouse and His Iron Oscillograph: Electrical Measurements Relating to the First Transatlantic Cable'. *The International Journal for the History of Engineering and Technology*. 82 (1): 68-92; Hunt, B (1996) 'Scientists and Wilderman Whitehouse: Measurement and Credibility in Early Cable Telegraphy'. *The British Journal for the History of Science* 29 (2): 155-169.

His understandings of electricity, magnetism, light and thermodynamics helped the success of



the cable in a number of areas. From the batteries, to the laying of the cable (and his development of a self-regulating laying machine with its own brake), to his recognition that the properties of the copper cable and the insulator were critical. However, these efforts were surpassed by what was probably his most significant contribution, which was the mirror galvanometer (in itself, this invention was an improvement on existing scientific understandings and technology). This not only allowed very faint signals to be read with greater accuracy, it also permitted the signals to be transmitted faster.[68]

The fifth, and final, challenge was finance. As it was, the climate was right for raising large amounts of capital. The Industrial Revolution already had a very strong link with profit. There was a strong link between the legal systems which granted patents, the political systems that established monopolies and/or the markets from which entrepreneurs could find financial reward. This was especially the case with telegraphs, which had already proven their economic potential before the Atlantic was crossed.[69] However, crossing the Atlantic was something extra special, and entrepreneurs could see clear economic benefits, if it could be done.[70]

The man who solved the financial side of the equation was Cyrus Field.[71] Field saw submarine telegraphy as an art that was 'in its infancy' but it could be taken to 'the act of making the stride of a full grown giant'.[72] He realised that this giant could make him, and his partners,[73] incredible amounts of money. Bluntly, Chandler White, one of the original

---

68 Erlichson, H (2006) 'Kelvin and the Trans-Atlantic Cable'. *The Physics Teacher* 44(9): 426-435; Trainer, M (2004) 'The Patents of William Thomson: Lord Kelvin'. *World Patent Information* 26: 311-317; Anon (1910) 'The Work of Lord Kelvin in Telegraphy'. *NATURE* 1910. March 3. 23-28; Whipple, R (1934) 'The Evolution of the Galvanometer'. *Journal of Scientific Instruments* 11 (2): 2-35; Anon (1949) 'The Atlantic Cable and a Silver Thimble'. *NATURE* 1949. Dec 3. 616.

69 Muller, S (2015) 'The Telegraph and the Bank: On the Interdependence of Global Communications and Capitalism, 1866-1914'. *Journal of Global History* 10: 259-283.

70 Headrick, D (2001) 'Submarine Cables, Business and Politics'. *The Business History Review* 75 (3): 543-578; Boyce, R (2000) 'Imperial Dreams and National Realities: Britain, Canada and the Struggle for a Pacific Telegraph'. *The English Historical Review* 115 (460): 39-70; Britton, J (2004) 'Showdown in South America: United States and British Cable Competition'. *The Business History Review* 78 (1): 1-27.

71 Carter, S (1968) *Cyrus Field: A Man of Two Worlds* (Brown, NYC). McDonald, P (1937) *A Saga of the Seas: The Story of Cyrus Field and the Laying of the First Atlantic Cable.* (Gibb, NYC).

72 Field, as noted Cookson, G (2006) *The Cable* (Tempus, Gloucestershire) at 60.

73 See the Charter of the Atlantic Cable Company, as noted in Oslin, G (1992) *The Story of Telecommunications* (Mercer UP, Georgia). 167

investors in the transatlantic cable scheme, explained the attraction of the venture in the following terms, ‘in the light of a great commercial enterprise, directed to the realisation of profit, the acquisition of gain, the accumulation of wealth’.[74] Daniel Huntington’s painting *The Atlantic Cable Projectors* (below)[75] captured many of the men involved in this entrepreneurial activity, with Field as the most striking figure in the picture, in the long coat with red lining.

