

CURRICULUM VITAE – Professor Harald Haas June 2015

Office Address:

Chair of Mobile Communications
College of Science and Engineering
School of Engineering
The University of Edinburgh
The King's Buildings
Edinburgh EH9 3JL

1. UNIVERSITY EDUCATION AND DEGREES AWARDED

Ph.D. *Interference analysis of and dynamic channel assignment algorithms in TD-CDMA/TDD systems*, University of Edinburgh, July 2001

Dipl.-Ing. *Comparison of conventional controller with fuzzy controller*, Georg-Simon-Ohm University of Applied Sciences, Nürnberg (Germany), 1997

2. CAREER SINCE GRADUATION

08/10 – to date Professor of Mobile Communications, School of Engineering / Institute of Digital Communications (IDCOM), University of Edinburgh.

12/13 – to date Director of *Li-Fi Research and Development Centre*, University of Edinburgh

01/12 – to date Chief Scientific Officer (CSO) for pureLiFi Ltd (part-time)

08/08 – 07/10: Reader, School of Engineering / Institute of Digital Communications (IDCOM), University of Edinburgh.

06/07 – 07/08: Lecturer, School of Engineering / Institute of Digital Communications (IDCOM), University of Edinburgh.

09/02 – 06/06: Associate Professor of Electrical Engineering, School of Engineering and Science, Jacobs University Bremen

02/01 – 08/02: Project Manager, Siemens AG / Information & Communication Mobile Networks, Munich (Germany)

05/99 – 01/01: Research Associate, Department of Electronics & Electrical Engineering / Signals and Systems Group, University of Edinburgh

03/99 – 02/00: Consultant, Nokia Networks, Nokia / Oulu

08/95 – 10/97: Engineer, Siemens AG / Semiconductor Division (now Infineon), Munich (Germany)

02/95 – 07/95: Engineer (Heinz-Nixdorf scholar), Siemens AG, Bombay (India)

3. MAJOR RESEARCH INTERESTS AND IMPACT

Overview

- **£9.3M total**, in research grants as Investigator (**Principal Investigator & Co-Investigator**)
- **£5.0M** in research grants as **Principal Investigator**
- Successfully spun-out a company, **pureLiFi Ltd.**, from the Scottish Enterprise funded proof-of-concept project, D-Light, and raised **£1.5M** seed funding for pureLiFi Ltd within the first year after launch of company. The company has since developed and sold the first Li-Fi modems and is now in the process of raising a further **£7M** Series-A funding
- **£1.68M**, Awarded the only Established Career Fellowship of the Engineering and Physical Sciences Research Council (EPSRC) in Information and Communication Technologies (ICT) in the UK in 2012

- Leading the development of the University of Edinburgh's Li-Fi Research and Development Centre (Li-Fi R&D Centre) – <http://www.lifi-centre.co.uk/> since December 2013. The Li-Fi Centre has to date secured in excess of **£8M** in competitively won funding.
- **£100k** Equipment Donation from National Instruments for 5G testbed in the UK, <http://online.wsj.com/article/PR-CO-20131120-907217.html>, 2013
- Selected as one of 10 **EPSRC RISE leaders** (Recognising Inspirational Scientists and Engineers) 2014
- Shortlisted for two 2014 **IET Innovation Awards**
- **296 refereed publications (82 Journal articles** – including a Science paper which has been **cited 413 times** (Web of Science, 06-11-2014), and **6 invited journal papers; 214 international conference papers including four best paper awards)**
- Recognised internationally as the 'Father of Li-Fi'. TED video "Wireless data from every light bulb" (http://www.ted.com/talks/harald_haas_wireless_data_from_every_light_bulb.html) has been watched more than **1,560,000** times
- Appearance in several international media channels such as BBC, NPR, CNBC, New York Times, Wired UK, NewScientist, The Economist, Financial Times and CNN International.
- Invented **Spatial Modulation** which is now researched world-wide. There are more than 100 papers in IEEEExplore that have "spatial modulation" in the title. Leading IEEE Transactions on Vehicular Technology paper entitled "Spatial Modulation" has been cited **217 times** (Web of Science, 6 November 2014).
- **1 book** published with Cambridge University Press, H. Haas and S. McLaughlin, "Next Generation Mobile Access Technologies: Implementing TDD"
- **1 book** published with Cambridge University Press: S Dimitrov and H. Haas, "Principles of Infrared and Visible Light Communications"
- **3 invited** book chapters (Wiley & Sons / Econ Verlag)
- **31 awarded** patents (and more than **30 pending** patent applications)

Supervision and Examination

- **1st supervisor** to **10 current PhD students** (Tezcan Cogalan, Yunlu Wang, Zhe Che, Cheng Chen, Yichen Li, Eric Yin, John Fakidis, Elham Sarbazi, Hossein Kasemi, Rui Ban)
- **2nd supervisor** to **two students** as part of the JRI for Signal & Image Processing between The University of Edinburgh and Heriot-Watt University (Ammar Ghazal, Fourat Haider)
- **Supervisor** to **7 current Research Associates** (*Dr Stefan Videv, Dr Dushyantha Basnayaka, Dobroslav Tsonev, Dr Muhammad Ijaz, Dr Oscar Almers, Xiping Wu, Athanathios Stavridis*)
- **1st supervisor** to **21 completed PhD students**: *Raed Mesleh, 2007; Hrishikesh Venkataraman, 2007; Denis Kolyuzhnov 2009; Ellina Foutekova, 2009; Birendra Ghimire, 2010; Hany Elgala, 2010; Rami Abu-Alhiga, 2010; Zubin Bharucha, 2010; Mostafa Afgani, 2010; Abdurazak Mudesir, 2010, Rui Wang, 2011 (joint with Prof Thompson); Harald Burchardt, 2012; Nikola Serafimovski, 2012, Bogdan Pricope; 2012; Svilen Dimitrov, 2012; Stefan Videv, 2013; Abdelhamid Younis, 2013; Thilo Fath, 2013; Hauke Holtkamp, 2013; Irina Stefan, 2013; Alan Anderson, 2014*
- **External examiner of 7 PhD students:**
 - *Janis Maniatis, University of Kaiserslautern (Germany), 2005;*
 - *Xia Li, Monash University (Australia), 2009,*
 - *Mai Tran, University of Bristol (UK), 2010*
 - *Xuan Tang, University of Northumbria (UK), 2012*
 - *Ahmed Helmi Azhar, Oxford University (UK), 2013*
 - *Serkan Uygungelen, Technical University Hamburg-Harburg (Germany), 2015*
 - *Mahmoud Beshr, Strathclyde University (UK), 2015*

- **Internal examiner of six PhD students**

- *Iyad Tumar*, Jacobs University Bremen
- *Christoph Burger-Scheidlin, Chao Wang, Yuanyuan Fei, Huquin Du, Hongjian Sun*, The University of Edinburgh

Research achievements

Haas' research is concerned with novel techniques and algorithms for wireless communications. Key achievements can be summarised as follows:

