



The Beginnings of Radio Communication in Germany, 1897-1918

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This article surveys the prehistory of broadcasting in the German Reich. It focuses on wireless telegraphy, where the Telefunken Company succeeded internationally with its quenched spark system on the eve of the war. Telefunken's system was developed as an efficient military technology between 1905 and 1908, and it soon became the core of Telefunken's successful attempt to break Marconi's monopoly in maritime radio communication. Encouraged by this success, Telefunken started to establish wireless transoceanic connections to build a global German radio network. The properties of radio broadcasting as a possible new mass medium only gradually became evident before 1918.

There is hardly a technology that shaped the face of the 20th century more than the electrical communications technology and the mass media. Radio and television, telephone and fax machines are a part of the everyday life of billions of people. But before the radio age began around 1920, wireless communications technology was already 25 years old. In Germany—as in other countries—this time was a phase of a multitude of competing systems for wireless telegraphy. No less than four different technologies were widely used: spark transmitters, arc transmitters, high frequency alternators, and finally vacuum-tube transmitters. This diversity of technologies resulted from an intensive search for ways to generate electromagnetic waves. However, during the first years, radio communication stood in direct competition to submarine cables, a technology that had by 1900 been brought to a high degree of technical efficiency. Therefore wireless telegraphy was mainly used where the gaps in the existing communications technology were large enough to give the new mode a chance to establish itself. It took more than

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20 years before the ability to transmit messages simultaneously to multiple locations became the basis of a completely new and unrivaled application field—broadcasting.

DISCOVERY OF ELECTROMAGNETIC WAVES & MARCONI'S FIRST WIRELESS TELEGRAPH SYSTEM

In 1887 and 1888, Heinrich Hertz (1857–1894) conducted a series of experiments in Germany that convincingly demonstrated the existence of the electromagnetic waves predicted in 1864 by James Clerk Maxwell. He used a laboratory arrangement that could be used for the generation, propagation, and detection of electromagnetic waves. In Britain, independently of but concurrently with Hertz, Oliver Lodge (1851–1940) also experimentally verified the existence of electromagnetic waves. Although Hertz and Lodge clearly had all the necessary elements of an elementary wireless telegraphy system, there is no indication that the sending of any "messages" was accomplished or even attempted with these—or any other—early apparatuses (Aitken, 1976).

As a student of physics at the University of Bologna, Guglielmo Marconi (1874–1937) had seen Augusto Righi's experiments with "Hertzian waves" in 1894. Marconi immediately started his own experiments with electromagnetic waves that led to his first patents. In some experiments, Marconi connected one of the poles with the earth and the other with a vertically hanging wire and thus reached a transmission range up to 1.5 miles. When Marconi moved to England in 1896, he brought a system with him that contained well-known components that he had changed and improved. As transmitter, he used the Righi oscillator with an enlarged spark gap to obtain a larger range. As a receiver and detector for incoming waves, he used the coherer, a device that had been invented by the French physicist Edouard Branly (1844–1940) and improved by Oliver Lodge. A grounded vertical antenna that was originally invented by the Russian physicist Alexander Popov (1859–1905) and a Morse writer for recording the received characters completed Marconi's first system. With this arrangement, he now achieved a range of approximately 10 miles (Aitken, 1976). Marconi's apparatus was innovative in as much as he wanted to use it explicitly for wireless telegraphy—that is, for transmitting coded characters over larger distances.

When seeking an appropriate partner to support his work, he finally contacted William H. Preece, the Engineer-in-Chief of the British Post Office. Recognizing the economic potential of the invention, Preece allowed Marconi to continue his work, using the resources of the British telegraph laboratories (Aitken, 1976). After the formation of his own company in July 1897, Marconi was able to exploit his invention commercially. Thus the business of wireless telegraphy was operated by a private enterprise, while the existing electrical communication technologies were under government control in Great Britain after 1870. As early as November 1899, Marconi established an American branch and thereby documented his global goals (Douglas, 1987).

[Figure 1]

Marconi's merit was the systematic unification of existing components and the

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application of well-known physical phenomena for the wireless transmission of messages. He also created suitable techniques for the area of sea shipping, which expanded the conventional electrical communication network by connections among ships on sea and between ships and coastal stations. Before the introduction of wireless telegraphy, a ship was almost excluded from communication as soon as it had left the port. In maritime radio, wireless telegraphy had no technical competition. Marconi took advantage of this market gap in 1900 when he established the "Marconi International Marine Communication Company" that remained without serious competition until about 1908. At first the enterprise sold individual apparatuses to the coastal service and to hull insurers. But because the operation of the equipment required well-trained personnel, Marconi was not very successful with this business model.

