Institution: University College London

Unit of Assessment: 13 – Electrical and Electronic Engineering, Metallurgy and Materials

Title of case study: Growth and success of wireless technology company Zinwave Ltd

1. Summary of the impact

Zinwave Ltd has introduced wideband distributed antenna systems (DAS) to the global marketplace, with systems deployed in Europe, the USA, Australia, China and the Middle East. Zinwave, a company founded to exploit the underpinning research, [text removed for publication] employs 25 staff. The first sales were recorded in 2008 and Zinwave's annual revenue has grown tenfold since then, [text removed for publication]. The Zinwave 3000 system is the only DAS on the market able to carry a wide range of wireless services on a single optical fibre and the company has built up a global network of more than 40 partners to integrate its systems, which are used in hospitals, stadiums, airports and power stations, among others. In 2012, Verizon, the USA's largest mobile operator, selected Zinwave to supports its 4G network rollout in the USA.

2. Underpinning research

The context of this research is that within buildings, coverage from outside cellular wireless base stations is poor due to the absorption of wireless signals by typical building materials. Since the 1980s, wireless signals have been distributed within buildings by coaxial cable, which is heavy, has high losses (> 245 dB/km, LMR-400, 3 GHz) and is becoming increasingly costly, making installations uneconomical in many buildings. The transmission of wireless signals over optical fibre based on the work of UCL and other groups, described in [1], has resulted in commercial systems; these use either single-mode optical fibre (e.g. Andrew Inc.), which requires the use of expensive packaged single-mode optoelectronic devices, or multimode fibre (e.g. LGC Wireless), where the limited bandwidth makes it generally only possible to carry a single wireless service on each fibre. These approaches make the products high cost where multiple wireless services are to be carried, due to the expense of single-mode fibre components and complex filtering schemes, or of multiple multimode fibre links, respectively. There is thus a cost barrier to providing widespread wireless coverage in buildings.

The UCL group had carried out extensive research on wireless-over-fibre links and the underpinning microwave photonics technologies [1]. This included EPSRC-funded work starting in 2000 on techniques for maximising the dynamic range of links, and for reducing the noise and distortion of links carrying multiple signals simultaneously. At Bristol University, Dr. Penty had shown that it was possible to increase the data transmission capacity of multimode fibre through the use of sub-carrier multiplexing (SCM). Professor Seeds, Professor of Opto-Electronics at UCL, realised that it might be possible to adapt this research to transmit wireless signals over multimode fibre without the need for down-conversion/up-conversion as used in commercial systems. In addition to simplifying the system by removing the need for frequency synchronisation this could enable multiple wireless signals to be distributed over a single multimode fibre with consequent major cost reductions arising from the cheaper multimode fibre component costs.

Professor Seeds proposed a joint research project to explore this possibility to Dr Penty and his colleague Professor White; together they wrote the proposal for the collaborative project "Fibre-Radio for In-Building Distributed Antenna Systems (FRIDAY)". This was funded under the EPSRC-DTI LINK scheme, with project partners Agilent Technologies (UK) Ltd and Airtech Ltd, and undertaken between 2001 and 2004 between UCL and the University of Cambridge (Dr, later Professor Penty and Professor White having moved to Cambridge). The UCL PI was Professor A J Seeds and the Research Associate was Dr D Wake (2001-2003). The UCL researchers showed for the first time that it was indeed possible to transmit wireless signals over multimode fibre without down-conversion [2]. The FRIDAY research showed that it was possible to carry multiple wireless services (such as cellular and Wi-Fi) over a single optical fibre, and that multimode optical fibre could be used to carry wireless services with carrier frequencies beyond its -3 dB (electrical) frequency cut-off reliably (< 4 dB/km, 3 GHz). This led to a joint UCL/Cambridge patent [3].

The inventors named on the patent are Professor Seeds and Dr Wake (UCL), and Professors Penty and White, together with Dr Webster and Dr Hartmann (Cambridge). The revenue-sharing agreement confirms that the contributions of the UCL and Cambridge teams to the intellectual property are equal [3].The patented technology has enabled multiple wireless services to be

carried on a single multimode fibre, offering a major cost reduction [4, 5].

