Francesco Paresce Marconi

Guglielmo Marconi: personal reflections on «an Italian adventurer»

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Introduction

It is almost exactly 100 years since my grandfather's masterful technological and public relations coup of sending and receiving the first wireless message across the Atlantic ocean at the age of 27. At this point in his career, he was the majority stockholder and director of research of a reasonably well established and financially sound company called the Marconi Wireless Telegraph Co. with an industrial-size plant in Chelmsford, England, the owner of two fundamental English patents on a wireless communication system, the holder of a practical monopoly on wireless communication in the British Empire and the focus of an incredible amount of international attention and acclaim.

All of this from a young foreigner with no formal training, with scant if any understanding of the physics involved and using what looked to most serious scientists as homemade and rudimentary techniques borrowed, for the most part, from other workers in the field. No wonder then that, in 1897 when the details of Marconi's apparatus became better appreciated, the eminent English physicist G. FitzGerald labeled him derisively «an Italian adventurer». Great experimental physicists like Hertz, Righi and Lodge had, after all, set out the basic concepts involved in the generation, transmission and reception of electromagnetic waves in the laboratory well before Marconi. The task of «harnessing these oscillations» for practical purposes, as Marconi put it, seemed rather trivial to these representatives of the scientific establishment if they thought about it

at all. Over-the-optical-horizon communications with these waves seemed to them in any case far-fetched if not impossible.

So, how did this astonishing almost meteoritic success come to pass? What were the crucial elements in the development of his "invention" in just a few short years and the background from which they sprang? What drove Marconi to take on the world for what seemed to most an impossible dream? Was he one of those one-of-a-kind geniuses or fanatics that just happened to walk on to the stage at the right time and place with an unshakable but quixotic vision? Was he born with super-natural powers as the "wizard of the waves" or the "magician of the ether" as he is best known in his native Italy? Or was he a rather special but otherwise ordinary mortal striving against long odds in showing the way to a sympathetic but mostly uncomprehending public? More importantly, are there lessons to be learned from his example that could be useful for future 21st century technological enterprises of the same caliber?

In the following paragraphs, I will try to answer briefly some of these questions on the basis of the most recent research on the genesis of his invention and on the development of long distance wireless communication systems in his lifetime. I hope to show by this work that Marconi's personal history, although obviously peculiar in some respects, followed a rather predictable path wherein his successes and failures can be rather naturally attributable to specific causes inherent in his training and in the basic process of bringing an invention to successful commercial exploitation. Of particular interest is the very difficult role

Marconi had to play in the "transition region" between science, technology and the commercial market place.

There are many good books, articles and monographs on Marconi and his times to which the interested reader may refer for more details and broader coverage than I can afford in this brief contribution. The outstanding technical, personal and sociological overview of Marconi's place in the history of wireless communications entitled "Spark and Syntony" by Hugh G.J. Aitken merits the place of honor in my estimation. Barbara Valotti's thesis entitled "La formazione di Guglielmo Marconi" at the University of Bologna is the most recent worthy and important addition to the subject of Marconi's early training.

The European Patent Office's recent re-examination of the basis of Marconi's English patents (EPO Gazette # 12, 30 June 1997) presents an extraordinarily interesting modern view of this rather esoteric and still controversial subject. Finally, my mother's (Marconi's first daughter) biography contains the best view of Marconi as a man from the one person who was closest to him for the longest period of time. I will concentrate here on what I personally consider to be the most salient and compelling issues illuminating his life and times from a modern scientific perspective.

1. Growing up in Italy, 1874-1895: formation and development of the basic idea

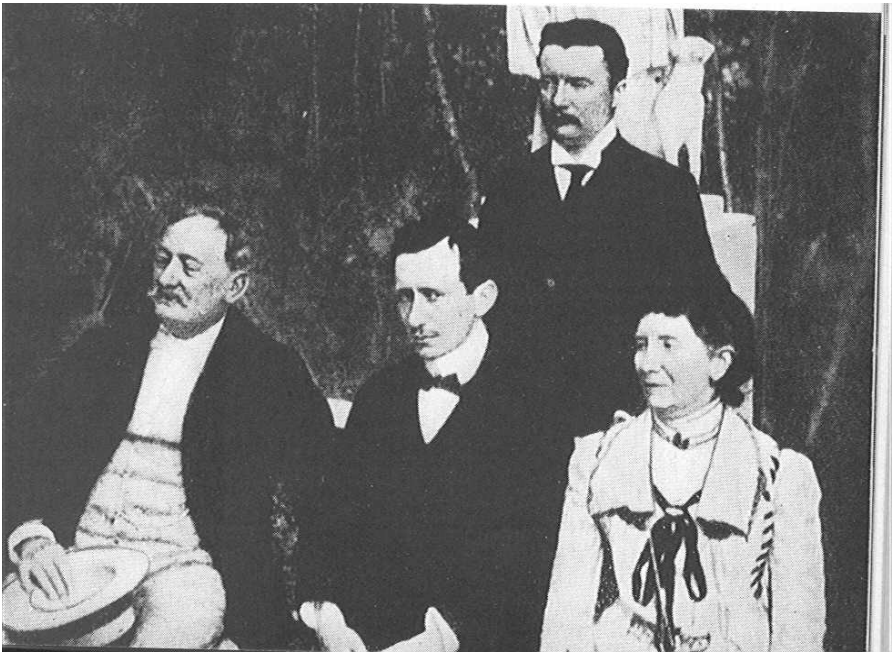
Guglielmo Marconi was born in Bologna, Italy on April 25, 1874 from the union of Annie Jameson and Giuseppe Marconi. Giuseppe belonged to the upper middle class of his town and was an eminently practical man intent on taking good care of the administration of his agricultural interests. Much has been said about this man in the past not all very favorable but it is quite clear today from all available reliable sources that he gave Guglielmo all the financial support and moral encouragement one could expect under the particular circumstances in which the family lived at the time. Giuseppe's practical, utilitarian, cost conscious, down to earth approach to life was certainly passed on from father to son. Relations between the two were always formal (Giuseppe was 51 years old when Guglielmo was born) as befitted the times but cordial even when Guglielmo was at his head-strong worst. In the most difficult times at the beginning of his career in England, Guglielmo never failed to inform his father of the tribulations and concerns he was going through and to ask for his advice and financial support.