- 1) Professor Haas and his team have recently demonstrated that solar cells can be used as VLC data detectors. This means that solar cells can harvest energy of a signal that carries high speed digital data, in addition to harvesting ambient light. Haas' group have recognised this as a dual principle of using LED light for data communication and illumination (Wang, *et al.*, 2014). This could pave the way for battery-free, self-powered and low complex high speed data transceivers for the internet-of-things (IoT), for example. His group have demonstrated record speeds of 15 Mbps from an off-the-shelf 20 cm x 20 cm solar cell as well as 25 Mbps from a 2 mm x 2 mm organic solar cell in collaboration with Prof Samuel and Dr Turnbull at St. Andrews University.
- 2) Professor Haas published the first proof-of-concept results demonstrating that it is possible to exploit the high crest factor, or peak-to-average power ratio (PAPR), of OFDM (orthogonal frequency division multiplexing) to turn commercially available LED (light emitting diode) light sources into high speed wireless transmission systems (Afgani, *et al.*, 2006), The PAPR is commonly accepted as a disadvantage in RF (radio frequency) communications. His group has turned this disadvantage into an advantage in intensity modulation (IM), direct detection (DD) systems. Haas and his team have further developed closed-form solutions to model the impact of LED non-linearities on system performance (Tsonev, *et al.*, 2013), and found the optimum system parameters such as the direct current (DC) bias level, the standard deviation of the modulation signal, and optimum bit and power loading to minimise the bit error ratio (BER), while maximising the data rate (Dimitrov, *et al.*, 2012). This has led to record speed transmissions in free space visible light communication (Tsonev, *et al.* 2013) and has been mentioned in online BBC News - <http://www.bbc.co.uk/news/technology-24711935>.
Recently, Haas' group have achieved 15 Gbps by mixing incoherent red, green and blue light. This work is not yet published. Theoretic work by his group has shown for the first time that IM/DD systems can achieve Shannon capacity limits if the DC bias can be reduced to zero (Dimitrov, *et al.* 2013). Since IM/DD requires unipolar and real valued signals existing attempts to minimise the DC bias have always led to techniques that ended up in 50% rate loss, such as asymmetrically clipped optical OFDM. Haas' group have first overcome this long-standing problem by introducing a new technique that they dubbed enhanced unipolar OFDM (eU OFDM) (Tsonev, *et al.*, 2014). They have demonstrated theoretically as well as experimentally that it is indeed possible to overcome the 50% rate loss completely. The cost is increased decoding complexity, but due to the capabilities of modern signal processors this does not really constitute a hurdle for practical systems. In fact, as part of the EPSRC project *Dynamic Adaptation in Heterogeneous Multicore Embedded Processors* (EP/I013539/1) in collaboration with Prof. Nigel Topham at the School of Informatics, University of Edinburgh, a multicore signal processor chip has been developed. As a consequence of these significant advancements free space visible light communication, or Li-Fi, achieves link data rates that are comparable to, or even higher than state-of-the-art RF systems. This is a turning point as VLC has now reached a state where other people start to consider it as a complementary part of a future 5G cellular standard.

- 3) Haas and his team have pioneered networked VLC, which they also refer to as Li-Fi attocell networks (Haas, 2012). They have shown that the directivity of LED light and photodetectors can be harnessed to achieve effective co-channel interference avoidance techniques in Li-Fi attocell networks by exploiting angular diversity at the transmitter and the receiver (Zhe, *et al.*, 2014). They have shown that the property of power signals in IM/DD systems to superimpose only constructively can be exploited to realise very effective fractional frequency reuse systems by using cooperative multipoint transmission at the cell edges (Chen, *et al.* 2014). Moreover, Haas has first started to compare the area spectral efficiency of indoor small cell RF networks with the area spectral efficiency that can be achieved by an indoor Li-Fi attocell network, and they have reported gains of up to 1000. They have also shown that very effective load balancing techniques between radio and optical wireless systems can be developed which off-load significant amount of traffic from over-crowded RF indoor wireless networks. One such technique hands off users to the Li-Fi attocell network when they have become stationary or quasi-stationary (Wang, *et al.*, 2014). Along with the breakthrough developments on the physical layer as described in 2), the works on Li-Fi attocell networking, and the selected route to commercialisation by his spin-out company, pureLiFi, Haas' group has laid a broad and in-depth foundation for the use of LED lights in future wireless networks.
- 4) Haas first proposed *spatial modulation*, also sometimes referred to as *space-shift keying*, which combines multiple antenna transmission and digital modulation and coding in a radically different fashion and completely solves the inter-channel interference problem of MIMO (multiple-input-multiple-output) systems (this was investigated under EPSRC grant EP/G011788/1). This idea was jointly patented by Samsung/South Korea and The University of Edinburgh. A further patent on trellis coded spatial modulation was filed by The University of Edinburgh (February 2009). The research community acknowledged this work, and several works that build on the initial publications can now be found in literature, *e.g.*:
- Basar, E.; Aygolu, U.; Panayirci, E.; Poor, H. V.; "Space-Time Block Coded Spatial Modulation", *IEEE Trans. on Commun.*, Vol. 59, Iss. 3, March 2011
 - Jeganathan, J.; Ghrayeb A.; and Szczecinski, L.; "Spatial Modulation: Optimal Detection and Performance Analysis", *IEEE Commun. Lett.*, vol. 12, no. 8, pp. 545–547, August 2008.
 - Handte, T.; Müller, A.; Speidel, J.; "BER Analysis and Optimization of Generalized Spatial Modulation in Correlated Fading Channels," *IEEE Vehicular Technology Conference Fall (VTC 2009-Fall)*, pp.1-5, 20-23 September 2009
 - Sugiura, S.; Chen, S.; and Hanzo, L.; "Coherent and differential space-time shift keying: a dispersion matrix approach," *IEEE Trans. on Commun.*, 2010
 - Zhang, Rong; Yang, Lie-Liang; Hanzo, Lajos, "Generalised Pre-Coding Aided Spatial Modulation," *IEEE Transactions on Wireless Communications*, , vol.12, no.11, pp.5434,5443, November 2013

For the first time the practical feasibility of *spatial modulation* could be demonstrated on the UK testbed of the UK-China Science Bridge project R&D on 4G Wireless Mobile Communications (EP/G042713/1) at the end of 2011. This has involved the collaboration of research groups from Heriot-Watt University and the Universities of Bristol and Edinburgh.

Currently, spatial modulation is considered as potential technique for energy efficient massive MIMO systems as it only requires a **single** RF chain, independent of the number of transmit antennas. This constitutes a significant advantage for future energy efficient **and** spectrum efficient wireless transmission systems. Haas and his colleagues Dr. Renzo and Prof. Ali Ghrayeb have given more than 10 tutorials on SM at major IEEE conferences.

- 5) Spatial modulation extends the well-known two dimensional signal constellation diagram, that is underlying all digital modulation techniques, into a three dimensional constellation diagram where the spatial position of the transmitting elements constitute the spatial constellation points. As a consequence of the spatial constellation point, SM exhibits spatial multiplexing (MIMO) gains. At the receiver, a detector estimates the active transmitter in the transmitter array, and can thus decode the spatial information. This principle is not only applicable to coherent RF transmission systems, but also to IM/DD systems, i.e., to VLC systems, and the respective concepts were filed for patent by the University of Edinburgh (September 2009). This patent partially forms the scientific basis for the proof-of-concept (PoC) project, D-Light, funded by Scottish Enterprise. The D-Light project has resulted in the spin-out company, pureLiFi Ltd. Further analyses of SM in comparison to spatial multiplexing optical MIMO and repetition coding optical MIMO has underpinned the advantages of SM in VLC systems (Fath, *et al.*, 2012, 2013).

