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5G HUDDLE

Delivering a Sustainable 5G Ecosystem

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Post Conference Report

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Executive Summary

The 5G Huddle 2015 was organised to review progress on 5G developments made in the year since the inaugural conference, and one of the key messages from speakers seemed to be that spectrum, consideration of 5G from the user's perspective, and security are becoming increasingly important issues. Consensus about the technical requirements for 5G and the need for global standardisation continues to solidify, but work needs to be done to create a compelling business case. Most in the industry are still committed to rolling out 5G around 2020, though some question whether some 5G features may be provided later.

5G will require hard work, a lot of research and difficult decisions if it's to succeed, but "succeed we must," Confederation of Danish Industries, Industry Association for IT, Telecoms, Electronics and Communications Companies Director **Adam Lebech** said in opening the conference.

Since the Wireless World Research Forum began 5G workshops several years ago, discussion has centred on the question of whether there is a need for a new generation of networks or a continuation of current ones, WWRF Chairman **Nigel Jefferies** said in setting the scene. WWRF is already looking beyond the near future because 5G could be the mobile platform that delivers an era of ubiquitous communications. But there is still "less clarity about the business cases," because 5G poses major challenges to costs and return on investment and could seriously disrupt the mobile market. One focus now is on identifying new ways in which vertical industries such as automotive and health can serve their customers via 5G services.

The ITU has been working on IMT for around three decades, ITU Secretary-General **Houlin Zhao** said in a video presentation. 3G is available to 69% of the world's population, and the ITU is working to develop IMT 2020. One important development in IMT 2020 is the role 5G will play in the Internet of Things (IoT), and stakeholders must identify the needs of vertical markets such as e-health, energy and automotive.

The European Commission sees 5G as a key factor in the digital single market, **Mário Campolargo**, DG CONNECT "Net Futures" director, said in a keynote address. Value chains in Europe are still fairly traditional, but 5G in connection with the IoT and the cloud will trigger deep and lasting transformation in all value chains and lead to a model of "product as a service." Virtualisation is "an unstoppable trend" that will change the dynamics and structure of the telecoms market. The verticals are the "game-changers." The three "burning issues" around 5G are ensuring that standards match ambitious 5G visions; stakeholders agree on the right time line for deployment and resist short-term commercial exploitation; and spectrum regulatory constraints not be allowed to hinder 5G.

"Rolling out 5G will involve huge investments," but there are questions about what will spur them and whether there is sufficient demand for 5G, **Jørgen Abild Andersen**, Organisation for Economic Co-operation and Development Committee for Digital Economy Policy chairman, said in a keynote presentation. Today's focus on full geographic mobile coverage and Internet speeds of 100 Mbps is too narrow, because mobile coverage and broadband speeds are only a means to a goal. Governments are facing the key challenges of poor innovation, low growth and high unemployment, and a flourishing digital economy can be one of the

most important tools to address them. That means taking a holistic approach that looks at all parts of the ecosystem and involves the “whole of government.”

The Third Generation Partnership Project (3GPP) has recently begun a standardisation process for 5G, said Chairman **Dino Flore** in a keynote address. There are three emerging high-level use cases for 5G: enhanced mobile communications; massive machine-to-machine communications; and ultra-reliable and low-latency communications. 3GPP's 5G work is expected to roll out in two phases. The first phase, to be completed by the first half of 2018, should address commercial needs; the second phase, due by December 2019, an IMT 2020 submission.

The second session, moderated by **Rahim Tafazolli**, director, 5GIC and Institute of Communications Systems, looked at how to build a globally agreed vision for 5G development and deployment.

5G is key for developing and developed nations, particularly in areas such as e-health and e-education, said Commonwealth ITU Group Chairman **Bashir Gwandu**. Everyone has a stake and must work collectively to find ways to meet the expectations of different parts of the world.

China Mobile considers the evolutionary and revolutionary paths to 5G important, said **Chih-Lin I**, China Mobile Research Institute chief scientist of wireless technologies. Its key themes remain “green and soft,” meaning the need for more efficiency and agility. The operator is aiming for a pre-commercial 5G trial in 2018/2019, and wants to investigate open source in 5G. China Mobile's focus is on spectrum below 6 GHz, with the C band a priority.