Annie Jameson was altogether of another breed and how the two met is an interesting story in itself too long to describe here and how they survived such a peculiar union is a mystery but it is, in any case, again testimony to the patience and devotion of Giuseppe to his family that he supported all their peculiar habits with equanimity and restraint. And peculiar they were indeed because Annie,

brought up in the country in Ireland, had very particular ideas regarding the civil and religious education of her son Guglielmo.

One of the enduring mysteries surrounding Marconi is his almost complete lack of any kind of formal schooling which would seem at odds at a superficial glance both with family tradition and the open-mindedness and worldliness shown in other occasions by both parents.
In my mind, this had certainly something to do with Annie's profound distaste for the Catholic Church ingrained in her by her Protestant Irish upbringing and probably confirmed by her association with the late 19th century society of Bologna, a very recent and somewhat reluctant convert from a Papal state to the secular constitutional monarchy of Savoia Italy.

In a letter to Giuseppe, for example, Annie asks him to make sure that his son will be able to «learn the good principles of my religion and that he not come into contact with the great superstition that is commonly taught to small children in Italy». In another letter she makes her husband swear that «he will not let his son be educated by the Priests». That in itself would have been quite difficult in Bologna where the good bourgeoisie almost invariably sent their sons if not their daughters to the best schools then available namely those run by Jesuit "Priests".



Guglielmo Marconi between his parents Annie and Giuseppe. His older brother Alfonso looks on behind him.

The considerable distance between their country home and the city center where these schools were located and Guglielmo's early health problems may have been other incidental causes of Marconi's unorthodox education but it is likely that they were used by Annie as expedients to cover the real reason behind her educational methods. Consequently, Guglielmo was essentially taught at home by Annie herself and a series of tutors initially and in a variety of temporary schools in Florence and Leghorn where Annie took her son on extended visits later.

Especially unorthodox, at least for the conservative and rather rigid educational establishment of most European countries of the time, was Annie's insistence that her son

be given free rein to seriously study only what he enjoyed most and gave scant, if any, attention to his performance in those subjects in which he had no interest which, unfortunately, were those that most schools set great store in including grammar, literature, history, arithmetic etc. She made, instead, a great effort to find for him the best possible tutors in his favorite subjects mainly in the sciences and music. Of particular significance was his apprenticeship with the Leghorn high school physics professor Vincenzo Rosa in whose laboratory Guglielmo picked up the first important notions and mastery of those experimental techniques that were to form such a crucial aspect of his later career.

An especially enduring myth of the many about Marconi concerns the seemingly miraculous and mysterious early appearance in his life of his interest and involvement in electrical phenomena and, in particular, in wireless communication. Recent research in this period of his life by Barbara Vallotti has convincingly shown that the actual development of his interest was gradual and systematic throughout his formative years between 15 and 20. He apparently carried out a rather impressive series of experiments in electrical engineering of increasing complexity both in Rosa's laboratory and in the attic of the Marconi country home in Bologna. These experiments culminated in the famous "gunshot" experiment of the winter of 1895 when he was just 21 wherein he was able to send electromagnetic signals a distance of 2 km over a hill blocking direct "optical" view of the receiver.

Several significant elements characterized these early efforts. One was that he was able to develop, without annoy-

ing interruptions due to the usual scholastic and social obligations of other boys his age like lessons, exams, parties, etc, a manual dexterity and general laboratory experience and practice that was to prove crucial in his later experiments. This certainly included a good dose of stubborn persistence in the face of adversity and, especially, a healthy resistance to frustration.

Another was his reliance for all kinds of electrical engineering information and equipment on a weekly semi-professional science magazine called L'Elettricità akin to The Electrician of today. From this periodical, which probably represented almost his sole reading text in those years, he extracted most of the early technical notions and ideas that he needed to carry out his experiments. In particular, it gave Marconi the possibility of ordering the proper materials that were critical to the success of his enterprise. For example, the special materials needed for the filings in the heart of his "invention", the coherer detector, were all obtained this way.

It seems quite plausible, moreover, that he hit upon the very idea of wireless communication by reading this magazine since issue 44 of 1893 contains an article extolling the importance of electricity and claiming that «the slow vibrations of the ether would allow the marvelous concept of wireless telegraphy without underwater cables, without any of the expensive installations of our time». It is doubtful, but not impossible, that he was aware of Crookes' famous prescient article on the same subject that appeared in the Fortnightly Review in February 1892.

Another important characteristic clearly present in his

early outlook was the concept already well formed in his mind that he needed to properly protect his ideas from infringement by others by means of patents. Already in early 1893 at the age of 19 he was informing his cousin that he had «been very busy with my electrical experiments which I hope may succeed at last. I think of getting out my patents in August». Thus, he already felt keenly the necessity to proceed efficiently with the commercial exploitation of the «all kinds of inventions and discoveries» he was playing with since the age of fifteen. It also illustrates how much Marconi was influenced by his father's earthy, practical mentality from the very beginning, a mentality that would prove useful much later in his career when he was faced with the hard task of turning his invention into a successful commercial enterprise.