Commercial success began when the Marconi Company decided to rent their equipment (including trained operators) to shipping companies and to practice a nonintercommunication policy. All Marconi operators had strict instructions not to communicate with the wireless operators of any other company except in case of emergency. Together with the company's head start in business, this policy clearly led to monopoly. A shipping company wanting to equip their ships with wireless sets hardly had a choice. To remedy the situation, the German government invited the interested nations to the first International Radiotelegraph Conference in 1903. All the participants, with the exception of Italy and Britain, voted in favor of intercommunication. Britain chose to ignore the resolution. Three years later at the second International Radiotelegraph Conference, held again in Germany, 21 countries were in favor of marine intercommunication, while six, Britain among them, were against it. Thus the field of wireless communication remained internationally unregulated and Marconi continued to dominate the field with his relatively simple system for some more years (Friedewald, 1999).

TECHNOLOGY TRANSFER TO GERMANY: NATIONAL AND INTERNATIONAL COMPETITION

Early in 1897, German daily papers reported that the Italian Marconi had invented a system that allowed the transmittal of messages without wires. As a consequence, at least three groups of scientists and engineers in Germany started working on the scientific and technical advancement of wireless telegraphy, but with different approaches and goals:

- Adolf Slaby (1849–1913), professor of mechanical and electrical engineering at the Technical College Charlottenburg (today Technical University Berlin) with his assistants Georg von Arco (1869–1940) and Martin Tietz (b. 1866).
- Ferdinand Braun (1850–1918), professor of experimental physics at the University of Strasbourg with his assistants Mathias Cantor (1861–1916) and Jonathan Zenneck (1871–1959).
- In summer 1897 the physicist Adolf Koepsel (1856–1933) and the engineer Carl Rode started the research and development activities of Siemens & Halske, the largest

manufacturer of communication technologies in Germany, and developed their own wireless telegraph system—most likely at the instigation of the military (Allgemeine Elektrizitäts-Gesellschaft, 1956; Hars, 1999; Siemens, 1953).

Adolf Slaby, who was a famous specialist and advisor to the military and political leaders, had experimented with Hertzian waves before he was invited by the British Post Office to visit one of Marconi's test series in the spring of 1897. After that he became instrumental in the transfer of the new technology to Germany. In Berlin, he reported about his experiences and was the first who copied Marconi's apparatuses in Germany.

With generous support from Emperor Wilhelm II, and with the practical assistance of naval units, Slaby and his assistant Arco started further experiments in the summer of 1897. As soon as it was evident that they could supply useful arrangements, they got the order to develop wireless equipment and circumvent Marconi's patents that were not granted in Germany at that time. In the course of the years 1898/1899, Slaby and Arco filed five patents, which protected their whole telegraphing system, mainly in separation from Marconi. It was developed in cooperation with "Allgemeine Elektrizitäts-Gesellschaft" (A.E.G.) and with substantial support from the German navy (Slaby, 1898).

As in many other countries, there had been attempts in Germany to communicate wirelessly with means other than electromagnetic waves. In Strasbourg, Ferdinand Braun began to experiment with wireless telegraphy only a few months after Slaby. As a consultant for three citizens of Strasbourg, he was in charge of a scientific explanation for the so-called "hydro telegraphy" that finally led him to experiments with radio waves. In the spring of 1898, Braun filed his patent for a "telegraphingsystem without sequential line" but was also engaged with electromagnetic oscillations. Potential users of wireless telegraphy measured its success almost exclusively by the obtained transmission range. Braun like Marconi was faced with this demand, which he sought to fulfill by using longer wavelengths and by increasing the transmitting power. With the simple Marconi transmitter, this objective was realized by increasing the spark voltage and/or enlargement of the antenna. Braun solved the problem of the limited antenna capacity by coupling it inductively to a second closed resonance circuit (Braun, 1898). He was aware of and refined some of the tuning or "syntony" principles that Oliver Lodge had demonstrated as early as 1889 and patented in 1897. Braun's assistants, Cantor and Zenneck, successfully tested the new "tuned spark transmitter" circuitry for the first time in the summer of 1899. For the commercial exploitation of Braun's patents, the backers of Braun's project—a banker from Giessen and the chocolate manufacturer Ludwig Stollwerck from Cologne—established the "Gesellschaft für drahtlose Telegraphie Professor Braun," and tried to get into contact with shipping and hull insurance companies. Financial difficulties and Braun's desire to escape from commercial pressure and concentrate on his scientific research again, led to a majority holding of the "Siemens & Halske AG" in 1901 (Hars, 1999).