Uniquely for the Industrial Revolution, this pursuit of wealth had to be facilitated by the governments involved. The American Congress passed *A Bill to Expedite Telegraphic Communication for the Use of the Government in its Foreign Intercourse,*[76] whilst the British Parliament also directly assisted the project, providing vessels, men and money. This support from government paved the way for the creation of independent companies, in which entrepreneurs could invest.[77] With the support of governments and the financial markets in both the United States and England, over the space of ten years, millions of pounds were raised,

[74] White, as noted in Cookson, G (2006) *The Cable* (Tempus, Gloucestershire) at 31.
[75] See Kusserow, K (2010) ‘Technology and ideology in Daniel Huntington’s Atlantic Cable Projectors’. *American Art* 24 (1): 94-113.
[76] Hearn, C (2004) *Circuits in the Sea: The Men, the Ships and the Atlantic Cable*. (Praeger, NYC). 48-50; Russell, W (1865) *The Atlantic Telegraph* (Naval Institute, London).24-29.
[77] Shavar, S (2002) ‘British Companies and the Search for Government Guarantees with Telegraph Concessions’. *Middle Eastern Studies* 38 (4): 19-193; Nonnenmacher, T (2001) ‘Promotion and Regulation of the Telegraph Industry, 1845-1860’. *The Journal of Economic History* 61 (1): 19-36.

spent and lost, raised again, spent and lost, raised again and spent and lost, - all with great public outcries, and resultant official inquiries[78] - before full success was found in 1866.[79]

The perseverance of the speculators paid off. By the end of 1868, when the system was finally up and running at speed, it produced nearly 3,000 messages per day between the United States and Valentia Island, Ireland. In the same 24 hour period, the Anglo-American company was taking some 2,500 (USD) per day in profit. By this stage, the cost of each message was falling. Profits came from mass communication, rather than high price individual messages (as the first messages cost of 100 (USD) for ten words). By the turn of the 20th century, the north Atlantic connections were processing 10,000 messages per day, and reaping a profit of around 17 million pounds per year, making them amongst the most lucrative multinationals of the day.[80]

b. The Success

The celebrations of the success, albeit brief, of the 1858 cable were spectacular and unprecedented. Parades, fireworks and parties were part of the celebrations in the United States. Records of the celebration of the 'Atlantic Telegraph Jubilee', with a view of the procession up Broadway, NYC, are recorded in both photos, as below.[81] The US Congress awarded Cyrus Field a gold medal, and the newspapers called him Lord Cable. The feeling was well captured in the idea that the trans-Atlantic cable was the 'Eighth Wonder of the World'.[82]

[78] As a result of the successive failures of the 'Atlantic' Company and the 'Red Sea and India' Company (the joint losses which amounted to more than a million sterling) a government Inquiry was held in 1860. The Inquiry found that the fault was due to causes which might have been avoided had the conditions been sufficiently understood beforehand. The failure of the first cable in 1858 was attributed to many factors. The end result was that the science, technology and idea of submarine cables was sound, but greater care, knowledge and application was required.

[79] Shelangoskie, S (2016) 'Public Discourses and the Failure of the Atlantic Telegraph Cable'. *Nineteenth Century Contexts* 38 (3): 209-218.

[80] Richardson, A (2015) 'The Cost of a Telegram: Accounting and the Evolution of International Regulation of the Telegraph'. *Accounting History* 20 (4): 405-429; Ramirez, A (2015) 'A Wire Across the Ocean'. *American Scientist* 103 (3): 180-183; Winseck, D (2007) *Communication and Empire* (Duke UP, London) 24-25.