But what exactly did this invention he made while still not much more than a boy in Italy in the years 1894-1896 when he defined himself «n ardent amateur of electricity» actually boil down to technically? His truly "unique" discovery, in essence, regarded the fact that by elevating his transmitting and receiving antennas a fair distance above ground and grounding properly one end of the antenna he could transmit intelligible signals over the then astonishing distance of several kilometers even over such obstacles as walls and hills that should have been impossible to penetrate if the waves acted like those in the optical spectrum.

In retrospect it is clear that, by pure trial and error and considerable will power exercised over several years of painstaking experimentation and not in the "flash" so dear to later chroniclers, he discovered that electromag-

netic waves of long wavelength would propagate in free space over considerable distances and interposed obstacles in contrast to the short ones used up to then in the laboratory.

We should emphasize here at this point that although his "invention" was always the subject of intense and sometimes acrimonious controversy and debate as to its exact character and priority there is no question whatsoever that absolutely nobody before him had been able to accomplish as much. Although the concept of the grounded vertical antenna was not new in itself (Franklin's kite and Popov's lightning conductor being well known precursors), it was Marconi's use of it as a device to transmit and receive signals that was completely new and revolutionary.

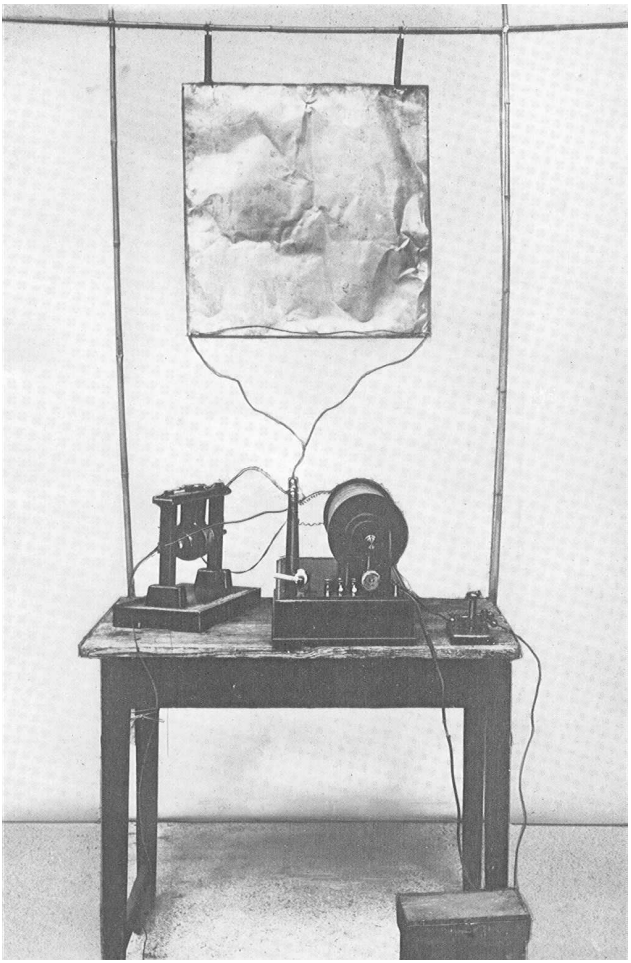
We now know, of course, that, at the roughly 1-10 meter long wavelengths he was probably using, he was taking good advantage of the ground or surface wave that, at these low frequencies, follows closely the contours of the earth. Higher frequency waves such as those generated by a small dipole antenna in the lab would be quasi-optical in their propagation characteristics and not penetrate much beyond the line of sight. For greater distance coverage, use of the ionospherically reflected sky wave would be more practical but VHF waves would not have been the best choice either since they do not refract well from a plasma.

Everything else about his wireless telegraphic system he developed in Bologna besides, perhaps, the exact form of his inspired antenna system was known and developed in

one form or another by a whole suite of very able experimenters like Hertz, Lodge, Calzecchi Onesti, Branly, Righi, and Popov (who used his grounded antenna for detecting atmospheric disturbances) of whose work he had quite detailed information through his assiduous reading of L'Elettricità or directly through his personal association with Righi in Bologna.

What was essential is that he had brought each previously known component of his system to the best level of performance possible with the technology of the day, a system that was very precisely suited to his one and very simple and almost obsessive objective: sending and receiving intelligible signals over the greatest possible distances.

All the people mentioned above did much to advance basic knowledge in the science and technology of electromagnetic waves but none saw their practical potential for wireless communication. Marconi himself was to remark that, at that time: «My chief trouble was that the idea was so elementary, so simple in logic that it seemed difficult to believe no one else had thought of putting it in practice». As Aitken put it «the commercial potential of wireless telegraphy which was so obvious to Marconi was not self-evident to others».



The first device developed by Marconi in Bologna in 1895 for wireless transmission. The antenna is a tin plate from an oil barrel. Another metal plate was laid on or buried in the ground. At the transmitting station, a spark gap (instrument on the table on the left) was connected between the two plates while at the receiving station the detector (a coherer, instrument on the table at the right) was connected between the plates.

2. Marconi in England and the commercialization of wireless

Another enduring myth about Marconi was that he naturally turned to the Italian authorities for practical support of his concept but was turned down by an uncaring and uninterested bureaucracy. No matter how much one might enjoy this idea or how plausible it might seem in a place like Italy even today, there is actually no hard proof whatsoever that he ever did so. In fact, in retrospect, what he did do made much more sense from his particular perspective.