INTERNATIONAL TECHNOLOGY—NATIONAL INDUSTRIES

The knowledge about wireless data transmission and the ability to build a working

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telegraphing system arose in several countries at the same time. In addition to Marconi and the German groups, researchers and scientists in all industrialized countries were active in this field, although with different objectives. The application of the new communication technology almost immediately required an international perspective and international agreements. In the German Reich, political and military interests led to most of the technical development being made under the control of the two leading manufacturers of electrical machinery—A.E.G. and "Siemens & Halske AG."

Direct negotiations between Marconi, the German government and A.E.G. or Siemens & Halske about purchasing or licensing patents had already failed in 1897. Soon it became clear that the army and naval administration wanted a uniform wireless telegraphy system that was developed and manufactured independently by German firms. Therefore they supplied suitable research and test conditions—for example, in the form of warships, aircraft, and logistic assistance and guaranteed a substantial sale. To reach these externally set goals, the two big electrical firms made a cooperation contract and addressed the technically challenging problem together. The strong export orientation of the two German firms intensified this cooperation. It was expected to be able to meet the foreign competition better and to get assistance from politicians, from the legislature, and from the banks (Chandler, 1990).

The fear of a worldwide monopoly of the Marconi Company that was equated with a monopoly of Great Britain, existed not only in the German Reich, but also in other European great powers. This argument was used both by industry and by government and accelerated the formation of the "Gesellschaft für drahtlose Telegraphie GmbH (Telefunken)" in 1903 after Emperor Wilhelm II had intervened in the managerial policy of the two competing companies. Slaby's former assistant Georg von Arco became technical director of the new firm. The formation of Telefunken was an early example of national cooperative management on the European market and of a syndicate of otherwise competing enterprises. According to the arrangement between A.E.G. and Siemens & Halske, Telefunken should concentrate on the solution of technical problems and the "professional invention" of components for wireless telegraphy. Furthermore, Telefunken supplied the devices that were manufactured by the parent companies and specialized in the delivery and installation of complete stations. Here the enterprise developed extraordinary organizational abilities, with the effect that by 1914 Telefunken was represented in 39 countries worldwide (Beckmann, 1925).

WIRELESS TECHNOLOGY FOR MILITARY PURPOSES

In the first instance, Marconi used a simple spark transmitter that was strongly damped and lacked any sort of effective tuning, with the effect that everyone who possessed an appropriate device could receive the transmitted characters in a very broad frequency spectrum. Therefore wireless messages were difficult to keep secret. However, secrecy was the most important requirement of both the military users and the national telegraph administration. Besides secrecy they also needed increased range, freedom from interference, mobility, fast establishment of connections, and a written document of the received message. Finally, the possibility of "tuning" was required because smallband

radio made unauthorized reception of messages more difficult (Cochrane, 1913; "Nauticus," 1906; Ristow, 1926; Schmiedecke, 1911).¹

During the first 3 years after its formation Telefunken operated in close cooperation with the military authorities and tried to unify the types of transmitters and receivers that had been developed by the different German research groups. The use of the tuned spark transmitter (Braun transmitter) and improved receivers resulted in an increase of the efficiency. Although it was still possible for trespassers to "read" radiograms sent by a tuned transmitter, this was a more difficult task without the exact knowledge of the used frequency. Finally the military accepted frequent frequency changes combined with encoding and declared that wireless telegraphy met essentially the requirements for a communication medium. Until 1908, military stations constituted more than 70% of Telefunken's sales (Nesper, 1905).

TELEFUNKEN'S QUENCHED SPARK SYSTEM

When Marconi presented his first wireless telegraphing system critics were already of the opinion that it was necessary to generate undamped, continuous oscillations without using an inductor or spark gap (Aitken, 1985). In 1903, the Danish engineer Valdemar Poulsen (1869–1942) presented a practically useful method to generate such oscillations by using a special arc light. This instrument generated continuous streams of waves and embodied principles discovered by Elihu Thomson in 1892 and by William Duddell around 1900 for the generation of slower alternating currents (Poulsen, 1906). Poulsen's arc transmitter offered advantages regarding the tuning of the transmitter and receiver and thus was suitable for wireless telephony—that is, for transmitting language and music. At this time of history, however, this feature that is the basis for radio broadcasting as a mass medium was of no importance for the army and the navy. Their interest concentrated on the possibility of transmitting encoded messages; hitherto this feature had been offered only by wireless telegraphy (Jentsch, 1909).