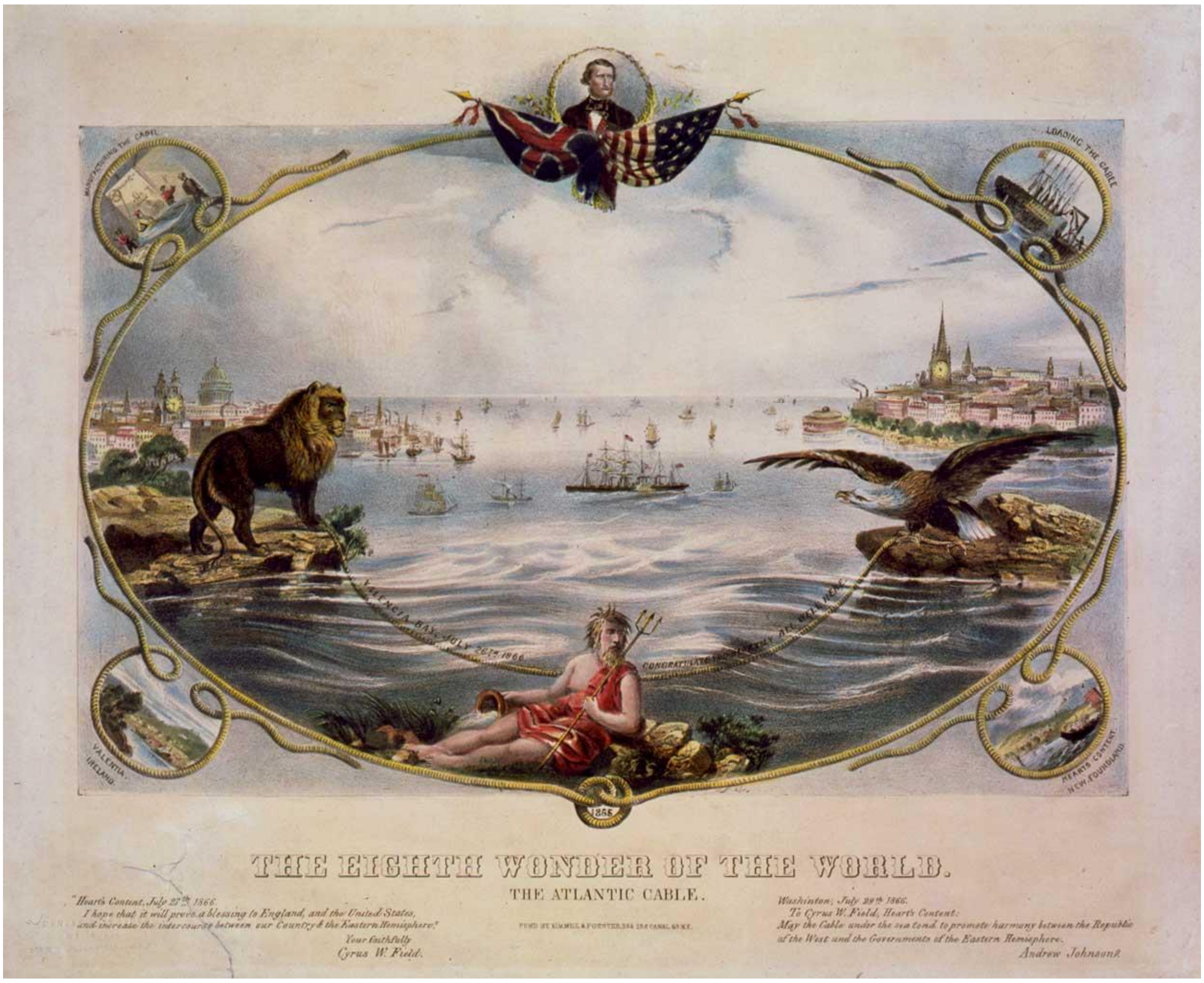
[81] This photograph is reproduced on the website of the Trans-Atlantic Cable. It was taken by William England, and sold by the London Stereoscopic Company, at the time.

[82] This image is from the Library of Congress, Prints and Photographs Division. The reproduction number is LC-USCZC4-2388. It also is on the website for the trans-Atlantic cable.

Broadsheets of the period also produced images of the celebrations.[83]

Celebrations were also held in Britain. There, Queen Victoria knighted four of the cable engineers.

[83] These images, also from the website of the Trans-Atlantic Cable, come originally from the *Manual of the Corporation of the City of New York*. (NYC, Valentine Publishers, 1861).

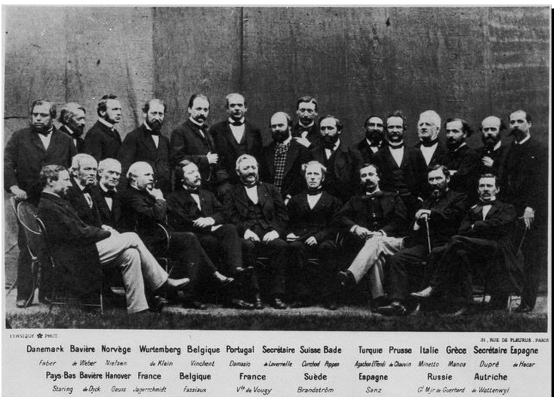


c. The Impact of the Transatlantic Cable: Globalisation

The trans-Atlantic cable, as opposed to national or regional cables, changed the world by making communication truly global as the United States and Europe could now directly communicate. The world was now directly en-route to being fully interconnected by instantaneous communication. The same benefits noted previously for national telegraphs were now multiplied with transnational communications for the media,[84] the military,[85] and the business community.[86] The most novel benefits were in the diplomatic world, because whilst national telegraphs had made little difference to this world, international ones did.[87]