- 6) An entire new framework for *cooperative interference mitigation* in cellular wireless networks based on one key invention, the "busy burst" principle, has been developed and analysed by Haas in collaboration with DOCOMO Euro Labs (Munich). This invention solves one of the most fundamental problems in wireless communications, namely that a new transmitter in a wireless network cannot sense the location of a vulnerable receiver (also called the hidden node problem) where a transmission would cause detrimental interference to the ongoing transmission. We exploit a key feature of time division duplex (TDD), channel reciprocity, and let the receiver transmit a "busy burst" in a mini slot. The proposed concept solves the hidden node problem and at the same time provides a powerful feedback channel and is, therefore, applicable to a wide range of wireless access means such as cognitive radio, *ad hoc* communication, spatial division multiple access (SDMA), multiuser MIMO, *etc.*. To date, this has led to *eight granted* patents and several journal and conference publications. DOCOMO has recently proposed parts of this work for the 3GPP LTE standard, Release 9 and Release 10. In this context, DOCOMO submitted the following technical contribution at a standardisation meeting in Shenzhen/China, August 2009.
(Available online at [http://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_52/Documents/-document number: R4-093244](http://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_52/Documents/-document%20number%3A%20R4-093244):
 - DOCOMO Euro Labs, "Downlink Interference Coordination Between eNodeB and Home eNodeB," *3GPP TSG-RAN Working Group 4 (Radio)*, meeting #52, R4-093244, (Shenzhen, China), 24-28 August 2009

- 7) Collaborative research work with Professor Jäger (Jacobs University Bremen), whose research interest is in machine learning, has led to an article in Science Magazine. In this work it was shown for the first time that the novel "bio-inspired" echo-state networks can be used to save energy in mobile receivers since it has been found that these particular neural networks can be designed to effectively mitigate the detrimental effects (e.g., inter-symbol interference) caused by the non-linear characteristics of the power amplifiers in mobile devices. In 2003, when this work was conducted, "green" information and communications technology (or "green" radio) was not the major research topic it is now. To date, the paper has been cited 413 times (Web of Science) and the fundamental techniques proposed in the paper are now being considered for application to a large variety of open engineering problems.

- 8) Haas and his group developed a signal feature extraction algorithm for anomaly detection based on the Kullback-Leibler divergence metric. While many algorithms exist that allow for the detection of anomalies in a data file in a post-processing manner, the strength in the proposed approach lies in the fact that anomalies can be detected in real time – essentially acting as a real-time filter. This avoids the requirement for storing large amounts of data which is important in the test and measurement area, surveillance, data security and cognitive radio fields. The core concepts have been patented by Agilent Technologies. The developed algorithm has successfully been implemented in a FPGA (field programmable

gate array) to be used within Agilent measurement instruments. The prototype was demonstrated to product divisions during an internal fair at the Agilent headquarters in Santa Clara (USA) in June 2009.

- 9) A novel indoor positioning technology based on pedestrian dead reckoning was developed. This method requires accurate speed estimation at very low speeds. This has been accomplished via a novel speed estimation approach that uses relative RF signature matching in combination with multiple antennas at the receiver. The technology was patented by Jacobs University, and the Bremen and Bremerhaven based company MobilTec GmbH & Co. KG is currently exploiting this technology. In addition, this work resulted in an **invited** journal publications (Afgani, M., Sinanović, S., Khashaba, K. and Haas, H., "Radio Frequency Signature Correlation Based Speed Estimation for Indoor Positioning," *Journal of Communications*, vol. 4, no. 2, pp. 96 – 107, March 2009.
- 10) At Siemens and in collaboration with the University of Ulm, a novel MIMO transmission technique, named *cyclic delay diversity* (CDD), was developed which led to an invited journal paper: Hübner, F. Schühlein, M. Bossert, E. Costa and H. Haas, "On Space-Frequency Coding Using Cyclic Delay Diversity for OFDM Based Transmission Systems," *European Transactions on Telecommunications* (ETT), vol. 14, no. 6, pp. 491 - 500, Nov./Dec. 2003 and a patent. Cyclic delay diversity is now part of the 3GPP – LTE (3rd generation partnership project – long term evolution) standard. This standard is the leading standard for cellular mobile communication.
- 11) During his PhD, Haas developed the “TDD underlay” concept which is a spectrum sharing and cognitive radio technique. Both areas were only starting to attract the interest of researchers at the time, and Haas contributed pioneering work on this topic. A paper on the TDD underlay concept presented at the IEEE international conference on Personal, Indoor and Mobile Radio Communications (PIMRC 1999) was awarded the best paper prize. Moreover, a patent on the TDD underlay filed by the University of Edinburgh was sold to Siemens in 1999. This was one of the first cases where a patent generated within the Signals and Systems Group at The University of Edinburgh was sold to industry, and it demonstrated the significance of the work undertaken. Now the TDD underlay is proposed for standardisation by Nokia Siemens Networks.
- 12) Haas continued with research on dynamic channel assignment (DCA) technologies for cellular CDMA-TDD systems. He demonstrated with the novel TS (time slot)-opposing algorithm that additional interference issues inherent to cellular TDD systems can be mitigated by DCA. It was, to the best of the author’s knowledge, for the first time claimed that TDD can be employed for cellular networks without sacrificing the key advantage of TDD – which is the support of channel asymmetry. This work was in cooperation with Nokia (Finland), and Nokia pursued a patent application which was awarded in 2006. Further DCA algorithms were developed and published. The key finding was that TDD offers *interference diversity* which essentially was exploited by the novel algorithms to achieve even better system performance than an equivalent FDD system. Three reports about these issues were submitted to UKTAG (now Ofcom) in 1999.
- 13) From 2001 to 2002, Haas was research project manager at Siemens (Information and Communication Mobile Networks). He was responsible for an international company-funded research project involving three Chinese and three German universities. The main goal of this project was to develop a patent portfolio for 4th generation wireless access technologies. As a result, more than 18 patents were filed within the period of about 1.5 years.

Private-Sector Cooperations

- *Agilent Technologies, United Kingdom*
- *EADS, UK*
- *EADS, Germany*
- *NTT DoCoMo Euro Labs, Germany*
- *Airbus, Germany*
- *Nokia, Finland*
- *Siemens, Munich*
- *Samsung, Korea*
- *Huawei, Beijing*
- *Alcatel Lucent, Bell Labs, Ireland*
- *OHB, Bremen, Germany*
- *Thales, France*

Academic Cooperations

- *Keio University, Japan (Prof. Masao Nakagawa, Prof. Riaz Esmailzadeh, Keio University)*
- *Beijing University of Posts and Telecommunication, China (Prof. Ping Zhang)*
- *Southeast University Nanjing, China (Prof. Xiaohu You)*
- *Beihang University, China (Prof. Chenyang Yang)*
- *Oxford University, UK (Prof. Dominic O'Brien)*
- *Cambridge University, UK (Prof. Richard Penty, Prof. Ian White)*
- *Strathclyde University, UK (Prof Martin Dawson)*
- *University of St. Andrews , UK(Prof. Ifor Samuel)*
- *University of Bristol, UK (Prof. Dimitra Simeonidou)*
- *Heriot-Watt University, UK (Prof. Steve McLaughlin, Prof. Cheng-Xiang Wang)*
- *Lancaster University, UK (Prof. David Hutchison)*
- *University of Southampton (Prof. Lajos Hanzo)*
- *CNRS, France (Dr. Marco Di Renzo)*

4. PRINCIPAL RESEARCH GRANTS

Total funded as **PI ≈£5,300,000**, as PI + Co-I = **≈£9,300,000** (during last 10 years)

5. RAE STATUS

Full submission for UK RAE (research assessment exercise) 2008 and 2014.

6. RESEARCH SUPERVISION

Current, as principal supervisor (PhD Students)

1. Zhe Chen (commenced 01.09.2012), *MIMO in Optical wireless Networks*, UoE
2. Chen Cheng (commenced 01.10.2012), *Interference mitigation in Optical Wireless Networks*, UoE
3. Yichen Li (commenced 01.11.2012), *Digital Modulation techniques for Optical Wireless Systems*, UoE
4. Tezcan Cogalan (commenced 01.01.2014), *Interference mitigation in Optical Attocell Networks*
5. Yunlu Wang (commenced 01.01.2014), *Hybrid Optical Wireless RF Systems*
6. John Fakidis (commenced 01.10.2012), *Li-Fi for Wireless Backhaul*
7. Eric Yin (commenced 01.09.2014), *Multiuser Access in Li-Fi Networks*
8. Elham Sarbazi (commences 01.01.2015), *Channel Models for VLC Systems*
9. Hossein Kazemi (commences 01.01.2015), *Single photon VLC Receivers*
10. Rui Ban (commences 01.01.2015), *Adaptive Optics for Li-Fi*

Current, as principal supervisor (Research Fellows)