And that was to pack up and head straight for London, England which he did together with his mother Annie in February 1896. Several pretty obvious reasons prompted him or, maybe, one should say Annie to do this. First and foremost was the simple fact that his device had one unique and very simple application at the time: naval mobile telegraphy. What better place to market it than in England, then the pre-eminent naval power? Second, and, probably, just as important, the Jameson family to which Annie belonged was financially well off and politically and socially well connected enough in the English commercial if not the technical entrepreneurial class to provide the support that would be required to carry out the Marconi "grand design". Finally, their good knowledge of the language and customs of the country (assuredly better even than those of Guglielmo's native Italy) was another deciding factor.

The fact that Giuseppe may have been less than enthusiastic to lose in one go both his wife and son for a long time did not seem to faze the Marconis much. Giuseppe may have been easily convinced of this necessity in view of his apparent distaste for the new Italian authorities. In any case, this is another example of his rather selfless dedication to his son's obsession and success which is quite in contrast to the way he is usually described in the popular view of Guglielmo's struggle against a hostile and unfriendly father.

There is no question that Annie provided much of the first inspiration and strong moral support and encouragement Marconi needed to overcome the natural reluctance all people have for change. How she became so convinced of her son's invention's real worth is difficult to understand as she had no technical background to speak of. Like many others before and after, she must have been convinced simply by Marconi's incredible persistence and determination, two things that were very much in indisputable evidence. A more speculative motive may have been her own determination not to repeat with her son her own family's history of obstruction of her singing career and marriage to a foreigner.

Notwithstanding such strong potential family support, it is important to stop a moment here to consider the tremendous odds Marconi was up against when he arrived with his black boxes and assorted paraphernalia in London on that February day in 1896. As Aitken again so aptly put it: «in 1896 Marconi was in effect a nobody, a man with practically no formal education, an inventor whose equipment differed in no basic way from the

already known and demonstrated “state-of-the-art”, an alien with no family connections that could not safely be ignored if one had a mind to ignore them».

Marconi, 22, as he appeared in London in the spring of 1896. The Morse code sounder and two pieces of copper wire acting as the receiving antenna are on top of the black box on the right containing the coherer while, on the left, is the Hertzian dipole oscillator.

One could add that, especially in England, many other technically and scientifically more able people and certainly more astute entrepreneurs were, in principle, available by the dozens to accomplish the same task. So, how did he actually succeed in convincing such people he held the trump card in such a seemingly difficult if not impossible situation?

In my opinion, simply because he was the right man in the

right place at the right time. He was the right man because he had the ideal combination of personal characteristics for the job: persistence, daring, technical ability, charisma and flair for public relations, just enough scientific understanding to convince a skeptical layman he knew what he was talking about but not enough to be intimidated by the potential obstacles to be overcome, an extremely practical outlook geared to a simple marketing objective to be pursued with unshakable determination, and last but not least, a very healthy dose of courage and pluck. Nobody else at the time had this very special combination.

He was in the right place because his mother had strong family connections there, England was the premier commercial and military market for his system and because of the ideal match between what Marconi had to offer and what England could properly protect by its patenting system. The critical point here is that Marconi's wireless communication system as he had developed it up until at least World War I, was not at all competitive with cable as later PR embroidery would have it. The only rather narrow market niche it did have was communication with ships and, to some lesser degree, with lighthouses that, in bad weather (a typically British situation!), were as isolated as ships on the high seas.

British ships covering the immense British empire scattered about all over the globe desperately needed, both from a commercial and military standpoint, a way to communicate rapidly with home base and amongst themselves. Wireless telegraphy offered the only practical way to do that. The Marconi Co. that Marconi founded in 1897

enjoyed for many years a virtual monopoly on this business.

Another reason is not so obvious and needs to be emphasized more. The core issue in Marconi's case was that he had not invented anything really new or at least easily recognizable as such but what was new was the use to which he put the old concepts and techniques in order to exploit them for a very practical purpose. His, then, would be a very difficult device to patent where priority of discovery of each component is emphasized as in the US and Italy, for example, especially since his predecessor's results (mainly Oliver Lodge) were of common knowledge in the world at the time. In England, on the other hand, what mattered most at the time was the possibility to claim the method itself as property and that was exactly what Marconi did with his crucial patents. These were used by him and his company to protect them, at least for the crucial first years, from potentially fatal attacks from powerful competitors.

Finally, he was in the right place at the right time because his first real break came when he was allowed to work under the protection and support of William Preece, chief engineer of the British Post Office, the most powerful man in communications in England at the time.

The only reason that this very important man was more than welcoming to an unknown entity such as Marconi was that he found himself at that exact moment in somewhat of a quandary, one that Marconi alone might help him to resolve. His problem, quite predictably, was to how to satisfy his obligation to his government to develop an

effective, stable and secure system of communications within the British empire especially with moving ships.