Professor Seeds and Dr Wake, with Professors Penty and White from Cambridge, and Dr Parker (CEO of SPI Lasers), founded the company Zinwave Ltd in November 2002 to exploit the research commercially. On behalf of the patent owners (UCL and Cambridge), UCL licensed patent WO2004056019 and associated know-how to the company in 2003.

To facilitate transfer of UCL radio-over-fibre technology to Zinwave, Professor Seeds obtained an EPSRC Research Associate Industrial Secondment (RAIS) grant of value £36.5 k, enabling radio-over-fibre researcher Dr Chin-Pang Liu to work at Zinwave half time for two years, commencing May 2004. Since 2005, Professor Seeds has obtained further support for UCL wireless-over-fibre and related research totalling some £15.8 million.

3. References to the research

1. Seeds, A. J.: "Microwave photonics", IEEE Trans. Micro. Theory & Tech., 2002, MTT-50, pp. 877-887, (Invited Paper) http://dx.doi.org/10.1109/22.989971 Cited 389 times on Google Scholar

2. Wake, D., Dupont, S., Vilcot, J.-P. and Seeds, A.J.: "32-QAM radio transmission over multimode fibre beyond the fibre bandwidth", International Topical Meeting on Microwave Photonics. Post Deadline Papers. MWP'01 (Cat. No.01EX476), 2001, pt. suppl., 4 pp. http://dx.doi.org/10.1109/MWP.2002.982299

3. WO2004056019: A. J. Seeds, D. Wake, R. V. Penty, M. Webster, P. Hartmann, I. H. White, priority 13 December 2002 http://patentscope.wipo.int/search/en/WO2004056019; Revenue Sharing Agreement concerning the patent between UCL and Cambridge University available on request.

4. Seeds, A. J.: "Wireless access over optical fibre: from cellular radio to broadband; from UHF to millimetre-waves", 15th Annual Meeting of the IEEE Lasers and Electro-Optics Society, Glasgow, Scotland (Cat. No.02CH37369), 2002, pt. 2, pp. 471-472. (Invited Paper). http://dx.doi.org/10.1109/LEOS.2002.1159385

5. Seeds, A. J. and Ismail, T.: "Broadband Access Using Wireless Over Multimode Fiber Systems", IEEE/OSA J. Lightwave Technol., 2010, 28 (16), pp. 2430-2435 (Invited Paper). http://dx.doi.org/10.1109/JLT.2010.2053347

References [2], [3] and [5] best demonstrate the quality of the research.

Research funding: EPSRC grants GR/N13616/01 (2000-2004, £0.17m) and FRIDAY GR/R40364/02 (2002-2004, £98,124), EP/D037026/1 (2005-2011, £0.43m); EP/D076722/1 (2006-2010, £0.33 m); EP/G037256/1 (2009-2018, £7.2m) and EP/J017671/1 (2012-2017, £6.6m) and EU Contracts FP7 ISIS (2006-2008, €0.16m); FP7 IPHOBAC (2006-2009, €0.46m); FP7 iPHOS (2010-2013, €0.58m) and ITN MITEPHO (2010-2013, €0.37m).

4. Details of the impact

Since its founding in 2002, Zinwave has had increasing commercial success [text removed for publication]. The company's annual revenue has grown by a factor of 10 [text removed for publication] despite difficult market conditions [a]. Professor Seeds was a Zinwave Director from its founding until 2005, and together with Professors Penty and White served on the Technical Advisory Board until 2011 [b].