- Dr Stefan Videv (since April 2013), University of Edinburgh
- Dr Dushyantha Basnayaka (since June 2013), University of Edinburgh
- Dr Oscar Almer (since October 2012), University of Edinburgh, joint with Dr. Henderson
- Dr Mohammad Ijaz (since October 2013), University of Edinburgh
- Dobroslav Tsonev (since September 2014), University of Edinburgh
- Xiping Wu (since September 2014), University of Edinburgh
- Athanasios Stavridis (since August 2014), University of Edinburgh

Past, as principal supervisor (Research Fellows)

- Dr. Zixiong Wang, (May 2013 – April 2014), University of Edinburgh
- Dr Abdelhamid Younis (October 2013 – October 2014), University of Edinburgh
- Dr Sinan Sinanovic (September 2016 – December 2012), Jacobs University and University of Edinburgh
- Dr Wasiu Popoola, (April 2010 – December 2011), University of Edinburgh
- Dr Enrique Poves, (September 2011 – August 2012), University of Edinburgh
- Dr Marco Di Renzo (May 2009 – December 2010), University of Edinburgh
- Dr Van-Duc Nguyen (April 2005 – March 2006), Jacobs University
- Dr Peter Omiyi (June 2003 – December 2007), Jacobs University
- Dr Stephane Beauregard (August 2004 – September 2005), Jacobs University
- Dr Raed Mesleh (Jacobs University) (June 2003- September 2010), Jacobs University
- Dr Mostafa Afgani (January 2010 – December 2011), University of Edinburgh
- Dr Gordon Povey (October 2010 – December 2011), University of Edinburgh
- Dr Birendra Ghimire (July 2010 – August 2011), Jacobs University
- Dr Hany Elgala (April 2010 – December 2011), Jacobs University

Current, as second supervisor (PhD Students)

- Ammar Ghazal, and Fourat Haider (principal supervisor: Dr Cheng-Xiang Wang)

Graduated, as principal supervisor (PhD Students)

1. Raed Mesleh (commenced November 2004; graduated September 2007), Jacobs University
2. Hrishikesh Venkataraman (commenced August 2004; graduated September 2007), Jacobs University
 - a. received best paper award for a paper entitled "prioritized adaptive multimedia streaming" at the World Congress on Engineering and Computer Science (WCECS'09), San Francisco, USA, 20-22 October, 2009
3. Denis Kolyuzhnov (commenced January 2005, graduated June 2009), Jacobs University
4. Ellina Foutekova (commenced January 2005, graduated November 2009), University of Edinburgh
5. Birendra Ghimire (commenced April 2006, graduated 2010, University of Edinburgh)
6. Hany Elgala (commenced January 2007, graduated 2010), Jacobs University
7. Zubin Bharucha (commenced April 2006, graduated 2010), University of Edinburgh
8. Rami Abu-Alhiga (commenced April 2006, graduated 2010), University of Edinburgh
9. Abdurazak Mudesir (commenced September 2006, graduated 2010), Jacobs University
10. Mostafa Afgani (commenced August 2006, graduated 2011), University of Edinburgh
11. Rui Wang (joint supervision with Dr John Thompson) (commenced August 2006, graduated 2011), University of Edinburgh
12. Svilen Dimitrov (commenced September 2009, graduated 2012); *Analysis of OFDM-based Intensity Modulation Techniques for Optical Wireless Communications*, UoE
13. Stefan Videv (commenced February 2009, graduated 2013), *Energy efficient scheduling and radio resource allocation*, UoE
14. Nikola Serafimovski (commenced January 2009, graduated 2013), *Extension and Practical Evaluation of the Spatial Modulation Concept*, UoE
15. Harald Burchardt (commenced 01.01.2010, graduated 2013), *Interference Management in Wireless Networks*, UoE

16. Bogdan Pricope (commenced October 2008, graduated 2013), *Indoor Positioning and Navigation*, Jacobs University Bremen
17. Stefan Videv (commenced February 2009, graduated 2013), *Techniques for Green Radio Cellular Communications*, UoE
18. Abdelhamid Younis (commenced September 2009, graduated 2013), *Spatial Modulation: Theory to Practice*, UoE
19. Hauke Holtkamp (commenced February 2010, graduated 2013), *Enhancing the Energy Efficiency of Radio Base Stations*, UoE
20. Irina Stefan (January 2009, graduated 2013), *Enabling Networked Visible Light Communications*, Jacobs University Bremen
21. Alan Anderson (September 2010, viva August 2014 with minor corrections), *Channel Prediction in Wireless Communications*

7. TEACHING EXPERIENCE

TEACHING EXPERIENCE

Teaching at The University of Edinburgh (2007 – date):

- **Communication Engineering 3** (U00444) (Semester 2, 2007 - 2012). On average 40 undergraduate students; 20 lectures, 9 tutorials, 9 example classes
- **Digital Communications 4** (U00367) + **Digital Communications Fundamentals** (P01808 / MSc course) (Semester 1, 2008 – 2012). On average 25 undergraduate students and 25 MSc students; 20 lectures, 9 tutorials
- **Advanced Digital Communications** (P01825 / MSc course) (Semester 2, 2008 - 2012). On average 25 MSc students; 10 lectures, 5 tutorials (jointly with Dr Thompson who delivers additional 10 lectures and 4 tutorials)
- **MSc project supervision**; on average three MSc projects are supervised per year between January and August (weekly one hour meetings with students).
- **BEng project supervision**; Supervised on average two BEng projects between January and August from 2010-2012

Teaching at Jacobs University (2002 – 2007)

- **Linear Circuit Analysis (2002 – 2004)**. On average 25 undergraduate students; 28 lectures
- **Digital Communications (2003 – 2006)**. On average 25 undergraduate students; 28 lectures
- **Bachelor Thesis Project Supervision (2004-2007)**. Supervision of more than 30 projects since 2004 – on average 8 student projects per year.
- **Wireless Communications I (2004 – 2006)**. on average 17 graduate and undergraduate students; 28 lectures
- **Wireless Communications II (2005 - 2007)**. Graduate course, newly developed and first offered in Fall 2005.
- **Wireless Communications: Research Project Supervision (2003-2007)**. Supervision of more than 25 projects since 2003 – on average 8 student projects per year.

8. SOCIETY MEMBERSHIP

- *Member IEEE*

9. CONTRIBUTION TO UNIVERSITY DEVELOPMENT AND MANAGEMENT

At the University of Edinburgh:

- **Course director** for the one year MSc program “Signal Processing and Communications” from September 2008 to March 2013

- **Course director** for a collaborative MSc program “Digital Communications and Signal Processing” which is exclusively with Beihang University (China) and was initiated by the former Head of School, Professor P. M. Grant. This program was approved 2010. First students arrived in academic year 2011/2012.

At Jacobs University:

- Major Representative of the Electrical Engineering Group at Jacobs University
- Member of the Dean’s task force meeting representing the EE faculty
- **Representative of Electrical Engineering** at the Perspectives Commission meetings (The Perspective Commission consists of highly recognised international scientists and company board members, e.g. Prof. Malcolm Gillis, PhD (former president of Rice University, Houston Texas), Prof. Arthur Jaffe, PhD (Professor of Mathematics, Harvard University), Prof. Dr. Mlynek (former president of Humboldt University Berlin and now president of the Helmholtz-Gesellschaft Deutscher Forschungszentren), Prof. Dr. Claus Weyrich (Member of the board, Siemens AG).
- **Representative of Electrical Engineering** in the Acquin **accreditation process** of the Electrical Engineering undergraduate curriculum. Coordinated the submission of required information to the Dean’s office. Took part in the question/answer meeting with the Acquin committee. The EECS major at Jacobs University was accredited in 2005.
- **Representative of Electrical Engineering** in the faculty search committee
- **Member of the committee developing an undergraduate curriculum** for the combined major ‘Electrical Engineering and Computer Science (EECS)’ at Jacobs University. Took a leading role in the development of the curriculum.
- **Initiator and Spokesperson of the Graduate Program in Electrical Engineering:** ‘*Communications, Systems, and Electronics*’ at Jacobs University (commenced Sep 2003). Until leaving the Jacobs University in June 2007, I represented the graduate program in the *graduate program coordinators committee*.
- **Member of the Information Resource Committee.** The committee was concerned with the improvement of information technology and resources across the university. Represented Electrical Engineering and Computer Science faculty.
- **Academic Advisor to more than 10 undergraduate and more than 15 graduate students.** The advisory role included the provision of guidelines and recommendations for the selection of study courses, seminars and projects, provision of contacts for internships (the Bachelor program at Jacobs University requires a 3 month Internship in the 2nd year), and provision of general advice.