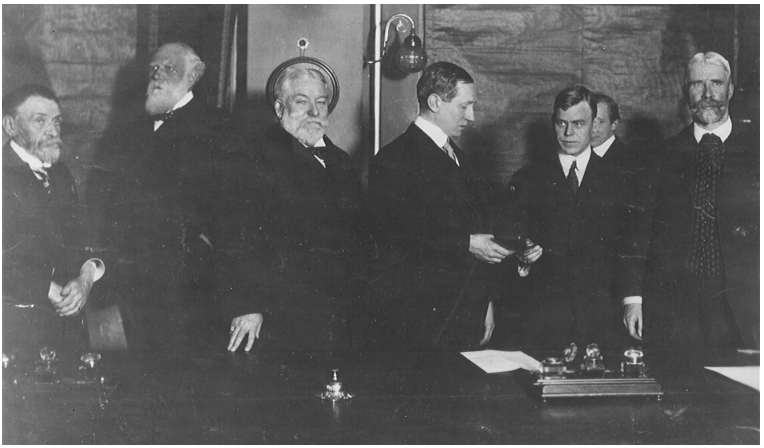
He had pinned his hopes on an inductive method of wireless communication which he himself had devised but which he had reluctantly just come to realize would not work. In Aitken's words: «William Preece in 1895-1896 found himself at a technological dead end and it says much for his intelligence that he recognized the fact». It was at this precise and lucky moment that Marconi showed up with his device that, potentially at least, could well represent the much sought after practical solution he was looking for. From Preece's perspective, then, what was there to lose from letting Marconi have a go at it with a little help from his office in terms of personnel and equipment? As it turns out, that's all that a person of Marconi's personality really needed and he certainly did not lose the wonderful opportunity.

Things moved fast from then on. In July, 1897, the Wireless Telegraph and Signal Co. was incorporated with Marconi as majority stock holder formally employed as engineer and his cousin Henry Jameson Davis as the first managing director. It is interesting to note that most if not all of the nine founding directors were cereal merchants in one way or the other associated with the Jameson family: a family syndicate as it were. In March 1899, the English channel was successfully bridged by wireless telegraphy and in April, 1900, the second extremely important master tuning patent was awarded to him.

In July 1900, a contract was signed with the British admiralty to install and maintain wireless equipment on a

number of ships and coast stations. In the same year the company name was changed to Marconi Wireless Telegraph Co. and the Marconi International Marine Communications Co. was created as a corporate subsidiary to oversee the establishment and maintenance of all shore and ship stations leased to the users by the Marconi company exclusively.

In 1901, «the master stroke of corporate strategy» described by Aitken was concluded with Lloyd's of London which bound this insurance company to use Marconi Co. equipment exclusively for at least 14 years. This contract effectively handed Marconi a virtual monopoly on the fledgling and potentially lucrative field. Not too bad for «an Italian adventurer» in just four years!



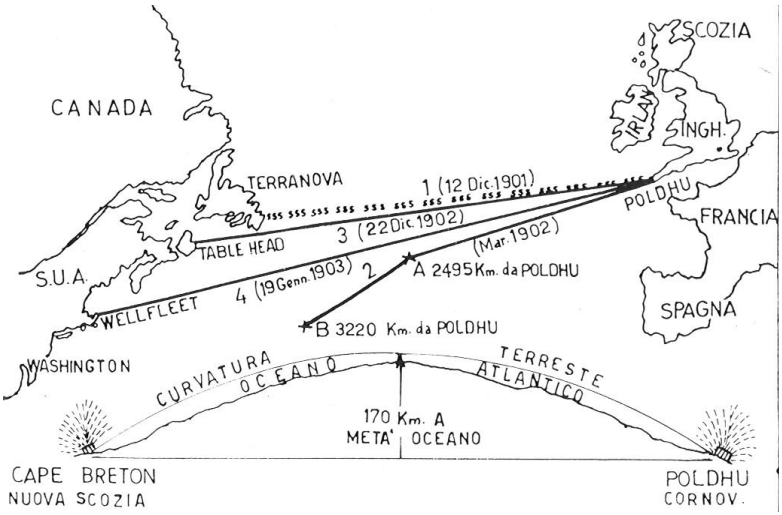
Marconi (in profile) amongst his business friends: the board of directors of the Marconi Co. in 1909. The first managing director, H. Jameson Davis is at the extreme right. The recipient of the award that Marconi is about to bestow is Jack Binns, the radio officer of the liner Republic lost at sea in a collision.

3. Signals across the Atlantic

What exactly induced Marconi to attempt such an ambitious project at such an early stage in the technical development of wireless telegraphy has been the subject of considerable speculation and controversy in the intervening years. There was every good and considered reason not to plunge considerable financial resources into such a venture at this time. The Marconi Co. was still just starting to find its feet and its financial situation was not yet secure. Submarine cables enjoyed an unparalleled supremacy in the business which wireless could not and, in fact, did not challenge until the early 1930s and that with completely different techniques. Wireless technology was definitely then on the steepest slope of the learning curve and without anything like a firm idea as to why or how electromagnetic waves propagated at all from point to point on the earth's surface.

Perhaps the most publicized problem to be overcome in such an undertaking was the apparently simple one: how could you "see" the receiving apparatus from the transmitting station separated by 3400 km, the minimum distance across the Atlantic, through a mountain of water approximately 170 km in height due to the earth's curvature? The only way foreseeable at the time was to hope the emitted waves would propagate through the water or, barring that, be conducted along the surface of the ocean. That there was absolutely no scientific justification to think that any such thing would be possible at the time did not deter Marconi one bit.

Why? This is truly a hard question to answer. The simplest and most straightforward one is that he needed to test how far he could maintain communications with a ship bound for the US. But this he could have done, as he did later, using an outbound ship equipped with a sensitive receiver. Another possibility is what I would call enlightened ignorance. He must have thought: since we understand so little anyway about the mechanisms involved in electromagnetic wave propagation, why not go the whole way and give it a try? In a similar vein, one can ask why did Columbus set sail towards the West well knowing, like the supposedly far wiser Portuguese did, that the Indies were far out of reach of the even remotely possible sailing range of the then current ships?



A sketch illustrating in Italian the main long distance experiments performed by Marconi in the early years of the last century. Points A and B correspond to the positions of a ship on which receiving apparatus were mounted. The lower part of the sketch shows the apparent line-of-sight problem faced by the early experimenters.