Zinwave Ltd has introduced wideband distributed antenna systems to the global marketplace, with systems deployed in Europe, the USA, the Middle East, Australia and China. The Zinwave 3000 System, which includes options increasing the flexibility of deployments, was released in 2008. Its unique selling point, namely wideband radio-over-fibre distribution of radio signals over a DAS network, uses the underpinning research carried out in the FRIDAY and subsequent RAIS projects. The Zinwave DAS is a three-stage system for in-building cellular and wireless services, constituting a primary hub, secondary hubs, and remote units. It uses multimode or single-mode fibre cable for connectivity. The technology features true wideband capabilities allowing simultaneous support for any wireless standard including 2G, 3G, 4G, LTE, PMR/LMR, DVB-H, TETRA, Wi-Fi, WiMAX and RFID. Full management control over this spectrum allows new services to be added on-demand without deploying additional system components. The technology can be configured in a single,

dual star or mixed architecture to meet exact service needs. The advantage to the customer is that a single distribution system can distribute multiple wireless services operating with different protocols and at different frequencies. For example, a single system may carry private VHF radio, public safety radio, such as TETRA, 2G cellular services at 900 MHz and 1,800 MHz and 3G services at 2,100 GHz from multiple operators. The conventional approach would require the installation of dedicated narrowband equipment for each and every different wireless standard, which is less flexible, more expensive and more complex to maintain.

As of mid-2013, the company has grown to some 25 employees, with its headquarters in Cambridgeshire, and offices and representation in the US, Middle East and Far East. Its systems provide wideband wireless coverage in shopping malls, auditoria, office buildings, casinos, convention centres, hospitals and airports, in the US, Europe, the Middle East and the Asia-Pacific region, including the Queen Alia international airport in Jordan, Erasmus MC and Martini Hospitals (Rotterdam and Groningen, Netherlands); a Garmin data centre in New Jersey; the 9/11 Memorial Museum in New York City; Jakarta International Airport; the Perry nuclear power plant outside Cleveland, Ohio; and the Westfield retail complex in Melbourne.

The company has established partnerships with more than 40 specialist in-building system integrators, extending its reach into both commercial and public safety markets. Testimonies from these partners attest to the cost-effectiveness, ease of use and flexibility of the Zinwave DAS for its customers:

The adoption of Zinwave technology has helped ensure public safety in stadiums at the UEFA Euro 2012 tournament. Zinwave's Ukrainian partner, Dolya & Co, said: "The Zinwave system offered great flexibility and was easy to install. Its simple architecture and its multi-frequency support enabled us to integrate UEFA's two-way radio system onto the overall DAS without affecting performance or signal output. During the opening ceremony it became apparent that our installation was the only one that provided reliable coverage underground. Zinwave's DAS therefore played an important role during the tournament – acting as the 'lifebuoy' for all critical radio and public safety communications" [c].

In 2010, Obelisk, a systems integrator, installed a Zinwave DAS at the Convention Centre Dublin. Obelisk said: "When deploying cellular coverage across multiple operator networks and multiple services, including O2, Vodafone and Meteor, throughout the conference centre across the full service mix, being able to simply plug them in without worrying about service-specific hardware is a major advantage. Zinwave's system has provided us with the most cost-effective solution while the intelligence and flexibility of the architecture simplified deployment of cellular sectorisation. Thanks to Zinwave's innovative, future-proof DAS, we can add any future service at any frequency that may become available, with the ability to easily expand to meet future needs" [d].

ROOTS Communications installed a system at the Esplanade in Singapore, one of the busiest performing arts centres in the world. One of their directors said of the 2013 project: "Flexibility, scalability and easy deployment are key to all our installations and Zinwave's DAS offers all of this. In addition, its ability to support all existing services as well as new ones on the same hardware layer makes it compelling to our customers because it eliminates the need for expensive rebuilds or upgrades." [e]

Zinwave's systems can also provide coverage for the complex wireless needs of hospitals. Radio Access BV (Netherlands), which installed the system in the Netherlands' largest hospital complex in 2012, stated: "We have deployed Zinwave's DAS in numerous projects because it essentially allows us to provide our customers with a "wireless highway" from which they can run multiple services, irrespective of the frequency, over a single platform. It is unique in its ability to support all cellular frequencies, such as GSM and UMTS, as well as closed networks, over a single hardware layer making it completely future-proof" [f]. The same company also said: "More and more of our customers are asking us for a wideband solution without installing thick coaxial cables in their building… We feel that by providing our customers with this cutting-edge technology, we are providing the very best solution for in-building wireless coverage" [g].