Telefunken was interested in the Poulsen patents, but the negotiations for a license broke down. Between 1906 and 1908, Telefunken engineers tested a self-developed variant of the arc sender, but rejected it as an inferior technology for telegraphy. Between 1906 and 1908, however, Telefunken conducted successful experiments to transmit speech using their arc transmitter and reached ranges between 25 and 45 miles (von Arco, 1908). The Poulsen patents for Germany and a part of the European market were finally acquired by C. Lorenz AG, a company from Berlin that was established in 1880 and had strong connections to governmental customers. Between 1906 and 1909 both the German army and navy ordered a large number of arc stations from Lorenz. Until 1911, C. Lorenz AG installed their system on ships as well as in stationary and mobile land stations, mainly for the army. These arc stations, however, were used for wireless telegraphy, because in 1911 the military establishment still regarded wireless telephony as useless in a war (Thurn, 1911b). Due to the strong competition and the disinterest of the customer, Georg von Arco stopped even their successful experiments with wireless speech transmission by stating that "Telefunken had more important things to do than playing with such telephone gadgetry" (cited in

Nairz, 1928, p. 279).

The competition of the technical systems was quite welcome for the military and postal authorities and was not only an economic challenge for Telefunken. The financially critical situation after 1906 and tension with the military customers set Telefunken's management under pressure to develop a better technical solution, that would extend the market for wireless telegraphy systems (Schlee, c. 1925). As a result, Telefunken developed its "quenched spark system" that was introduced in 1909 and successfully marketed in the following years.

[Figure 2]

In 1906, Max Wien (1866–1938), professor of physics at the University of Danzig discovered, in the course of some research on electrical discharges between metal electrodes in close proximity, that the oscillations in a closed circuit could be quenched rapidly by a suitable gap to allow an open-antenna circuit coupled there to vibrate freely in its own period (Wien, 1906). This effect became the starting point for the construction of Telefunken's quenched spark system. The spark gap of this system (figure 3) consisted of a series of flat, silver-plated copper discs (a); the outside of each disc was turned down to form a cooling flange (e), and a groove was cut right round the disc on each side. These discs were placed against one another, and separated by mica rings (b), which projected halfway around the groove. Two discs (i.e., one spark gap) were required for about every 600 volts when mica rings of 0.1 mm in thickness were employed (Blake, 1928; D.R.P. 198544, 1907; D.R.P. 237729, 1908). This sophisticated arrangement avoided the loss of energy and doubled the efficiency of the transmitter. In the headset of the receiver, one could hear a clear tone of a unique frequency instead of the cracking noises that could be heard with the simple spark transmitter—for this reason it was also called the "singing spark transmitter" (Tonfunkensender). The tone was clearly discernible from the noise and crackles of atmospheric disturbances. These features brought another gain in reliability and freedom from interference. With the new quenched spark system, even the military users abandoned the Morse writer and turned to audio reception. Using a crystal detector and a receiver headphone, it was possible to detect even the weakest signals, whereby the transmission speed increased (von Arco, 1909; Friedewald, 1999). The new system also met most of the requirements of the army and the navy. Having the same electrical performance quenched spark transmitters obtained a range that was three times that of arc or simple spark transmitters. At the end of 1909, the admiralty decided to equip all 90 German warships with quenched spark stations by Telefunken. Additionally, numerous naval administrations from foreign countries ordered quenched spark stations. Apart from the powerful naval stations, Telefunken's production program contained models with a middle range, simple design and small dimensions for the army, which ordered a total of 35 stations before the war (Schott, 1925).

[Figure 3]

THE MARKET DIVISION BETWEEN MARCONI AND TELEFUNKEN: WIRELESS TELEGRAPHY AND THE MERCANTILE MARINE

To survive in a phase of technical and economic difficulties, Telefunken tried to enter the market for civilian maritime radio. Up until World War I Telefunken succeeded in controlling the German and a part of the European market.

Table 1: Market share of the main suppliers of naval stations, 1909-1914. Sources: Thurn, 1910a; Thurn, 1910b; Thurn, 1912; Roscher, 1913a; Anonymous, 1914a.