[84] Winseck, D (2008) 'Communication and Empire: Media Markets, Power and Globalisation, 1860-1910'. *Global Media and Communication* 4 (1): 7-36; Pike, R (2004) 'The Politics of Global Media Reform'. *Media, Culture and Society* 26 (5): 643-675; Rantanen, T (1997) 'The Globalisation of Electronic News in the 19th Century'. *Media, Culture and Society* 19 (4): 605.
[85] Beauchamap, K (2001) *History of Telegraphy* (Institute of Electrical Engineers, London) 102-132.
[86] Engel, A (2015) 'Buying Time: Futures Trading and Telegraph in Nineteenth Century Global Commodity Markets'. *Journal of Global History* 10 (2): 284-306; Lew, B (2006) 'The Telegraph, Co-ordination of Tramp Shipping and Growth in World Trade, 1870-1910'. *European Review of Economic History* 10: 147-173; Hoag, C (2006) 'The Atlantic Telegraph Cable and Capital Market Information Flows'. *The Journal of Economic History* 66 (2): 342-353; Manning, D (1996) 'The Ideology of Technology and the Birth of the Global Economy'. *Technology in Society* 18 (1): 71-77.
[87] Shulman, P (2015) 'Ben Franklin's Ghost: World Peace, American Slavery and the Global Politics of Information Before the Universal Postal Union'. *Journal of Global History* 10 (2): 212-234; Lampe, M (2014) 'Spanning the Globe: The Rise of

The best proof of this new and novel globalisation was the creation of the first international organisation in international law. That is, although bilateral cooperation had begun in 1849 when Prussia and Austria agreed to create a shared telegraph system, the need for true international cooperation in this area became pressing when it became apparent the technical, scientific and political considerations that had to be reconciled were international, not local or regional. Accordingly, the French Emperor, Louis Napoleon III called for an international gathering (below left), which ended up creating the first international organisation, the International Telegraph Union (below right) in 1865.[88]



The striking fact the first international organisation is not that it predated a similar international convention and organisation on postal services by nearly ten years, but rather that technology was the basis for the cooperation, and not the relative power or status of any given member. To suggest that this type of internationalism was a revolutionary development in international law is an understatement. It was a new world that the cable had enabled.[89]

d. The Local Impact: The Working Community

Telegraph workers were often hidden behind the ‘scientific heroes’ and ‘captains of enterprise’ who brought national, regional and international cable communication to fruition. They are also an exemplar of a profession that changed quickly (it became very feminised in

Global Communication Systems and the First Globalisation’. *Australian Economic History Review* 54 (3): 242; Paull, D (2003) *Under the Wire: How the Telegraph Changed Diplomacy* (Harvard UP, Cambridge MA); McMahon, P (2002) ‘Early Electrical Communications Technology and Structural Change in the International Political Economy: The Case of Telegraphy’. *Prometheus* 20 (4): 379-390; Solymar, L (2000) ‘The Effects of the Telegraph on Law and Order, War, Diplomacy and Power Politics’. *Interdisciplinary Science Review* 25 (3): 100-125; Headrick, D (1991) *The Invisible Weapon: Telecommunications and International Politics, 1851-1945*. (Oxford UP, Oxford); Knuesel, A (2007) ‘British Diplomacy and the Telegraph in Nineteenth Century China’. *Diplomacy and Statecraft* 18 (3): 517-537; Nickles, D (1999) ‘Telegraph Diplomats: The United States’ Relations With France in 1848 and 1870’. *Technology and Culture* 40 (1): 1-25.

[88] See Rutkowski, A (2011) ‘Public International Law of International Telecommunication Instruments: Treaty Provisions Since 1850’. *The Journal of Policy, Regulation and Strategy for Telecommunications, Information and Media* 13 (1): 13-31.