10. INVITED PAPERS & BOOK CHAPTERS

Invited Papers

- Invited paper Optics Express: Tsonev, Videv, and Haas, “Towards a 100 Gb/s Visible Light Wireless Access Network”, submitted
- Invited paper at Photonics West, 1-6 February 2014, San Francisco
- Invited paper at IEEE ICC, 12-14 August 2013, Xi’an, China
- Dimitrov, S.; Haas, H.; Cappitelli, M.; and Olbert, M.; “On the Throughput of an OFDM-based Cellular Optical Wireless System for an Aircraft Cabin“, in *Proc. of 5th European Conference on Antennas and Propagation (EuCAP 2011)*, (Rom, Italy), IEEE, 11. – 15. April 2011, 5 pages
- Burchardt, H.; Bharucha, Z.; Haas, H.; and Auer, G.; “Uplink Interference Protection and Fair Scheduling for Power Efficient OFDMA Networks“, in *Proc. of 8th International Workshop on Multi-Carrier Systems & Solutions (MC-SS 2011)*, (Herrsching, Germany), IEEE, 3. – 4. May 2011, 5 pages
- Mesleh, R.; Elgala, H.; Hammouda, M.; Stefan, I.; and Haas, H.; “Optical Spatial Modulation with Transmit-Receiver Alignments“, in *Proc. of 16th European Conference on Networks and Optical Communications*, (Newcastle, UK), IEEE, 20. – 22. July 2011, 5 pages

- Di Renzo, M., and Haas, H., "Performance Analysis of Spatial Modulation", in *Proc. of 5th International ICST Conference on Communications and Networking in China (ChinaCom)*, 25 – 27 August 2010, 7 pages
- Elgala, H., Mesleh, R., Haas, H., "Non-Linearity Effects and Predistortion in Optical OFDM Wireless Transmission using LEDs," in *International Journal of Ultra Wideband Communications and System*, vol. 1, no. 2, pp. 143 – 150, 2009
- Afgani, M., Sinanović, S., Khashaba, K. and Haas, H., "Radio Frequency Signature Correlation Based Speed Estimation for Indoor Positioning," *Journal of Communications*, 2009, vol. 4, no. 2, pp. 96 – 107, March 2009
- Hübner, F. Schühlein, M. Bossert, E. Costa and H. Haas, "On Space-Frequency Coding Using Cyclic Delay Diversity for OFDM Based Transmission Systems," *European Transactions on Telecommunications (ETT)*, vol. 14, no. 6, pp. 491 - 500, Nov./Dec. 2003
- E. Costa, H. Haas, E. Schulz and A. Filippi, "Capacity Optimisation in MC-CDMA Systems", *European Transactions on Telecommunications (ETT)*, 3rd *Special Issue on Multi-Carrier-Spread-Spectrum*, Vol. 13, No. 5, pp. 455 - 463, September/October 2002
- Bharucha, Z., Cosovic, I., Auer, G. and Haas, H., "Throughput Enhancement Through Femto-Cell Deployment", *Proc. of 7th International Multi-Carrier Systems & Solutions (MC-SS 2009)*, (Herrsching, Germany), 10 pages on CD-ROM, 5. – 6. May 2009
Invited to submit journal paper to Special Issue on Multi-Carrier CDMA, ETT, Issue 4, 2010

Invited Book Chapters

- Harald Haas and Peter Valtink, „Sprechendes Licht – Leuchtdioden übermitteln Daten“ in T. W. Hänsch (ed) *100 Produkte der Zukunft - Wegweisende Ideen, die unser Leben verändern werden*, Econ Verlag, September 2007
- Harald Haas, 'Air-Interface Requirements for Mobile Data Services,' in H. Bidgoli (ed) *The Handbook of Information Security*, New York, John Wiley & Sons, January 2006

11. LECTURES AS GUEST LECTURER

- Osram, invited lecture within their 'Science and Coffee' series, "Li-Fi – Enhancing Light Services" Munich, Germany, 28 October 2014
- Alcatel Lucent, Bell Labs Ireland, November 2014, "Li-Fi: Pathway to 5G"
- IET Scotland South East, 15 November 2011, "The Light Bulb - The Future Wireless Access Point!" <http://www.theiet.org/local/uk/scotland/southeast/lightbulb.cfm>
- Beijing University of Posts and Telecommunications (BUPT), Beijing (China); November 2008; Title: "*TDD - Enabling Future Generation Wireless Systems*"
- Seminar at Beijing University of Posts and Telecommunications (BUPT), Beijing (China); November 2008; Title: "*Spatial Modulation*"
- Seminar at Beihang University, Beijing (China); November 2008; Title: "*Spatial Modulation*"
- Beijing Beijing Information Science & Technology University, Beijing (China); November 2008; Title: "*TDD - Enabling Future Generation Wireless Systems*"
- Beijing University of Posts and Telecommunications (BUPT), Beijing (China); December 2007; Title: "*Spectrum Sharing in Wireless Communications Utilizing TDD*"
- Seminar at Beijing University of Posts and Telecommunications (BUPT), Beijing (China); December 2007; Title: "*Spatial Modulation: A Spatial Multiplexing Technique for Efficient Wireless Data Transmission*"
- Seminar at Beihang University, Beijing (China); December 2007; Title: "*Spectrum Sharing in Wireless Communications Utilizing TDD*"

- Seminar at the Samsung Advanced Institute of Technology (SAIT), Seoul (Korea); August 2007; Title: "*Cognitive Radio from a Capacity Perspective*"
- The University of Edinburgh; June 2005; Invited Speaker at the International Next Generation Wireless Network Workshop; Title: *Radio Resource Management – A Key Challenge in 4G Networks*
- Universität Bremen, Germany; May 2003; Prof. Carmelita Görg, invited guest lecture at the ETIT Kolloquium. Talk was entitled: *Next Generation Mobile Access Technologies: Implementing TDD*
- Invited seminar at Qualcomm to present on selected chapters of textbook [Harald Haas and Stephen McLaughlin, "Next Generation Mobile Access Technologies: Implementing TDD," Cambridge University Press, January 2008 (420 pages)]; June 2008; Title: "*Dynamic Resource Allocation in Cellular OFDM TDD Networks using Busy Burst Signalling*"

