RTT TECHNOLOGY TOPIC
April 2018

Beam Radio

100 years ago the Marconi Company were testing the technical and commercial feasibility of establishing a direct wireless telegraphy service between the UK, Waunfawr near Caernarfon, and Australia, the Amalgamated Wireless Australasia station at 'Logan Brae', Pymble, an adjacent suburb to Wahroonga, near Sydney, part of a local authority area named after the aboriginal tribe, the Gurringai.

The 'official' first transmission was made on September 22nd an occasion which will be marked by an exchange of messages on short wave radio between Caernarfon and Wahroonga organised by local short wave radio enthusiasts and coordinated by the Ku-Ring-Gai Historical Society.

https://www.khs.org.au/local/localHistory.html

Using radio to reach Australia in 1918 required a 400 kilowatt transmitter powered from a hydroelectric power station adjacent to the Waunfawr transmitter on the top of the Cefn-du Mountain in Snowdonia coupled to ten 400 foot masts. Locals remarked that snow never settled near the site due to the heat from the power and transmission lines, a snowless Snowdonia.

In this month's technology topic, we track the component and technology innovations that have taken us from these early pioneering days of trans-oceanic transcontinental radio to the 5G and satellite and Wi-Fi systems being developed and implemented today. In particular we review the use of beam forming as a key determinant of bandwidth and power efficiency.

Read on

Marconi's Wireless Telegraph Company had established its first factory in Chelmsford, Essex in 1898 moving into a larger factory just down the road in 1912.The Caernarfon transmitter was built in 1914 with a receive site in Tywyn on the coast some miles south and played a crucial role in providing a war time radio telegraphy link with the US. The allies had successfully disrupted submarine cable connections to and from Germany and Germany at least theoretically could have done the same to us so having an alternative communication capability was considered vital (though British dominance at sea, both in terms of the Royal Navy and cable ships made this unlikely).

Achieving a service directly with Australia only became feasible due to advances in vacuum tube receivers developed for military radio equipment (and radio broadcasting) but these long wave radio systems were extravagantly inefficient in terms of bandwidth occupancy and power consumption and costly to run and repair.

Experiments by Marconi in 1923 suggested that the answer was to move to short wave and to use antenna structures to shape the radio beam to send more radio frequency (RF) energy in the right direction and less RF energy in the wrong direction.

These short wave radio transmission techniques provided the basis for the radio stations built by the Marconi Company for the British Post Office known as the Imperial Wireless Chain though Marconi also built his own transmitting station at Dorchester with a receiving station 30 miles north-west at Somerton. In December 1927, the short wave ‘beam radio’ (SWB) service to New York was inaugurated followed by a route to South America, Japan and Egypt and then Bangkok, Nairobi and Tehran.

The frequency range was 3-30 MHz equivalent to a wavelength of 100 to 10 metres and the antenna arrays were realized as stacked dipoles suspended from triatics attached to 90 foot wide cross arms on top of 287 foot high lattice steel masts. These are often called Franklin Beam Aerials in honour of their inventor, Charles Samuel Franklin. The transmitters were linked to the aerials by coaxial feeders, another of Franklin’s inventions.

http://ethw.org/C._S._Franklin

The transmitters used paraffin cooled power valves with copper to glass seals achieving an output of 11 kilowatts (compared to the 400 kilowatts of the Waunfawr long wave transmitter).

A sensitively restored but largely original example of the short wave transmitter used to communicate with South America, working at a centre frequency of 11.42 MHz (26 metres) can be seen at the Science Museum in South Kensington. It remained in service for about 40 years.

Transmitter Number 7 short wave beam (SWB) telegraph transmitter of the Dorchester Radio Station manufactured by Marconi’s Wireless Telegraph Company Ltd and on display on the second floor of the Science Museum in South Kensington – image reproduced by permission of the Science Museum/SSPL

The technical and commercial success of these short wave beam (SWB) radio services meant that the cable companies became less viable though still considered as strategically critical. As a result, a political decision was made in 1928 to merge communications with the British Empire into one operating company, originally Imperial and International Communications Ltd, later renamed Cable and Wireless Ltd. The Marconi Company had the resources to contribute financially to this merger, drawing on the income from government payments for the use of Marconi patents and technologies during the First

Wold War. At this point (1928), short wave radio systems carried about half the world's international telegraph traffic with the other half delivered by long wave radio and submarine cable.