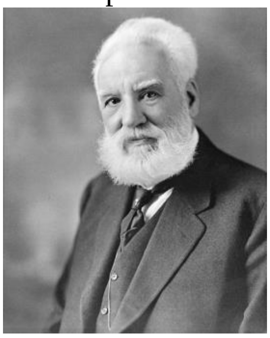
[89] Douglas, H (2015) ‘An Alternative Mode of International Order: The International Administrative Union in the Nineteenth Century’. *Review of International Studies* 41 (1): 161-183.

the 20th century). It was subject to regulatory control (for fear that telegraph workers could exert too much control over communications), and it had a strong sense of identity. Telegraph workers tended to be more educated that other workers and have been considered by many to have been 'the very first mass of white collar employees'.[90]

Those located in remote connection points, such as Valentia Island in Ireland, often found themselves as educated elites. As the Atlantic Telegraph was beginning, the initial conditions for the telegraph workers on land were rudimentary. According to records of the time, 'the telegraphic staff and operators were lodged in primitive apartments… and did not possess any large personal facility for enjoying social intercourse with the outside world, although so much intelligence passed through their fingers'.[91] Recognising the importance of their workers to the success of their industry, the companies went to great lengths to support them and make them happy in their remote locations. They were, according to some, the equivalent of 'internet companies' of the 19th century. For example, in Valentia, facilities were built to ensure that good housing and social amenities, from libraries, to sporting facilities, were made available for both the workers and their families. [92]

7. The Telephone

The telephone was the next major advance in communication. This device, whereby the human



voice could be transmitted electronically across distances via wires, was also invention that was a combination, and culmination, of many

[90] Downey, G (2001) 'Virtual Webs, Physical Technologies and Hidden Workers: The Spaces of Labour in Information Networks'. *Technology and Culture* 42 (2): 209-235; Gabler, E (1988) *The American Telegrapher* (New Brunswick, Rutgers UP). 57; Joseph, P (1948) 'The International Federation of Christian and Telegraph Workers' Unions'. *International Labour Review* 57 (1): 95-105; Chodhury, D (2003) 'The First Virtual Community and the Telegraph Strike of 1908'. *International Review of Social History* 48 (11): 45-57; Lubrano, A (1997) *The Telegraph: How Technology Innovation Caused Social Change*. (Garland, NYC). 131-137; Parfitt, S (2014) 'Whither Industrial Democracy: The Federal Government and Organised Labour in the Telegraph Industry During the First World War'. *Journal of American Studies* 48 (2): 517-539; Kingsford, P (1968) *Electrical Engineers and Workers* (Edward Arnold, London). 114-120. Anon (1878) 'The Society of Telegraph Engineers'. *NATURE* XVII (432): 277; Winseck, D (2007) *Communication and Empire* (Duke UP, London). 17.

[91] Russell, W (1865) *The Atlantic Telegraph* (Naval Institute, London). 45.

[92] Ramirez, A (2015) 'A Wire Across the Ocean'. *American Scientist* 103 (3): 180-183; Anon (1885). 'The Cable Station at Valentia'. *The Telegraphist*, No. 25. Dec 1.7-9; Graves, J. (1900) *Thirty Six years in the Telegraphic Service 1852 to 1888: Being a brief Autobiography Of James Graves MSTE*. Transcribed by Dominic de Cogan, and edited by Donard de Cogan. This is available from: http://dandadec.files.wordpress.com/2013/07/technical-autobiography.pdf.

overlapping ideas. [93] Using electromagnetic transducers to convert acoustic energy to electrical energy was patented by Alexander Graham Bell (left) in 1876.[94]

This technology, quickly adopted throughout the United States, Europe and Britain, went into direct competition with the telegraph, making radical changes to the speed of communication. It bypassed the technology and gatekeepers of telegraphy, with its direct and one-to-one instant verbal contact over distance. Like the telegraph, it too had direct impacts upon government, military,[95] business[96] and individual consumers who were able to utilise the new device.[97] Although most of the key sites where this industry was developed have disappeared, a few of the early exchanges, in which this technology became commercialised, still exist. Others, such as the first commercial exchange anywhere in the world, stood in Connecticut from 1878 (below left)[98] before it was demolished in 1973.[99]