19A. AWARDS

- Shortlisted for two **IET Innovation Awards** 2014
- Selected as one of ten **RISE Campaign Leaders** in 2014. The campaign, in partnership with the Royal Academy of Engineering, was launched by the Science Minister, David Willetts in November 2013 to mark the 20th anniversary of EPSRC (<http://bit.ly/1coPkon>), recognising inspirational scientists and engineers.
- Recipient of the **Tam Dalyell Prize 2013** awarded by the University of Edinburgh for excellence in engaging the public with science.
- Co-recipient of **Best Student Paper award** at IEEE VTC-Fall 2013 conference for the paper entitled "Performance of Spatial Modulation using Measured Real-World Channels"
- Recipient of the only **Established Carrier Fellowship** of the Engineering and Physical Sciences Council (EPSRC) in Information and Communications Technology in 2012.
- Shortlisted for World Technology Award, New York, October 2011 – now **Fellow of the World Technology Network (WTN)**
- Appointed as **Regular High Level Visiting Scientist** of Beijing University of Posts and Telecommunications (BUPT), 17 December 2007 (inauguration ceremony led by Vice President Professor Ren Xiaomin of BUPT)
- **Best Paper Award** for: F. Haider, C.-X. Wang, X. Hong, H. Haas, D. Yuan, and E. Hepsaydir, "Spectral-energy efficiency tradeoff in cognitive radio networks with peak interference power constraints," in Proc. *International Conference on Communication Technology (ICCT'11)*, (Jinan, China), September 2011
- **Best Paper Award** for: F. Haider, C.-X. Wang, H. Haas, D. Yuan, H. Wang, X. Gao, X.-H. You, and E. Hepsaydir, "Spectral-energy efficiency tradeoff for mobile femtocell networks with resource partitioning schemes," in Proc. *International Conference on Communication Technology (ICCT'11)*, (Jinan, China), September 2011
- **Best Paper Award** for: H. Haas and G. Povey, "*Capacity Analysis of a TDD Underlay Applicable for UMTS*" IEEE International Symposium on Personal, Indoor & Mobile Radio Communications (PIMRC), Osaka, Japan; September 1999
- Siemens Semiconductor (now Infineon AG), Munich, Germany; May 1998; Co-Winner of Business Plan Competition for Microelectronics 1997/1998 (*AddVenture*) with the proposal: *Software Licenses & Services (Software Lizenzen & Dienstleistungen)* awarded with DEM 50,000
- Recipient of the Heinz-Nixdorf Scholarship aimed at obtaining work experience in the South East Asia and Pacific regions.

19B. INVITATIONS

- Invited to present Li-Fi at this years' Royal Institution Christmas Lectures, broadcast by the BBC to estimated 2 million viewers
- Invited to join the International Solid State Lighting Alliance as Advisor

- Invited keynote at China SSL 2014, “Light as a Service Enabled by Li-Fi”, Guangzhou (China), 6-8 November 2014
- Invitation to give Plenary Keynote and keynote at the workshop on *Terrorism and Counter Terrorism Innovation* at the World Summit on Counter-Terrorism, International Institute for Counter-Terrorism, Herzliya (Israel), 8-11 September 2014
- Invited tutorial at OFC 2015, “Visible Light Communication”, 22-26 March 2015, Los Angeles, USA
- Keynote at Edinburgh University North America Office opening, along with the Principal and Vice Chancellor, Sir Timothy O’Shea, and Sir Tom Devine, “How Light can Change the World”, New York, USA, 22 October 2014
- Keynote, ForumLED, 2014, “Intelligent Lighting & Intelligent Building”, Paris, France, 15 October 2014
- Keynote at China SSL 2014, “Light as a Service Enabled by Li-Fi”, Guangzhou, China, 7 November 2014
- Keynote at NI Days, Austin, “Improving Spectral Efficiency in 5G With Visible Light Communications”, USA, 6 August 2014
- Invitation as speaker at BoldTalks 2014, Dubai, 22 March 2014
- Invitation as speaker at the Global Leader Forum (organised by Chosun TV), 29 November 2013, South Korea
- Editor for Optical Wireless Systems of *IEEE Transactions on Communications*
- Invited talk at the Edinburgh Science Festival 2013, “Li-Fi: Data Through Illumination”, 7 April 2013
- Invited talk at Login 2013 (Vilnius), “How to use light to transmit data: Story of Li-Fi”, <http://www.login.lt/konferencija>, 18/19 April 2013 (3000 participants / speakers included Steve Wozniak)
- Invited keynote at Plasa Focus 2013 (Leeds), “Li-Fi: Broadband through Light”, <http://www.plasafocus.com/leeds>, 30 April 2013
- Keynote at Global Phosphor Summit on Li-Fi technology, 18 – 20 March 2013, New Orleans (LA, USA)
- Invited talk at the Museum of Communication, 14 March 2012, “Shedding Light on Future Wireless Communication”
- Li-Fi work mentioned as one of “*the 50 best inventions in TIME Magazine of the year 2011*”, November 2011
- Invited to present work on Visible Light Communications at “TED (Technology Entertainment and Design) Conference”, Edinburgh, 11-15 July, 2011 – video of talk has been watched more than 865,000 times
- Invited to serve as Guest Editor for a special issue in *EURASIP Journal on Wireless Communications and Networking* on Visible Light Communication
- Invited by NTT DOCOMO to serve on the DOCOMO Euro Labs *Advisory Board* in 2009 and 2010
- Invited panellist at ACM MobiMedia 2009, London, 7-9 September 2009 to represent the academic view on “Future Wireless Multimedia Communications”.
- Invited by Prof. Zhang Ping (Beijing University of Posts and Telecommunications – (BUPT)) to join the guest academic talents programme for the development of university disciplines in China (briefly “111 program”). He was appointed *Regular High Level Visiting Scientist* to conduct joint research. The Program is established and supported jointly by the National Bureau for Foreign Experts of China and the Ministry of Education of China. About 100 Guest Academic Talents Bases will be established in some selected universities in China during the period from 2006 to 2010. Haas was officially inaugurated at a ceremony with two other scientists from the research group of Professor Z. I. Alferov in December 2007. The Program entails fully funded visiting stays of up to 3 month per year at BUPT.

- Invited to join The Fifth Editorial Committee of The Journal of China Universities of Posts and Telecommunications (English Edition) from November 2008 – November 2013 (obtained from President, Professor Binxing Fang, of BUPT).
- Invited to the Samsung 4G Forum, Seoul (Korea), August 2007 (Samsung covered business class travel and accommodation)
- Invited by Prof. Jon Altuna (University of Mondragon, Bilbao Mondragon, Spain, seminar on decentralized radio resource management in cellular TDD based systems: Title of talk: "Decentralized Link Adaptation Using Busy Bursts", November 2006.
- Invited to the research labs of Professor Masao Nakagawa, Keio University, Yokohama (Japan), January 2004 (3 weeks); resulting in one joint patent application and a peer-reviewed conference paper. As part of the invitation delivered lecture entitled: "Dynamic Channel Assignment in Cellular Systems"

19C. CONTRIBUTION TO STANDARDS

- Three reports on spectrum allocation issues related to UMTS (universal mobile telecommunications system) submitted to UKTAG in 1998 and 1999.
- DOCOMO Euro Labs, "Downlink Interference Coordination Between eNodeB and Home eNodeB," *3GPP TSG-RAN Working Group 4 (Radio)*, meeting #52, R4-093244, (Shenzhen, China), 24-28 August 2009
- Work on cyclic delay diversity (CDD) is part of LTE Standard: M. Bossert, A. Huebner, F. Schühlein, H. Haas and E. Costa, "On Cyclic Delay Diversity in OFDM Based Transmission Schemes," *Proceedings of the 7th International OFDM-Workshop (InOWo'02)*, (Hamburg, Germany), 5 pages on CD ROM, 10-11 September 2002