Year	Marconi		Telefunken		Others		Total
	Stations	Share	Stations	Share	Stations	Share	
08/1909	161	67 %	24	10 %	55	23 %	240
10/1910	203	63 %	53	16 %	66	20 %	320
07/1912	900	37 %	798	33 %	752	32 %	2,450
01/1913	1,047	37 %	871	31 %	879	31 %	2,797
01/1914	1,521	39 %	1,281	33 %	1,100	28 %	3,902

In German merchant shipping, wireless stations were at first considered a dispensable luxury, that were useful only for large shipping companies for advertisement purposes on their transatlantic routes. As early as shortly after the turn of the century the two biggest German shipping companies, "HAPAG" and "Norddeutscher Lloyd," had signed long-term contracts with Marconi to equip their vessels (Thurn, 1911a). In the opinion of most of the other shipowners, wireless telegraphy was too expensive and offered too little benefit for smaller passenger and cargo steamers. Adolf Woermann, owner of the "Woermann Line," once said that he was not willing to pay for a technology that would be used by his captains only to send "Good Morning" messages to one another (as cited in Bredow, 1954). The meaning of wireless telegraphy for the distress rescue entered the public consciousness by a series of spectacular ship rescues beginning in 1909 and the "Titanic" disaster in 1912. In fact, the traffic in the North Atlantic actually doubled between 1900 and 1912 to more than 1 million ship movements per year. Thus there was a rising need for more security in shipping (Anonymous, 1913; Winkler, 1916).

To make the "quenched spark system" useful and attractive for civilian merchant shipping and to conquer the German market that was dominated by Marconi, it was necessary to develop new technical facilities and organizational structures. Telefunken engineers revised the transmitter and the receiver of their radio system, designed add-on modules for the maritime radio, and made the operation of the devices more uniform and user-friendly. Like Marconi, Telefunken started to operate stations on shipboard with their own devices and personnel to make it easier for the German shipowners to use wireless technology on their ships. Additionally, by approximately 1913 Telefunken built 10 coastal stations on their own initiative (mainly in South America) and thus further extended the radio network (Friedewald, 1999).

Starting in 1909, the Marconi Company came under growing economic and political pressure. Marconi continued to reject communication with other systems, because the International Radiotelegraph Convention of 1906 had not yet been signed by all of the participating nations. This policy provoked worldwide protest. Because the

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British government was one of the parties that delayed the translation of the convention into national law, and the national telegraph administration wanted to remain credible, they did not hesitate to buy all British coastal stations and open them in accordance with the International Radiotelegraph Convention for communication with all systems. The German Post Office and the military establishment put pressure on the shipowners to equip their vessels with wireless stations from Germany. They thereby supported Telefunken when they put their quenched spark system on the market in autumn 1909 causing a further concentration of the communication (Bredow, 1954; Thurn, 1911a).

Soon Telefunken operated as many stations on board German ships as Marconi did. In January 1911, Marconi and Telefunken reached an agreement that led to the formation of "Deutsche Betriebsgesellschaft für drahtlose Telegraphie m.b.H" (Debeg), in which Marconi held a 45% interest and Telefunken a 55% share. The new corporation handled all the German mercantile marine business and thereby gave Telefunken access to a part of the European market. The Debeg-equipped vessels with the newest wireless sets provided the personnel and even did the accounts for the entire communication (Deutsche, 1936). After that time the number of the stations on board German ships rose strongly (table 1). Due to this success 1911, was Telefunken's first business year with a net profit [Quiring, 1920].

Until 1914, the German Postal, Telephone and Telegraph Administration had established a number of maritime radio services that were broadcast by the high-power transmitter Norddeich and expanded the field of application of wireless telegraphy further. After 1909, the "Wolff'sche Telegraphen-Bureau," the leading German press agency, broadcast radiograms with important political and economic messages, which were used on board large steamers to publish a newsletter for the passengers. The most important service was the periodical transmission of the exact Greenwich time that was established in 1909 as well. It could be used for the adjustment of the ship's chronometers, which were important instruments for navigation. In 1911, the first weather service was introduced. At first weather radiograms were not longer than 25 words and were limited to information about air pressure, force, and direction of the wind as well as gale warnings for the North Atlantic. Only after World War I did the regular collection of meteorological data and their transmission ashore prove possible and subsequently permitted a better weather forecast (Friedewald, 1999; Nebeker 1995).

The introduction of maritime radio services marked the beginning of a fundamental change. Radio was no longer seen exclusively as a way to communicate point-to-point, but as a means to communicate from one social unit to a large number of more or less anonymous social units. However, without the possibility of transmitting voice and music, this new paradigm could not develop its whole potential (Lindqvist, 1992).