Marconi had every reason to be suspicious of scientists and their complicated theories. Everything he had accomplished so far had been either ridiculed or at most considered of no particular interest by most mainstream scientists. No scientific theory was available to explain how or why his system worked at all but work it did. Marconi, in an extreme way, represented the triumph of the practical empiricist over the theoretical scientist, a characteristic that also certainly endeared him immediately to Preece who had been embroiled in such controversies long before Marconi entered the scene.

Another reason is probably traceable to his daring and keen sense of the importance of capturing the imagination of the public at large that was always fascinated by this, to them, mysterious and intangible method of communicating through space. Although there was much to lose in case of failure this was more than compensated by the immense PR benefit that would be accrued by even a modest success and by the certainly interesting lessons learned even from a failure.

In any case, try he did and history records that signals were received from his transmitting station at Poldhu in Cornwall at his receiving station in St.John's, Newfoundland on December 12, 1901. The difficulties and hardships he and his assistants had to put up with to make it happen are now the stuff of legend and simply confirm the incredible stubbornness in the face of adversity that Marconi was surely well endowed with.

Marconi in the primitive surroundings of his receiving station in St. John's at the time of the first transatlantic wireless transmission.

It has been fashionable ever since to cast doubt on the reality of the reception of the signals from Poldhu not necessarily in the sense that Marconi actually made it all up since his very able assistants Paget and Kemp were also on hand but that they had all been deceived by the static or intense background of atmospheric noise.

Ironically in a sense for Marconi, it was the eminent scientist J.A. Ratcliffe (Electronics and Power, Vol.20, No.8, p.320) that dispelled that notion rather definitively in 1974.

Marconi (center) between his assistants G.S.Kemp (left) and P.W.Paget in St John's, Newfoundland in December 1901.

He calculated in laborious detail what the signal strength must have been under the particular circumstances of the experimental conditions at the time. This he could do with the hindsight afforded by his knowledge of the effect that the ionosphere has on the electromagnetic waves of the frequency (surprisingly mainly around 0.5MHz) and power emitted back then.

He found that by calibrating his calculations with the results of the tests performed later on a ship in mid Atlantic, he could indeed reproduce the power required for the signal generated at Poldhu to be perfectly audible above the noise in the head set used in St. John's in 1901.

4. Moving back to shorter wavelengths

After these hectic first 5 pioneering years, there followed a technical consolidation phase that saw a vast number of important improvements to the basic system that Marconi made with competent assistants recruited for the purpose and by others on both sides of the Atlantic such as Fleming, Vyvian, Franklin, Langmuir, Poulsen, Steinmetz, Armstrong, De Forest, Round and Isted. These improvements included the inverted-L directional antenna, the neon tube cymometer, the rotary spark gap or disc discharger, the diode vacuum tube, the arc and radio-frequency alternator, the oscillating triode and, later, the superheterodyne receiver.

All of these improvements allowed better, faster, cheaper wireless telegraphy over greater and greater distances. In particular, the development of the vacuum tube that permitted continuous wave transmission instead of the unstable discontinuous emission from the spark discharge ushered in the capability of actual voice transmission and its development opened up the new exciting frontier of broadcasting or the radio as we know it today. Notwithstanding all this otherwise wonderful activity and progress, however, by the early 1920s Marconi was in the throes of a strange dilemma.

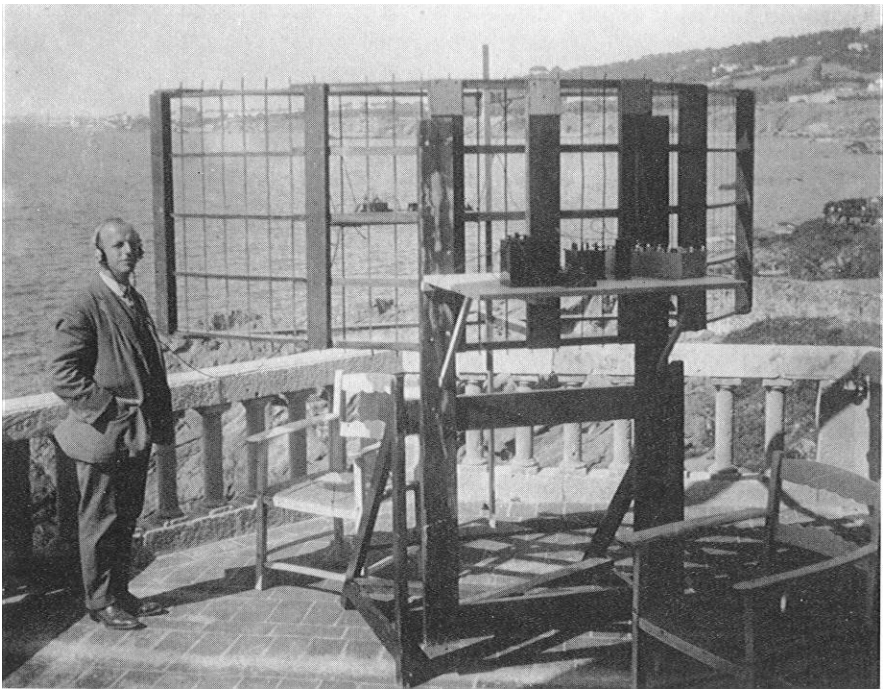
It seemed more and more evident to him as time went on in the first two decades of the last century that building ever larger and more powerful transmitting stations was not producing the kind of dramatic improvement in trans-

mitting range he expected. In fact, it was quite clear that he had reached a point of diminishing returns on his investment or a sort of saturation of the distance capabilities of the technique no matter how much brute force he poured into his transmitters. He had always relied on his own tried and tested formula for bridging ever greater distances by pouring higher power into ever larger antennas. Now this certainty was being slowly but surely undermined although it seemed to make good sense at the time to expect that emitting waves of increasing wavelength would make it easier for the waves to "bend" around obstacles in some, as yet, unspecified way.