The principle and practice of beam forming continued to be developed across a range of applications including radar in the Second World War and anti-missile missile systems in the Cold War.

In 1962, the launch of Telstar and the Satellite Communications Act marked the beginning of a gradual transition from long distance terrestrial radio to long distance links via satellite. Early Bird, launched into geostationary orbit in April 1965 delivered 'TV and telephone and telegraph and high speed data', the world's first quad play platform.

Over the following fifty years satellites have become incrementally more bandwidth and power efficient due to improved RF hardware including spot beam antennas. The ability to deliver RF gain efficiently at higher frequencies has allowed operators to implement high throughput satellites in Ku and Ka-band and very high throughput (terabit) satellites in V and W band.

Bandwidth efficiency has been improved by a combination of frequency reuse and band sharing. The new generation of high count low earth orbit constellations are designed to co share frequencies with existing GSO operators though there is an ongoing debate about inter system protection ratios.

In parallel, 5G terrestrial radio is moving mobile broadband towards beam forming as a mechanism for improving power and bandwidth efficiency. Many of the beam forming algorithms are already in widespread use in automotive radar.

Contemporary innovation in 5G terrestrial and satellite systems can therefore be considered as a continuation of a 100 year process.

Improved RF components allow higher frequencies to be used which in turn improves bandwidth efficiency through frequency re-use or, more controversially, frequency sharing.

In 1928, short wave beam radio provided an alternative to submarine cable with a lower cost base and reduced end to end delay. In 2018, inter satellite switched LEO constellations provide an alternative to long distance fibre with a lower cost base and reduced end to end delay.

However it is not just a story of moving to ever higher frequencies. Existing GSO and LEO satellite constellations in L band and S band are being upgraded to deliver higher data rates and a range of other added value capabilities (including LEO based positioning and location services) and new super small satellites are being used to provide low cost IOT connectivity and rural and remote voice messaging.

These ongoing innovations highlight the potential benefits to be gained from a closer integration of 5G terrestrial and satellite systems.

Ends

Satellite Session at this year's CWIC Conference

The role of the satellite industry in 5G mobile broadband is being debated in the satellite session at this year's **Cambridge Wireless International Conference (CWIC)**

We are delighted to have Meir Moalem, CEO of SAS and Dan Mercer VP EMEA & Russia of Iridium presenting their vision of the future of the satellite industry and providing an update on constellation upgrades (Iridium) and Cube SAT innovation(SAS).

Iridium will complete in 2018 the fastest and largest ever seamless refresh of a space constellation, having so far successfully placed fifty new satellites into low earth orbit (ten per launch) using Space X Falcon 9 reusable rockets, and has just hit it's 1,000,000th Iridium subscriber. SAS has a remarkable constellation programme based on small satellites with big capabilities including autonomous station keeping. Kieran Arnold from the Satellite Catapult will be chairing a discussion session.

For more information, follow the link
https://www.cambridgewireless.co.uk/events/cwic-2018/

New Book - 5G and Satellite Spectrum, Standards and Scale

We are delighted to announce that our new book, **5G and satellite spectrum, standards and scale** is now available for pre order from Artech House. Follow the link to take advantage of the pre-publication discount**.**
http://uk.artechhouse.com/5G-and-Satellite-Spectrum-Standards-and-Scale-P1935.aspx

If you apply promotional code VAR30, an additional discount applies which brings the price down to £88.90 (list price £127). There is also a bundle discount promotional code VARRALL5G which allows you to order a copy of our previous book, 5G Spectrum and Standards. The two books together cost £177.80 including free shipping.

About RTT Technology Topics

RTT Technology Topics reflect areas of research that we are presently working on. We aim to introduce new terminology and new ideas to help inform present and future technology, engineering, market and business decisions. The first technology topic (on GPRS design) was produced in August 1998. 19 years on there are over 220 technology topics **archived on the RTT web site**.
Do pass these Technology Topics and related links on to your colleagues, encourage them to join our **Subscriber List** and respond with comments.

Contact RTT
RTT, **Policy Tracker** and **The Mobile World** are presently working on research and forecasting projects in the mobile broadband, public safety radio, satellite and broadcasting industry and related copper, cable and fibre delivery options.

If you would like more information on this work then please contact **geoff@rttonline.com**
00 44 7710 020 040