LONG DISTANCE SIGNALING: A FACET OF IMPERIAL POLICY

Shortly after the German Reich had acquired colonial possessions,² the government started to feel that they were a political and financial burden. Nevertheless, Wilhelm II continued to propagate the acquisition of further colonial territories. Therefore in

1897/1898, the German Reich initiated a policy of expansion that should guarantee Germany's "place in the sun," as Chancellor Bernhard von Bülow declared. Like other imperialistic states in Europe at the end of the 19th century, the German public came to the conclusion that the reputation of a great power depended on colonial possessions. In the attempt to gain recognition in the world, the German Reich used the whole spectrum of propagandistic means and her entire industrial and military potential. The construction of a battle fleet and of an independent German communication network was part of this attempt (Hobsbawm, 1987).

Marconi had already planned, in 1902, to establish a transatlantic wireless telegraph connection, and started a regular service in 1907. The Canadian physicist and engineer Reginald Fessenden (1866–1932) was working on a similar project for the American weather service. German researchers considered such projects possible and technically interesting, too. Because there was political as well as military interest in wireless connections with the German colonies and because an economic potential was assumed, German industry started to develop wireless long-distance technology in 1908. At first, the quenched spark technology seemed to be an appropriate solution because the engineers had been able to increase transmitting power to 100 kW. In June 1911, Telefunken succeeded in transmitting single characters from the high-power transmitter in Nauen across more than 3,350 miles to a provisional station in Togo, West Africa. Because long-distance signaling was faced with different atmospheric disturbances (especially in the tropics), the quenched spark technology soon reached its physical and technical limits. In the meantime, the old idea of producing high-frequency energy with electromechanical means had become technically feasible. In 1902, Fessenden had built a first model of such a radio-frequency alternator. By 1906, he had built—with the assistance of E. F. W. Alexanderson—generators in sizes capable of transmitting messages several hundreds of miles. Until the end of World War I, there were an American, a French, and two German types of high-frequency alternators in use (Aitken, 1985; Fürst, 1923).

The German general staff considered that in a European war German submarine cables would be destroyed and that foreign cables could not be used for German communication. In this case, the United States would be the best sources for political and economic news; therefore the establishment of transatlantic wireless connections had a high priority. Public discussion, however, concentrated on the possibility of radio communication with the colonies, mainly with psychological and strategic arguments, emphasizing the advantages for the colonial administration—the acceleration and cheapening of the communication between the Reich and the colonies. Finally it was expected that radio communication would stimulate the sale of raw materials and the trade with the colonies as a whole (Roscher, 1913b). Compelling economic reasons, however, existed only for wireless connections with the United States, because the share of the German colonies of the overseas trade of the Reich constituted only 0.5% in 1914; only 2% of German investment abroad went to the colonies. Before 1914, German industry invested mainly in Europe, the United States, and South America, and rather in the English and French than in the own colonial territories (Treue, 1991). As a result, the German wireless stations in Africa were far from covering costs (table 4).

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Table 2: Number of radiograms, expenses and revenues for selected wireless stations in German colonies in Reichsmark (RM). Source: (Roscher, 1920, pp. 10ff.).

Station	July–September 1912			April–June 1914		
	Radiograms	Expenses	Revenues	Radiograms	Expenses	Revenues
Swakopmund, South-West Africa	549	3,823 RM	1,428 RM	879	3,874 RM	3,947 RM
Lüderitzbucht, South-West Africa	128	3,045 RM	405 RM	204	6,460 RM	825 RM
Duala, Cameroon	73	4,320 RM	477 RM	73	4,320 RM	477 RM
Daressalam, East Africa*	592	4,513 RM	1,174 RM	605	4,908 RM	1,442 RM

* Data for April–June 1913 and April–June 1914

The English submarine cable monopoly and the possible or actually exercised censorship (like during the Boer War 1899/1900), were a thorn in the flesh of all great powers, and not only Germany formulated the need for national submarine cables and other communications means independent of foreign control (Headrick, 1991). But the extension of the German submarine cable network, the established technology for long-distance communication, had encountered difficulties since 1895, because the necessary bases were missing, and new rights for landing cables were hard to get. Moreover submarine cables were considered difficult to protect in an armed conflict and could legally become war booty (Lenschau, 1908; Scholz, 1904). Because the German submarine cable network was therefore of little military value, it was determined that it should be complemented or even replaced by wireless telegraphy, a strategy that was also pursued in England and France (Schultze, 1912; Hansen, 1915).