He had come to another critical juncture in his life where, confronted with a seemingly impossible problem, he had to find a rapid and practical solution or face the collapse of his dream to circle the globe with an efficient, economical wireless communication system to rival the cable. How could he do this with a system that could stably and reliably cover the, by now, piddling distance of only a few thousand miles in daytime at most? Even the idea of setting up a commercial transatlantic wireless service was temporarily abandoned for this reason. It was reopened in 1907 but messages suffered significant delays due to reliability problems. Something was terribly wrong and nobody could tell him what exactly.

But he did have some clues as to the possible solution. One was that he himself had developed, together with C.S.Franklin in 1916 during World War I, a high frequency point-to-point communication system operating at 2 meters wavelength for the Italian Navy that worked surprisingly well at least over short quasi line-of-sight dis-

tances or just beyond. The second was the fact that amateur radio operators in the early 1920s working in the much shorter wavelength bands below 100 meters were enjoying much more success than they should have on the basis of the crude ideas of radio wave propagation then available.



C.S. Franklin of the Marconi Co. with the first short wave directional aerial working at 2 meters in 1916.

Incredibly enough he did not act on these clues until 1923 but when he did, he did it in characteristic Marconi fashion: empirical trial and error. For him, as usual, no reliance whatsoever on or guidance from the physical theory pioneered by Appleton that by then had clearly estab-

lished the existence of the ionosphere and its effect on over-the-horizon radio wave propagation was deemed necessary.

In any case, what really mattered to Marconi was the spectacular success he had with short waves he was using now. He established very quickly that the signals he was receiving on board a ship more than 4000 km from a transmitter in Cornwall operating at 97 meters with just 1kW input power were stronger, especially at night, than those from the high power transmitters operating there. Even better, signals could now be easily detected from Poldhu over most of North America and, incredibly enough, at times even in Australia. Even better results were obtained at 32 meters since at such high frequencies even the daylight hours could be used efficiently.

These encouraging results allowed the Marconi Co. to sew up a contract with the British government to furnish low power (20kW) transmitting stations based on highly directional antennas to reach the entire empire.

It is clear that, at this point, Marconi's dream had finally come true and he could take a well deserved rest.

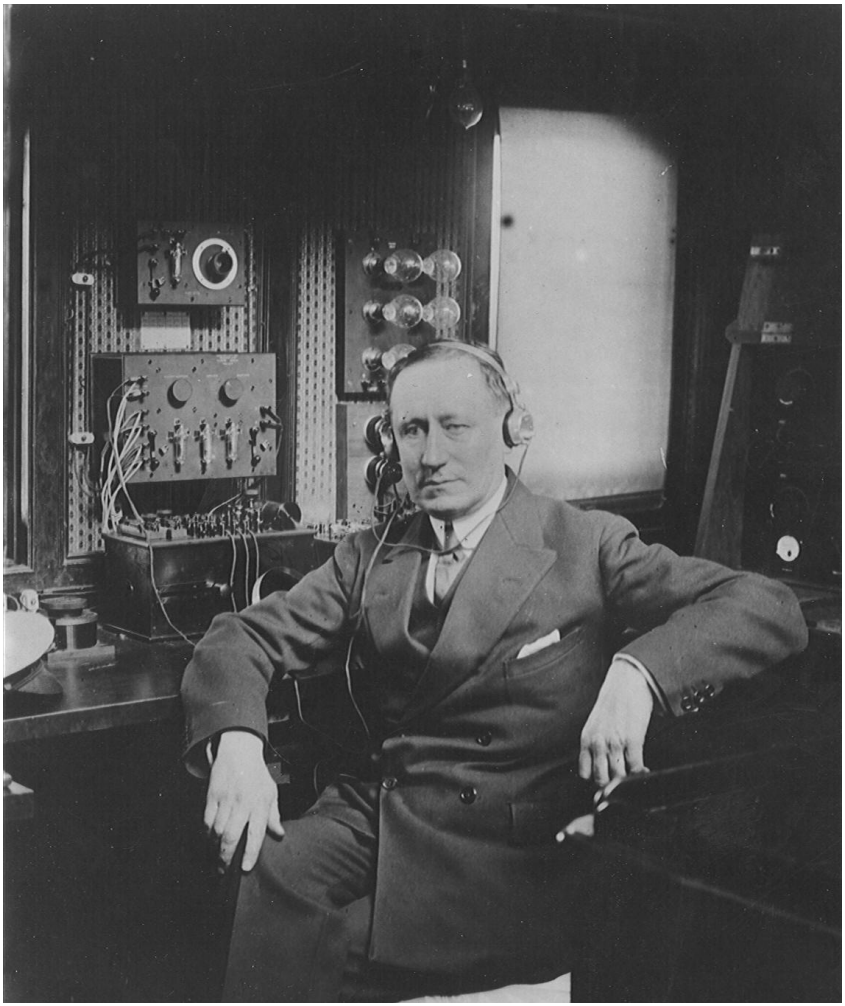
5. Last years and summary

Although afflicted with deteriorating health and serious personal problems, Marconi, however, doggedly kept experimenting all the way to the end which came in July 1937 at 63 years of age. Nothing much of great scientific or technical interest occurred in this period except his chance discovery of the effect that metallic objects in the transmitting beam had on the receiver. Already in an address to the American Institute of Electrical Engineers in New York in 1922 he claimed that «I have noticed the effects of reflection and deflection of these waves by metallic objects miles away».