In 2012, the largest wireless operator in the USA, Verizon Wireless, selected Zinwave to support the rollout of the new 4G mobile network in the USA. This is a significant achievement for a company of Zinwave's size and maturity, because large operators, such as Verizon, tend to be conservative and choose to buy from well-established large equipment suppliers. The speed with which Zinwave has attained formal supplier status is also impressive. This is related to Zinwave having a unique product and meeting all the requirements for quality, service and support. TriPower, a systems integrator for Verizon, set up Zinwave DAS in Denver's 21,000-seat Pepsi Center Arena in 2013. The President of TriPower said: "The joint effort between TriPower as the deployment partner and Zinwave's 3000 DAS system allows us to deliver an optimum wireless solution for high-demand coverage… In addition to ensuring calls are successfully connected, the DAS will allow smart phones, tablets and other mobile devices to access the Internet, send text messages and quickly share photos and videos to social networking sites, enabling visitors of the arena to have a great network experience" [h].

Commentators have identified Zinwave as a company on a high-growth trajectory: ABI Research named Zinwave in 2012 as "part of the next generation of DAS vendors and one of the companies to watch out for as the DAS market evolves" [i]; and the Red Herring Europe 100 Awards placed Zinwave among the finalists in April 2013 in its listing that "analyses and selects the top private companies in the European region … positioned to grow at an explosive rate" [j].

5. Sources to corroborate the impact

[a] Zinwave Ltd (England & Wales Company No. 04587255) and Zinwave Holdings Ltd (England & Wales Company No. 06496829) Annual Reports and Accounts, 2008-2012. (Available from www.companieshouse.gov.uk or from UCL)

[b] A statement from the Chief Technical Officer of Zinwave Ltd confirms details about the company (e.g. staff numbers, sales, the roles of Professors Seeds, Penty and White). Available on request.

[c] "Zinwave DAS technology guarantees TETRA coverage at Euro 2012", Zinwave press release, 22 November 2012, http://www.zinwave.com/news/release/zinwave-das-technology-guarantees-tetra-coverage-at-euro-2012/en

[d] "Zinwave addresses demanding multi-service requirements in prestigious International Conference Facility in Dublin", Zinwave press release, 1 September 2011, http://www.zinwave.com/news/release/zinwave-addresses-demanding-multi-service-requirements-in-prestigious-international-conference-facility-in-dublin/en

[e] "Zinwave's in-building wireless coverage system chosen by Singapore's Esplanade – Theatres on the Bay", Zinwave press release, 22 May 2013, http://www.zinwave.com/news/release/zinwaves-in-building-wireless-coverage-system-chosen-by-singapores-esplanade-theatres-on-the-bay/en

[f] "The largest hospital in the Netherlands selects Zinwave DAS technology for its indoor wireless coverage requirements", Zinwave press release, 25 September 2012, http://www.zinwave.com/news/release/the-largest-hospital-in-the-netherlands-selects-zinwave-das-technology-for-its-indoor-wireless-coverage-requirements/en

[g] Zinwave DAS solution sets the new gold standard for wireless coverage in the healthcare sector, Zinwave press release, 8 November 2011, http://www.zinwave.com/news/release/zinwave-das-solution-sets-the-new-gold-standard-for-wireless-coverage-in-the-healthcare-sector/en

[h] "Tripower to participate at ACI's 5th Annual DAS Congress", Tripower press release, 27 November 2012, http://tripower.com/tripower-to-participate-at-acis-5th-annual-das-congress-3/

[i] "Zinwave is recognised as a world leader in DAS innovation according to ABI Research", Zinwave press release, 17 October 2012, http://www.zinwave.com/news/release/zinwave-is-recognised-as-a-world-leader-in-das-innovation-according-to-abi-research/en

[j] 2013 Red Herring Europe Finalists, April 2013, http://www.redherring.com/events/red-herring-europe/2013_finalists/