The German general staff took the view that the development and interaction of all possible communication means were a prerequisite for the constant and reliable intelligence service that was considered a crucial factor for the operation of large armies. Furthermore, only the nation that was able to establish such long-distance connections would have commercial and military advantages. Wireless connections were considered indestructible and bridged hostile territory; finally the installation costs were lower than those of submarine cables, but only if the radio stations were located on the own national territory (Schmiedecke, 1911; "Nauticus," 1912).

[Insert Figure 4 about here]

The implementation of a long-distance radio network was a great technical challenge to the industry. The conditions encountered by the German engineers compared unfavorably to those of Marconi. The British companies conducted their experiments between stations in Cornwall and Newfoundland/Canada, thus bridging the shortest distance (2,000 miles) between Europe and America. The distance between Germany and the United States was more than twice as far. Therefore, in 1909, the Reich promoted a series of experiments to connect Germany with her colony Togo in West Africa at the same time when similar plans of Great Britain and France became public.

The core of the German radio network was the station in Nauen near Berlin, which had been erected for experimental purposes by Telefunken in 1905. It was enlarged in

several steps between 1908 and 1916 and finally represented the prototype of a long-wave station with quenched spark transmitters and high frequency alternators with a power of 100 kW or 250 kW respectively. With this equipment, it became possible to bridge the distance of 3,500 miles to the African colonies, and Germany began building stations for long-distance signaling in each of her colonies (Roscher, 1920). Until the beginning of the war in August 1914, only the station in Kamina (Togo) was completed and had started regular service. It should have become a junction for the wireless communication with the stations in Cameroon, East, and Southwest Africa. The station under construction in Windhoek (Southwest Africa) was already able to receive signals from Nauen in 1914. A regular communication, however, was never accomplished. The erection of a third large station in East Africa, planned for the financial year 1915 that would have enabled radio communication with the German possessions in the South Seas, was never even started. As early as the autumn of 1914, the German radio stations in Africa were captured and destroyed by allied forces. Nevertheless, during their few weeks of operation, they were used to alarm the German fleet about the crisis in Europe (Anonymous, 1914b).

In parallel with the colonial radio project, the industry made efforts to build direct radio connections between Germany and North America. In 1911, Telefunken acquired a site at Sayville on Long Island and established the "Atlantic Communication Company." The new station began operation as a coastal station in 1912, but after the transmission power had been increased to 100 kW in 1914, there was a direct connection between Sayville and Nauen. In 1913, a subsidiary of "C. Lorenz AG" operated radio connections between Eilvese near Hanover and Tuckerton, N.J. using a high frequency alternator.

[Figure 5]

WIRELESS TECHNOLOGY IN WORLD WAR I

The fears of the military authorities of being cut off from the worldwide cable network in the case of a war were realized in August 1914, immediately after the beginning of hostilities. British cable steamers cut the five German cables to the neutral states of Spain and the USA and to the German colonies. But the German Reich also isolated itself, because all telegraph and telephone services to foreign countries were interrupted, private radio communication, as far as it had already existed, was prohibited. All privately and publicly operated radio communication systems were seized for military purposes. The prerogative to operate radio stations passed from the Post Office Department to the War Ministry, and the entire communication network (including telegraph, telephone, and radio) was placed at the disposal of the army and navy (Lerg, 1980; Reichspost, 1925).

The large radio stations in Nauen and Eilvese were now Germany's only means of communication with America and Asia. But when the United States entered the war in April 1917, Germany was totally isolated as far as communication was concerned. Sayville and Tuckerton, which had been used to transmit orders to the German cruisers and submarines in the North Atlantic, were put under control of the American navy. From then on, it was the task of German stations in neutral countries to transmit radio

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messages "to all." This was the origin of public broadcasting in Germany that was institutionalized as late as 1923. During the war Nauen, Eilvese, and the station in Norddeich were used for propagandistic purposes. Several times a day the intelligence service of the Foreign Office, the communications department of the admiralty, and "Wolff's Nachrichten-Bureau" broadcast a news service for the neutral countries (Böhme, 1920; Douglas, 1987; Lerg, 1980).

For the fighting in the European theaters of war, wireless technology became a matter of course, and radio was developed into a strategic and tactical weapon. In addition to the large coastal stations of the navy, all the large battle ships, cruisers, torpedo boats, submarines and auxiliary vehicles were equipped with appropriate radio devices in 1914. The army, however, had no more than 35 mobile stations; only four out of ten fortresses had radio stations with a range of approximately 650 miles. They were mainly used for monitoring and disturbing the communication of the enemy. On military and naval aircraft, wireless telegraphy was used for the observation of cannon impacts over hostile territory (Niemann, 1919; Schott, 1925).