But it was not until 1934 that he actually found time to address this issue with proper experimental techniques. For this, he actually was able to successfully guide his research vessel into harbor with a radio beacon. Unfortunately his many other commitments and bad health conspired to curtail any further efforts along these lines.

The nature of these commitments sheds light on the nature of his relationships with the outside world that he had worked so hard to convince in the early days at the turn of the century. As usual, he had no problem with the lay or uninformed public especially of an almost totally humanistic society like the Italian one of the last century. For them, radio seemed a mysterious and basically unfathomable process whose benefits, on the other hand, were obvious and benign. Marconi, acclaimed rightly or wrongly as the principal architect of this wonder, was,

then, the wizard of the age, a genius whose intellect knew no bounds. He naturally abandoned himself to such adulation (who would not?) and reaped its benefits.



Marconi on board his research vessel the “Elettra” during short-wave trials of reception in 1934.

The fascist regime then in power in Italy adopted him as its symbol and proudest member. Thus was born the cult of personality that surrounded Marconi in his native country in the last ten years or so of his life, a cult that in many ways, good and bad, persists in Italy to this day. The most visible manifestations of this acclaim were his appointments to Senator, Marquis and President of the Royal Academy and the National Research Council not to mention the recipient of countless other awards. It is not clear how much he enjoyed all this attention and adulation as he was always quite objective about his real status. For example, he told my mother: «Do you hear them talking of genius, Degna? There is no such thing. Genius, if you like to call it that, is the gift of work continuously applied. That's all it is, as I have proved for myself».

Of course, all this attention did not endear him very much to the scientific community that he was supposed to belong to and even lead as the head of the Italian research council. Although he had received back in 1909 with Braun the Nobel Prize in Physics, he was never regarded as a fully paid up member of the scientific community at any time during his life and, to be honest, he never really cared to be either. This is certainly due to an enduring misunderstanding of the sometimes subtle difference between a scientist, an engineer, a technological entrepreneur and an inventor in the standard definition of the words.

A scientist, Marconi certainly was not. He showed none of the typical characteristics of a scientist. He had no formal training for it, never showed more than passing interest in the why anything happened the way it did, never suppor-

ted or even attempted simple experiments that might have been of purely scientific value (how easy it would have been for him to point his antennas at the sun, for example, and be the first to discover solar radio emissions or to help his contemporaries, the then struggling Grote Reber and Karl Jansky in characterizing the radio emission from the sky etc etc) and he very rarely wrote a paper in scientific journals. He never evolved a comprehensive research policy for his country as his high position as President of the National Research Council would have suggested and warranted and, finally, did not leave behind a school of researchers in the field to keep up the pace of his experiments. For this last absence, for example, Italy was to pay dearly in three short years when its navy went to war without so much as a clue as to how to exploit the radar techniques he had so nearly developed.

Marconi among his scientific friends: physicists at a nuclear physics conference in Rome in 1931. He can be seen standing between Madame Curie and Niels Bohr.

This is not to mean that he did not have a strong influence on science despite what many scientists might think even today. As Aitken points out wisely: «information passing from technology to science tends to be systematically discounted». Marconi's systematic empirical exploration of what we would call today the parameter space for radio wave propagation in and around all sorts of natural media such as fluids, solids and ionized plasma for which, at the time, pure science could give no direction was to prove enormously beneficial to a large number of physical problems.

In particular, the discovery of the earth's ionosphere in the end turned out to be Marconi's most important scientific contribution. Ironically, the ionosphere was precisely that "missing" element, much like the North American continent in Columbus' case, in the scientific calculations used by the so-called experts at the time to deny the feasibility of his "mad" dreams.

Hertz and Lodge had transferred Maxwell's purely scientific conceptual scheme into usable technology but left Marconi not only to transfer this knowledge in a commercially successful way to the market place but, in essence, even create a market for it. This he did even though he had no business experience. His own practical acumen and common sense with a considerable dose of advice and support from his family did the rest.

So, in the end, what was he? He obviously straddled the three basic cultures of our society: science, technology and business and was probably as such was conversant with some aspect of each but uncomfortable with the rules of

all of them. Personally I would call him now the master "technological entrepreneur and innovator" of his time and certainly the «first entrepreneur of the electronic age» as Aitken put it. He probably would have preferred his own humble definition as an «ardent amateur of electricity».

The dilemma for us now is to draw possible conclusions or lessons from this case. Is there a way to ensure the emergence of more Marconi's in this century? If so, what could be the recipe? Some basic considerations stand out:

1. Rigid, fossilized schooling and teaching methods are incompatible with this class of people. Flexibility and individualism especially in science subjects should be encouraged rather than suppressed for most bright and enthusiastic students. And no matter how trivial it may sound, great grade school science teachers are crucial.

2. Family intellectual and practical support is fundamental.

3. Serious scientific and technical popular journals and magazines have an enormous influence in the formation of young, budding scientists and engineers at a very early stage and their commercial viability should be protected.

4. Older, established figures in their fields should pay particular attention to the ideas and aspirations of the youngest members of their profession no matter how strange some of these ideas might seem at first sight.

5. Scientists should listen to engineers and vice versa. This seems obvious but rarely happens effectively.

6. A flair for and appropriate use of public relations should not be seen as evidence of a shallow charlatan but as an often necessary and effective tool in the advancement of technology.

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