Everyone seems to agree that the future is more than about just enhanced mobile and broadband, but is about high data rates everywhere versus

high traffic capacity, very low latency and high network energy performance, said **Erik Dahlman**, Ericsson Research senior expert in radio access technologies. The 5G platform must be adaptable and allow innovation. 5G should have an “ultra-lean design” that minimises network transmissions not directly related to user data delivery in order to achieve energy efficiency and future-proofness.

ETSI is studying network functions virtualisation, mobile edge computing and harmonisation in the way millimetre wave bands are administered regionally, said Chief Technology Officer **Adrian Scrase**. The time line for 5G is now clear, which is the biggest difference from last year's Huddle.

Session 3, moderated by University of Piraeus Professor and Digital Systems Department Chairman **Panagiotis Demestichas**, looked at the requirements, costs, regulatory framework and investment incentives for creating the 5G architecture.

The satellite community wants to play a role in 5G, said **Kumar Singarajah**, Avanti Communications Group plc director, regulatory affairs and business development, speaking for the European Satellite Owner's Association. The industry is good at efficiently transmitting data over larger areas in a cost-efficient manner.

If networks can provide universal mobile broadband, IoT and low latency, they can serve other nascent markets such as connected health networks, said **Paul Crane**, BT head of wireless network services and sustainability. Bringing verticals into the 5G requirements discussion is crucial.

The European Investment Bank sees great interest in 5G as it moves into the equipment R&D phase, said Senior Economist **Anders Bohlin**. The problem is that the bank does not really know what 5G is.

The financial community, banks and end-users need to know such things as what to expect from spectrum, how privacy/security will be handled, and whether the technology is standardised. Banks “always want the money back,” so 5G players need a business case and a business model everyone believes in.

The 5G Forum Korea Global Alliance Committee expects to take a phased approach to 5G standards, said Chairman **Lee Hyeonwoo**. The first phase should include potential solutions for spectrum above 6 GHz. Migration to 5G might be somewhat different from the past because 4G is flexible, there is no competing standard, and there has been huge investment in 4G. The alliance signed a memorandum of understanding with the WWRF at the conference for global co-operation on the development of 5G networks.

Regulators might have to overcome some obstacles to create a fruitful partnership with the 5G community, said **Jakob Henrik Juul**, Danish Energy Agency head of division. Whether 5G involves evolution or revolution, it needs the active participation of government for spectrum assignment and technological development. Regulators need clear time lines for 5G because it takes time to award spectrum licenses.

Another panel, chaired by Analysys Mason Principal **Janette Stewart**, addressed key challenges and issues facing 5G wireless network rollout. The first mini-session looked at spectrum challenges.

Lack of spectrum should not hamper 5G development, said **Andrew Hudson**, UK Office of Communications. It's not clear where the best spectrum for 5G will be, so Ofcom is looking at what mmWave opportunities say about the way spectrum will be used. There is consensus across the regions

on several bands for 5G: around 32 GHz; around 45 GHz; and 66-72 GHz.

5G might be introduced in existing mobile bands, said CEPT ECC Chairman **Eric Fournier**. Regulation is technology neutral, and bands already harmonised in Europe might be used there for 5G. The research and industry sectors want 5G spectrum in higher bands, and there is worldwide consensus that WRC-15 should launch studies for identification of 5G spectrum in those bands. The European Common Position for WRC-15 is that bands from 24.5 GHz to 86 GHz should be studied –although each carries compatibility challenges - but that the 27.5-29.5 GHz band should not because it supports satellite broadband communications. The key debate at WRC-15 will be on what happens with spectrum below 30 GHz or 40 GHz.

A clear majority of mobile carriers (63%) is still providing 2G services, with 32% offering 3G and 5% 4G, said **Wladimir Bocquet**, GSMA head of policy planning, government and regulatory affairs. There is “no formal definition or approach agreed” for 5G but there are two broad visions/drivers. At the service level, it will offer extremely reliable, near-universal coverage of high-speed mobile 2G, 3G and 4G mobile broadband. It will also achieve much higher data rates, lower latency and full connectivity. Policymakers should consider that 5G is likely to require significant additional capacity spectrum, and that it will need coverage spectrum to provide nationwide services. Sub-1 GHz spectrum is vital for digital inclusion.