At first, only operations staff of the army used radio for communication with their divisions, but with the change to trench warfare in 1915, the massive use of small portable radio sets became a necessity for the troops at the front. In 1917, Telefunken alone delivered more than 500 "portable" stations (still weighing more than 25 pounds). With the increasing number of stations, it became more and more difficult to communicate undisturbed. In October 1917, an order was issued that forbade the uncontrolled growth of radio communication (Bredow, 1954).

After about 1912, Telefunken had forced the further development of the electron tube that had been invented by Robert von Lieben (1878–1913) in 1906 (independently of, but concurrent with the American engineer Lee de Forest). In the subsequent years, the Telefunken engineer Alexander Meißner developed a circuit that used the electron tube as a means of generating continuous high frequency oscillations. In 1914, Telefunken started manufacturing such tubes in series and delivered about 2,000 receiver tubes and 150 transmitter tubes each week in 1915. In 1917, the first vacuum-tube transmitters were employed on board warships and by troops at the western front (Anonymous, 1919).

FROM WIRELESS TELEGRAPHY TO BROADCASTING

Due to strong military and political interests, radio engineering became the field of the two largest electrical companies in Germany, "Siemens & Halske AG" and "Allgemeine Elektrizitäts-Gesellschaft" around the turn of the century. With the formation of the "Gesellschaft für drahtlose Telegraphie" (Telefunken) in 1903, their joint developments were given a corporate framework. Until the end of World War I, Telefunken was the main driving force in the development of wireless technology in Germany.

Because telegraphy (including wireless telegraphy) was a prerogative of the German postal authorities and therefore under the surveillance of the government, the development of the radio industry in Germany was fundamentally shaped by these external factors. Under the specific German circumstances, however, a close cooperation

between industry and government became inevitable. The radio industry had obtained its legitimization and was able to represent the Reich's interest while pursuing its own commercial goals. Under those circumstances, the Reich did not hesitate to confer licenses for public functions to private enterprises like Telefunken. By defining new fields of application and new services, Telefunken's wireless telegraphy systems that were originally intended for military use, developed from a niche technology to a commercially successful product for civilian use. In shipping, the "quenched spark system" remained the prevailing technology until the late 1920s and was in use for another 10 years.

The potential that lies in the possibility to emit electromagnetic waves in all directions was not recognized by Marconi and the other pioneers of wireless telegraphy. Quite the contrary; on demand of the military users researchers and experimenters did everything to suppress exactly this characteristic of radio. The research during the early period focused on the problem of tuning and on methods of encoding radio messages. Beyond that, the value of wireless telegraphy was rated by the criteria of existing communication media, especially wire-bound electrical telegraphy. These criteria were speed, reliability, and low costs (Tenfelde, 1926; van der Borgh, 1912). Even in the annual report for 1913 Telefunken stated that for long distances, wireless telegraphy was only an inferior substitute for submarine cables.

But for most of the contemporaries—even if they were thinking within the conceptual framework of cable telegraphy—radio also had indisputable advantages: Radio could connect ships at sea to one another and with the coast. In the long run, radio offered the possibility for communication among all types of moving vehicles, on earth, on sea, and in the air. Finally, radio made communication possible where difficult terrain or political conditions made other solutions impossible or uneconomical.

In outline, a semantic change appeared around 1910 with the emergence of the first radio services. Apart from the traditional point-to-point connections, it became obvious that one-to-many connections had their own field of application and their own value (Lindqvist, 1992). Simultaneous transmission of messages to many recipients was utilized extensively for political and propaganda purposes for the first time during World War I. In times of great distress, the German Reich made a virtue of this originally unwanted feature of radio and began transmitting messages "to everyone."

This utilization already pointed to the completely new use of radio: broadcasting. But only the invention of the electron tube as a means of generation and amplification of continuous waves made the transmission of language and music technically and commercially feasible. The universality of this new component and the possibility of manufacturing it in quantity led to a bulk sale of radio products after the establishment of the German broadcasting system in 1923. Thus Emil Rathenau's vision to "bring a radio set into every house" could finally become reality (quoted in Bredow, 1954, p. 99).

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Notes

¹ This requirement had first been addressed by Nikola Tesla, who had conducted experiments with tuned, inductive signals for secure remote control of a toy boat that he presented in 1897 (Anderson, 1998).

² Togo, Cameroon, German Southwest Africa (today: Namibia), German East Africa (today: Tanzania, Rwanda, and Burundi), New Guinea, Samoa, the Caroline and Mariana Islands (today: Micronesia), and the Chinese port of Tsingtao.

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