93 Gorman, M (1997) 'Mind in the World: Cognition and Practice in the Invention of the Telephone'. *Social Studies of Science* 27 (4) 583-624; Gorman, M (1990) 'Interpreting Invention as a Cognitive Process: The Case of Alexander Graham Bell, Thomas Edison and the Telephone'. *Technology and Culture* 15 (2): 131-164.
94 Beauchamp, C (2010) 'Who Invested the Telephone ? Lawyers, Patents and the Judgements of History'. *Technology and Culture* 51 (4): 855-873; Howe, G (1947) 'Alexander Graham Bell and the Invention of the Telephone'. *NATURE* 4040, Apr 5 455-479; Oslin, G (1992) *The Story of Telecommunications* (Mercer UP, Georgia). 213-234.
95 Janson, M (2013) 'The Wires Go to War: The US Experiment with Government Ownership of the Telephone System During World War I'. *Texas Law Review* 91 (5): 983-1050.
96 Milne, G (2007) 'British Business and the Telephone, 1878-1911'. *Business History* 49 (2): 163-185.
97 Menke, R (2013) 'The Medium is the Media: Fiction of the Telephone in the 1890s'. *Victorian Studies* 55 (2): 212-221; Vanderbilt, T. (2012) 'The Call of the Future'. *Wilson Quarterly* 36 (2): 132-154.
98 This picture was sourced from http://connecticuthistory.org/the-first-commercial-telephone-exchange-today-in-history/
99 The source for this picture was https://www.nps.gov/nhl/find/withdrawn/telephone.htm

8. The Wireless

The Wireless, or Radio, was the last major communications technology to evolve before the

First World War. The invention of wireless will forever be associated with the Italian scientist, Gugliemlo Marconi (left).[100] Although he built on the the ground-breaking work on electromagnetic radiation by pioneers, such as James Maxwell[101] and Heinrich Hertz,[102] Marconi went one step further in recognising that (Hertzian) radio waves could be used for communications, and developed a functional transmitter and receiver.[103] Failing to get interest from the Italian government after transmitting a signal over the distance of one mile in 1895 in his home region of Bologna, Marconi went to Britain. There, he demonstrated the practicality, and genius, of his invention via a wireless communication from the Isle of Wight to a tugboat, 18 miles away, in early 1896.[104]

Marconi was granted a patent in the middle of the 1897 and given strong support, by both the military[105] and the financial sector, to make this technology work.[106] During 1898, Lloyds of London set up a radio installation to operate between Ballycastle (County Antrim) and Rathlin Island in the north of Ireland. The tests were so successful that Lloyds decided to equip all their signal stations with radio equipment and thus the radio station at Malin Head came into being. By 1899, Marconi was communicating over the English channel. Two years later, in 1901, after developing further stations in Ireland (at Rosslare and Crookhaven) and England (especially Poldhu in Cornwall), Marconi was able to transmit from one side of the Atlantic to the other (to Cape Cod, Massachusetts). By 1907, this was a working system.[107]

[100] This picture is sourced from https://en.wikipedia.org/wiki/Guglielmo_Marconi
[101] Hong, S (1994) 'Marconi and the Maxwellians: The Origins of Wireless Telegraphy'. *Technology and Culture* 35 (4): 717-749.
[102] Ramsay, P (2013) 'Heinrich Hertz: The Father of Frequency'. *The Neurodiagnostic Journal* 53 (1): 3-26.
[103] Gardiol, F (2011) 'About the Beginnings of Wireless'. *International Journal of Microwave and Wireless Technologies* 3 (4): 391-398; Luna, L (1999) 'Marconi's Vision Births Wireless Communications'. *Radio Communications* 18 (52): 10-18;
[104] Marconi, D (1962) *My Father, Marconi*. (Brown, London). 49-52; Seymour, T (2011) 'The History of Wireless Communication'. *The Review of Business Information Systems* 15 (2): 37-42; Oslin, G (1992) *The Story of Telecommunications* (Mercer UP, Georgia). 273-295.
[105] Hall, B (2012) 'The British Army and Wireless Communication, 1896-1918'. War in History 19 (3): 290-321.
[106] Guagnini, A (2009) 'James Fletcher Moulton and Guglielmo Marconi: Bridging Science, Law and Industry'. Notes and Records of the Royal Society of London 63 (4): 355-363.
[107] In his own words, see Marconi, G (2002) 'Wireless Telegraph Communication'. *Resonance* Jan: 95101; Hong, S (2005) 'Marconi's Error: The First Transatlantic Wireless Telegraph in 1901'. *Social Research* 72 (1): 107-124; Luna, L (1999) 'Marconi's Vision Births Wireless Communication'. RCR Technology 18 (52): 10-15; For the man, see Sherow, V (2004) *Guglielmo Marconi: Inventor of Radio and Wireless Communications* (Enslow, NJ).