5G will be a unified, scalable and flexible platform which will empower new user experiences in networks with lower cost of deployment and operation, with a more consistent user experience, higher capacity and better energy efficiency, said **Luigi Ardito**, Qualcomm government affairs director

– Europe, Middle East and Africa, speaking on behalf of DIGITALEUROPE. 5G will require spectrum below 6 GHz for mobile services, but also spectrum from 6 GHz to 70 GHz.

DIGITALEUROPE has proposed the ITU study the 6-20 GHz, 20-40 or 45 GHz and 45-70 GHz bands.

Other challenges include achieving higher speed and reliability and lower latency, and tackling cybersecurity.

Huawei European Research Centre Vice-President **David Soldani**, described 5G vertical industry accelerator tests and trials which examined use cases of connectivity to cars, drones, robots and other devices around mission critical machines. The Centre has developed a concept of “slicing” one physical infrastructure to enable many operators to provide different services.

Cybersecurity challenges are not restricted to 5G but arise from the connected world in general, said Symantec Government Affairs Manager **Zoltan Precsenyi**. Symantec believes that every type of attack or vulnerability seen on computers is possible in the IoT and with greater connectivity. Existing and future EU laws address issues such as data protection, network and information security, electronic signatures and payment security but not thoroughly enough.

Day two of the conference centred on the disruptive nature of 5G, and looked at new use cases and implications for industry.

Session 5, chaired by Wireless Test and Innovation Centre, UK Chairman **Stuart Revell**, addressed new services and applications 5G might enable, and how companies can take advantage of the new environment.

Revell discussed the Future Technologies Network (techUK) white paper on 5G innovation opportunities, an industry-academia collaboration. It recommends the creation of a 5G and IoT innovative network; test beds and trials enabling 5G “digital fabric” and technological validation; and the creation of a UK ecosystem to develop a leading position for international 5G standards activity.

Ming Lei, representing the FuTURE Forum, detailed China’s two main 5G groups – the IMT-2020 5G Promotion Group (PG), which targets standardisation and promotes Chinese competence in 5G R&D, and FuTURE Forum, an international non-profit seeking to develop and open, neutral, international platform to promote R&D.

5G “is all about use cases,” **Christian Kloch**, TDC vice president, mobile strategy and technology, said during the panel discussion. The IoT is a new concept for many operators and requires collaboration with other industries.

5G is the telecoms industry’s “last chance” to stretch its services and compete with big players like Google, said **Pasi Kemppainen**, NNE Pharmaplan senior consultant. 5G’s disruption isn’t in the radio access part but in the services infrastructure. Facebook, Google and others will “eat your lunch” in the future on services if operators don’t deal with their services infrastructure. Companies can start building the services and enablers for the IoT for customers today, and then when the radio access network is ready, “there you go.”

What’s exciting about the IoT is the size of the opportunity it offers, said Ming. But it’s also an unknown territory of which no one has any experience. The IoT exposes the weakness of the tech industry, which is highly segmented. And it will profoundly change the landscape and drive new disruptive business.

There is a converging view that 5G is a new kind of network that enables new services, connecting new industries and devices and empowering new user experiences, said **Wassim Chourbaji**, Qualcomm Vice President, Government Affairs Europe, Middle East and North Africa. But with a time frame of 2020, the key challenge is to move toward actual deployment. To do that, industry and policymakers should address the issues of who will invest in 5G, what spectrum will be made available and harmonised as much as possible, and what the business models will be. The companies “who will make money are the ones who are controlling the data.” Verticals will only move to digital if it boosts productivity.

Another panel, moderated by **Mischa Dohler**, King's College London professor in wireless communications, focused on what 5G's impact across a broad range of sectors will mean for traditional and new businesses and on new business models and potential commercial opportunities.

In his introduction, Dohler noted that 5G will bring a “massive shift” from business-to-consumer to business-to-business (B2B) that will mean serving the “people in the factory and the factory.” But he cautioned that while there might be a need for 5G services, there is no guarantee that there will be a demand for them.

Because 5G is a B2B world, it is vendors such as Ericsson and Nokia that speak its language. Once vendors have locked themselves into verticals they will be able to bring in the operators, who are customer-facing. 5G will offer opportunities for fixed operators but will not be a “cash cow.” However, the “tactile Internet” will move data to the edge, which the operators own, allowing them to move into the over-the-top space.