19D. CONFERENCE / WORKSHOP ORGANIZATION

- Track Chair *Future Trends and Emerging Technologies*, IEEE Vehicular Technology Conference – Fall, 2015, Glasgow
- Co-Chair of the 3rd Workshop on Optical Wireless Communications (OWC) at Globecom 2012, Anaheim (USA)
- Chair of the 2nd Workshop on Optical Wireless Communications (OWC) at Globecom 2011, Houston (USA)
- TPC member for the IEEE Summer Topicals 2012 of the IEEE Photonics Society
- Member of Technical Program Committee (TPC) of 16th European Conference on Networks and Optical Communications (NOC 2011), Newcastle, UK, 20 – 22 July 2011
- Member of Technical Program Committee (TPC) of IEEE GLOBECOM 2008, New Orleans, LA (USA), 30 November – 4 December 2008
- Member of technical program committee of Second International Conference on Communications and Electronics (ICCE 2008), HoiAn (Vietnam), June 4-6, 2008
- Member of technical program committee of Workshop on Communications and Navigations for the Development of Vietnam's Marine Economy (COMNAVI-07), Hanoi (Vietnam), 2007
- Member of Technical Program Committee of and session chair at PIMRC 2007, Athens (Greece), 2007
- Member of Technical Program Committee of and session chair at PIMRC 2006, Helsinki (Finland), 2006
- Member of Technical Program Committee of and session chair at PIMRC 2005, Berlin (Germany), 2005
- Session chair at the International Symposium on Spread Spectrum Techniques and Applications (ISSSTA 2004), Sydney (Australia), 2004
- Co-organised summer school: "Progress in Mathematics for Communication Systems" (<http://math.jacobs-university.de/summer-academy/main.php>), held at Jacobs University, Germany, in July 2007, and funded by VW Foundation (EUR 27,000); presenting professors from

Stanford (USA), University of California Davis (USA), Bar-Ilan University (Israel), Lund University (Sweden), Konrad-Zuse-Zentrum für Informationstechnik (Germany), Technical University Berlin (Germany), Ecole Polytechnique Fédérale de Lausanne (Switzerland), Siemens (Vienna), Infineon (Germany), Jacobs University Bremen (Germany)

- Organised Workshop on “4th Generation Mobile Communication – Key Enabling Technologies and Novel Applications”, held at Jacobs University, Germany, in June 2004; presenting researchers from Bremen universities (University of Bremen and International University Bremen), researchers from the Yokosuka Research Park (Japan) including representatives from NTT DoCoMo, KDDI, NEC, Panasonic and Fujitsu, representatives of the European commission and representatives of the German Aerospace Center (DLR).

19E. OTHER CONTRIBUTIONS

- Regular reviewer for IET, IEEE/OSA Journals as well as IEEE International Conferences, and EURASIP Journals

20. LIST OF PUBLICATIONS

Books

1. Dimitrov, S; and Haas, H., “Principles of Infrared and Visible Light Communications” *Cambridge University Press*, 400 pages, contract signed, delivery date 31.03.2015
2. Haas, H. and McLaughlin, S., (eds.) *Next Generation Mobile Access Technologies: Implementing TDD*, Cambridge University Press, ISBN: 13:9780521826228, 2008 (420 pages), currently being translated into Chinese
3. Harald Haas, and Peter Valtink, „Sprechendes Licht – Leuchtdioden übermitteln Daten“ chapter in T. W. Hänsch (ed) *100 Produkte der Zukunft - Wegweisende Ideen, die unser Leben verändern werden*, Econ Verlag, September 2007 (INVITED)
4. Harald Haas ‘Air–Interface Requirements for Mobile Data Services,’ chapter in H. Bidgoli (ed) *The Handbook of Information Security*, New York, John Wiley & Sons, Vol. 1, pp. 712 – 731, January 2006 (INVITED)
5. Mudesir, A., Haas H., "Radio Communication", INTECH, ch. Analytical SIR for Cross Layer Channel Model, Alessandro Bazzi (Ed.), ISBN:978-953-307-091-9, Apr. 2010 (INVITED)
6. Abualhiga, R., Haas, H., “Vehicular Technologies”, INTECH, ch. “Novel Co-Channel Interference Signalling for User Scheduling in Cellular SDMA-TDD Networks” (to appear) (INVITED)

Academic Journal Papers

1. Wu, X.; Claussen, H.; Dorenzo, M.; Haas, H., “Channel Estimation for Spatial Modulation,” *IEEE Transactions on Communications*, vol. PP, no.99, pp.1,1 doi: 10.1109/TCOMM.2014.2366750
2. Mesleh, R.; Badarneh, O.S.; Younis, A.; Haas, H., “Performance Analysis of Spatial Modulation and Space Shift Keying with Imperfect Channel Estimation over Generalized $\eta - \mu$ Fading Channels,” *IEEE Transactions on Vehicular Technology*, vol. PP, no.99, pp.1,1 doi: 10.1109/TVT.2014.2321059
3. Tsonev, D.; Videv, S.; and Haas, H., “Light fidelity (Li-Fi): towards all-optical networking,” *Proc. SPIE 9007, Broadband Access Communication Technologies VIII*, 900702, 10 pages, 1 February 2014; doi: [10.1117/12.2044649](https://doi.org/10.1117/12.2044649)

4. Popoola, W.O.; Haas, H., "Demonstration of the Merit and Limitation of Generalised Space Shift Keying for Indoor Visible Light Communications," *Journal of Lightwave Technology*, vol.32, no.10, pp.1960-1965, May 15, 2014, doi: 10.1109/JLT.2014.2310499
5. Basnayaka, D.A.; Haas, H., "Overcoming Large-Scale Fading in Cellular Systems With Network Coordination," *IEEE Transactions on Communications*, vol.62, no.7, pp.2589-2601, July 2014, doi: 10.1109/TCOMM.2014.2327099
6. Ghazal, A.; Wang, C.-X.; Ai, B.; Yuan, D.; Haas, H., "A Nonstationary Wideband MIMO Channel Model for High-Mobility Intelligent Transportation Systems," *IEEE Transactions on Intelligent Transportation Systems*, vol.PP, no.99, pp.1,13 doi: 10.1109/TITS.2014.2345956
7. Wu, S.; Wang, C.; Haas, H.; Aggoune, H.; Alwakeel, M.; Ai, B., "A Non-Stationary Wideband Channel Model for Massive MIMO Communication Systems," *IEEE Transactions on Wireless Communications*, vol. PP, no.99, pp. 1-1, doi: 10.1109/TWC.2014.2366153
8. Hyunchoe Chun; Manousiadis, P.; Rajbhandari, S.; Vithanage, D.A.; Faulkner, G.; Tsonev, D.; McKendry, J.J.D.; Videv, S.; Enyuan Xie; Erdan Gu; Dawson, M.D.; Haas, H.; Turnbull, G.A.; Samuel, I.D.W.; O'brien, D.C., "Visible Light Communication Using a Blue GaN μ LED and Fluorescent Polymer Color Converter," *Photonics Technology Letters, IEEE*, vol.26, no.20, pp. 2035-2038, Oct.15, 15 2014 doi: 10.1109/LPT.2014.2345256
9. Qian Zhang; Chenyang Yang; Haas, H.; Thompson, J.S., "Energy Efficient Downlink Cooperative Transmission With BS and Antenna Switching off," *IEEE Transactions on Wireless Communications*, vol.13, no.9, pp. 5183-5195, Sept. 2014 doi:10.1109/TWC.2014.2321385
10. Stavridis, A.; Basnayaka, D.; Sinanovic, S.; Di Renzo, M.; Haas, H., "A Virtual MIMO Dual-Hop Architecture Based on Hybrid Spatial Modulation," *IEEE Transactions on Communications*, vol.62, no.9, pp.3161,3179, Sept. 2014, doi: 10.1109/TCOMM.2014.2343999
11. Fath, T.; Schubert, F.; and Haas, H.; "Wireless data transmission using visual codes," *Photonics Research*, Vol. 2, Issue 5, pp. 150-160 (2014), <http://dx.doi.org/10.1364/PRJ.2.000150>
12. Di Renzo, M.; Haas, H.; Ghrayeb, A.; Sugiura, S.; Hanzo, L., "Spatial Modulation for Generalized MIMO: Challenges, Opportunities, and Implementation," *Proceedings of the IEEE*, vol.102, no.1, pp.56-103, Jan. 2014, doi: 10.1109/JPROC.2013.2287851
13. Burchardt, H.; Serafimovski, N.; Tsonev, D.; Videv, S.; Haas, H., "VLC: Beyond point-to-point communication," *Communications Magazine, IEEE*, vol.52, no.7, pp. 98-105, July 2014 doi: 10.1109/MCOM.2014.6852089
14. Holtkamp, H.; Auer, G.; Giannini, V.; Haas, H., "A Parameterized Base Station Power Model," *Communications Letters, IEEE*, vol.17, no.11, pp.2033,2035, November 2013 doi: 10.1109/LCOMM.2013.091213.131042
15. Tsonev, D.; Sinanovic, S.; Haas, H., "Complete Modeling of Nonlinear Distortion in OFDM-Based Optical Wireless Communication," *Journal of Lightwave Technology*, vol.31, no.18, pp.3064-3076, Sept.15, 2013, doi: 10.1109/JLT.2013.2278675
16. Tsonev, D.; Chun, H.; Rajbhandari, S.; McKendry, J.; Videv, S.; Gu, E.; Haji, M.; Watson, S.; Kelly, A.; Faulkner, G.; Dawson, M.; Haas, H.; O'Brien, D., "A 3-Gb/s Single-LED OFDM-based Wireless VLC Link Using a Gallium Nitride μ LED," *Photonics Technology Letters, IEEE*, vol. 26, no. 7, pp. 637 - 640, doi: 10.1109/LPT.2013.2297621
17. Burchardt, H.; Sinanovic, S.; Bharucha, Z.; Haas, H., "Distributed and Autonomous Resource and Power Allocation for Wireless Networks," *Transactions on Communications, IEEE*, vol.61, no.7, pp.2758-2771, July 2013, doi: 10.1109/TCOMM.2013.053013.120916
18. Younis, A.; Sinanovic, S.; Di Renzo, M.; Mesleh, R.; Haas, H., "Generalised Sphere Decoding for Spatial Modulation," *IEEE Transactions on Communications*, vol.61, no.7, pp.2805-2815,