From this point on, wireless technology spread quickly.[108] In 1909, the year that Macroni was awarded the Nobel prize for Physics, the British government obtained control of all of his stations, which were then centralised,[109] Thus, in Ireland, in 1914, the station at Crookhaven was closed, and its service transferred to Valentia Island. Across the Atlantic, via lawsuit and merger, Marconi acquired over 70 land stations and more than 500 ship-board installations.[110]

Although only landscapes or relics exist from the initial stations and towers that Maconi built,[111] the second generation ones, such as that from 1914 on Valentia Island in Ireland (left), which was used for trans-Atlantic communication, continue to exist. Indeed, the Valentia Island station operated until 1999. Others, such as those in Hawaii,[112] although in ruins, have significant potential as heritage sites. So too, do the well restored sites such as the Art Deco, Point Reyes, Marconi station.[113]

[108] Steinbock, D (2003) 'Globalisation of Wireless Value System: From Geographic to Strategic Advantages'. *Telecommunications Policy*. 27 (4): 207-235.
[109] Satia, P (2010) 'War, Wireless and Empire: Marconi and the British Welfare State, 1896-1903'. *Technology and Culture* 51 (4): 1-17.
[110] Kruse, E (2002) 'From Free Privilege to Regulation: Wireless Firms and the Competition for Spectrum Rights Before World War I'. *The Business History Review* 76 (4): 659-703.
[111] See Bradford, H (1998) 'Marconi's Three Transatlantic Radio Stations in Cape Breton'. *Journal of Royal Nova Scotia Historical Society* 1: 15.
[112] This picture is sourced from http://www.honolulumagazine.com/Honolulu-Magazine/November-2012/Hawaiis-Most-Endangered-Historic-Sites/index.php?cparticle=4
[113] This picture is found at https://www.nps.gov/pore/learn/historyculture/people_communications.htm

The one site on the World Heritage List, that is related to telecommunications dates from this period. This site is the Varberg Radio Station in Sweden (below),[114] which was built between 1922 and 1924. This well preserved monument to wireless trans-Atlantic communication retains both its original equipment and aerial, and as a post First World War site of communications technology, as used for trans-Atlantic communications, is considered to be of outstanding universal value.[115]

9. Conclusion

Improved of methods of communication have been a never-ending quest for humanity. Despite a history going back thousands of years, the most radical advances occurred with the Industrial Revolution, and the discovery, and utilisation, of electricity. The telegraph, followed soon after. This technology made accurate communication over land almost instant. The national and regional impacts were monumental, at the economic, social and military levels. In addition, at the local level, a new type of worker was created, the life of which was very different to many other workers in the Industrial Revolution. Despite this importance, telegraph heritage remains invisible as World Heritage.

The next step, where the telegraph was taken under the ocean and thus made global, required fundamental advancements in science, technology and capital. When these were achieved, and the Trans-Atlantic cable was a running success, the world truly changed as the national and

[114] This picture is sourced from https://en.wikipedia.org/wiki/Varberg_Radio_Station#/media/File:Varberg_Radio_Station.jpg

[115] UNESCO (2004) Twenty-Eighth Session of the World Heritage Committee. WHC-04/28. COM/INF.26. Paris, March 13. Paragraphs 792-820. The inscription is Decision 28 COM 14B.48.

regional benefits of the telegraph were now made global and, as such, globalisation (as in, near instant, international communication) began. The best proof of the change was not in the unprecedented celebrations of the societies in which such advances occurred. Rather, it was in the creation of the world's first international organisation, the International Telegraph Union (which is still going strong in the 21st century), to manage the new technology. The sites involved in these monumental changes of great benefit to humanity are also invisible as World Heritage.

The ensuing two communications technologies which also had profound impacts before the First World War were the telephone and the wireless. Of the telephone, all of the benefits of the telegraph were now projected into a much more personal realm. Again, the early heritage sites related to the development of the telephone and its operation, are omitted from considerations as heritage of global importance. Of the wireless, the one site on the World Heritage List that does recognise telecommunications, the Varberg radion station in Sweden, although clearly important, was built later than a number of comparable sites that achieved the same, or greater, breakthroughs.