July 2013, doi: 10.1109/TCOMM.2013.061013.120547

19. Serafimovski, N.; Younis, A.; Mesleh, R.; Chambers, P.; Di Renzo, M.; Cheng-Xiang Wang; Grant, P.M.; Beach, M.A.; Haas, H., "Practical Implementation of Spatial Modulation," *IEEE Transactions on Vehicular Technology*, vol.62, no.9, pp.4511-4523, Nov. 2013
doi: 10.1109/TVT.2013.2266619
20. Holtkamp, H.; Auer, G.; Bazzi, S.; Haas, H., "Minimizing Base Station Power Consumption," *IEEE Journal on Selected Areas in Communications*, vol.PP, no.99, pp.1,10, 0, doi: 10.1109/JSAC.2014.141210
21. Haas, H., "High-speed wireless networking using visible light, *SPIE Newsroom*, Online: <http://spie.org/x93593.xml> (invited)
22. Fath, T.; Haas, H., "Performance Comparison of MIMO Techniques for Optical Wireless Communications in Indoor Environments," *IEEE Transactions on Communications*, vol.61, no.2, pp.733,742, February 2013, doi: 10.1109/TCOMM.2012.120512.110578 (**among the top 10 downloads in April 2013**)
23. Fath, T.; Heller, C.; Haas, H., "Optical Wireless Transmitter Employing Discrete Power Level Stepping," *Journal of Lightwave Technology*, vol.31, no.11, pp.1734,1743, June, 2013, doi: 10.1109/JLT.2013.2257984
24. Popoola, W.O.; Poves, E.; Haas, H., "Error Performance of Generalised Space Shift Keying for Indoor Visible Light Communications," *IEEE Transactions on Communications*, vol.61, no.5, pp.1968-1976, May 2013, doi: 10.1109/TCOMM.2013.022713.120501
25. Popoola, W.O.; Poves, E.; Haas, H., "Spatial Pulse Position Modulation for Optical Communications," *Journal of Lightwave Technology*, vol.30, no.18, pp.2948,2954, Sept. 15, 2012, doi: 10.1109/JLT.2012.2208940
26. Burchardt, H.; Haas, H., "Multicell cooperation: evolution of coordination and cooperation in large-scale networks," *Wireless Communications, IEEE*, vol.20, no.1, pp.19,26, February 2013, doi: 10.1109/MWC.2013.6472195
27. Di Renzo, M.; Haas, H., "On Transmit Diversity for Spatial Modulation MIMO: Impact of Spatial Constellation Diagram and Shaping Filters at the Transmitter," *IEEE Transactions on Vehicular Technology*, vol.62, no.6, pp.2507,2531, July 2013, doi: 10.1109/TVT.2013.2244927
28. Di Renzo, M.; Haas, H., "Bit Error Probability of SM-MIMO Over Generalized Fading Channels," *IEEE Transactions on Vehicular Technology*, vol.61, no.3, pp.1124,1144, March 2012, doi: 10.1109/TVT.2012.2186158
29. Hanzo, L.; Haas, H.; Imre, S.; O'Brien, D.; Rupp, M.; Gyongyosi, L., "Wireless Myths, Realities, and Futures: From 3G/4G to Optical and Quantum Wireless," *Proceedings of the IEEE*, vol.100, no. **Special Centennial Issue**, pp.1853,1888, May 13 2012, doi: 10.1109/JPROC.2012.2189788 (invited)
30. Di Renzo, M.; De Leonardis, D.; Graziosi, F.; Haas, H., "Space Shift Keying (SSK—) MIMO with Practical Channel Estimates," *IEEE Transactions on Communications*, vol.60, no.4, pp.998,1012, April 2012, doi: 10.1109/TCOMM.2012.021712.100778
31. Dimitrov, S.; Haas, H., "Information Rate of OFDM-Based Optical Wireless Communication Systems With Nonlinear Distortion," *Journal of Lightwave Technology*, vol.31, no.6, pp.918-929, March 15, 2013, doi: 10.1109/JLT.2012.2236642
32. Dimitrov, S.; Sinanovic, S.; Haas, H., "Signal Shaping and Modulation for Optical Wireless Communication," *Journal of Lightwave Technology*, vol.30, no.9, pp.1319,1328, May 1, 2012, doi: 10.1109/JLT.2012.2188376
33. Ghimire, B.; Auer, G.; Haas, H., "Busy Burst Enabled Coordinated Multipoint Network with Decentralized Control," *IEEE Transactions on Wireless Communications*, vol.10, no.10, pp.3310,3320, October 2011 doi: 10.1109/TWC.2011.082011.101740

34. Videv, S.; Thompson, J., Haas, H.; and Grant, P., "Resource allocation for energy efficient cellular systems", *EURASIP Journal on Wireless Communications and Networking* 2012, **2012**:181 (28 May 2012)
35. Dimitrov, S.; Sinanovic, S.; and Haas, H., "Clipping Noise in OFDM-based Optical Wireless Communication Systems", *IEEE Transactions on Communication*, Vol: 60, Iss.: 4, DOI: 10.1109/TCOMM.2012.022712.100493, 2012, pp: 1072 – 1081
36. Mesleh, R.; Elgala, H.; Haas, H., "LED nonlinearity mitigation techniques in optical wireless OFDM communication systems," *IEEE/OSA Journal of Optical Communications and Networking*, , vol.4, no.11, pp.865,875, Nov. 2012, doi: 10.1364/JOCN.4.000865
37. Ghimire, B.; and Haas, H.; "Self Organising Interference Coordination in Optical Wireless Networks", *EURASIP Journal on Wireless Communications and Networking*, 2012, **2012**:131 (4 April 2012)
38. Sinanovic, S.; Burchardt, H.; Haas, H.; Auer, G., "Sum Rate Increase via Variable Interference Protection," *IEEE Transactions on Mobile Computing*, vol.11, no.12, pp.2121,2132, Dec. 2012, doi: 10.1109/TMC.2011.228
39. Di Renzo, M.; Haas, H.; "Bit Error Probability of Spatial Modulation (SM-) MIMO over Generalized Fading Channels", *IEEE Transactions on Vehicular Technology*, January 2012, DoI: 10.1109/TVT.2012.2186158
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