Soldani introduced a 5G Public-Private Partnership (5G PPP) white paper which examines use cases for the technology in the automotive sector. Its main conclusions are that latency and security are key issues, and that a possible business model is pay-as-you-drive mobility.

From a telecoms manufacturer's perspective, Nokia sees many opportunities in 5G for the automotive industry, said Principal Engineer **Preben Mogensen**. There are three domains for 5G in the automotive sector: mobile broadband, massive machine-to-machine applications, and critical machine communications. He discussed the requirements for the different use cases.

From the road operator's standpoint, the connected car is about vehicles talking to other vehicles and to the infrastructure, said **Peter Vermaat**, principal ITS consultant, Transport Research Laboratory. The types of applications available can generally be divided into several categories: safety; efficiency; convenience; financial; and gathering floating vehicle data in real time. The transport industry has heard that 5G “will solve all our problems” but is cynical because it heard the same about 3G and 4G and nothing happened. 5G proponents will have to overcome that scepticism.

Vodafone believes that 5G will be mainly characterised by a new air interface and new core or family of cores, said **Ilaria Thibault**, principal researcher and subject matter expert, 5G technologies, who presented a cross-industry perspective. Mobile operators already offer machine-to-machine (telematics) and infotainment packages services in vehicle-to-infrastructure communications. There are also standards that address safety-related use cases in vehicle-to-anything communications. 5G can be considered an autonomous vehicle-to-anything-type network.

Unless safety applications are combined with infotainment or other packages, there won't be a business case.

Concluding, **Knud Erik Skouby**, director, Center for Communication, Media and Information Technologies, Aalborg University, said that compared with last year's event, spectrum "has a much more prominent place" this year, possibly because WRC-15 is imminent and 5G implementation is moving closer. There was also more talk about 5G from the perspective of the end-user. The new services 5G can deliver also led into a discussion of security issues.

Jefferies, summing up, said discussions with participants signalled that perhaps the question of what 5G is has not yet been completely resolved. He cautioned against over-hyping 5G as being everything to everybody, but reiterated 5G's potential to be the platform for ubiquitous mobile communication.

DAY ONE

Session 1

Keynote Presentations

5G will require hard work, a lot of research and difficult decisions if it's to succeed, but "succeed we must," said Confederation of Danish Industries, Industry Association for IT, Telecoms, Electronics and Communications Companies Director **Adam Lebech**, who welcomed participants to the conference.

Wireless World Research Forum Chairman **Nigel Jefferies**, setting the scene, noted that over the past few years there has been a great deal of discussion about 5G, particularly on the question of whether there is a need for a new generation of networks or a continuation of current ones. WWRF is already looking beyond the near future, because 5G could be the mobile platform that delivers an era of ubiquitous communications.

But "there is less clarity about the business cases," Jefferies said. Major challenges for 5G will be costs and return on investment, and it could seriously disrupt the mobile market. One focus has been on how vertical industries such as automotive and health can deliver services to their customers via 5G services.

5G also offers, among other things, the potential for the Internet of Things (IoT), efficient use of spectrum, and highly reliable real-time applications through lower network latency. Developments in networks such as virtualisation will be needed for 5G performance. Current Internet protocols may not be appropriate for 5G. Privacy and security concerns must be addressed.

Research on 5G is taking place around the world, Jefferies said. On 13 October, the WWRF signed an agreement with the 5G Forum of Korea for global cooperation for the development of 5G networks. Lee Hyeonwoo, chairman of 5G Korea's global alliance committee, said the memorandum of understanding will be key to setting out a roadmap and a phased approach to 5G standards and network migration. The agreement will facilitate the exchange of information and identify issues of common interest between the two organisations, with the aim to push for a global vision of 5G.

The ITU has been working on IMT for around three decades, ITU Secretary-General **Houlin Zhao** said via a video presentation. It is an open process that involves member states, network operators, academia, industry forums and other stakeholders. The collective achievement has revolutionised how people communicate around the world today. 3G is available to 69% of the world's population, and the ITU is working with the same and new interested parties to develop IMT 2020. ITU-R Recommendation M.2083-0, approved on 29 September 2015, provides a framework and overall objectives for IMT 2020 and beyond, as well as an overview of the process and time lines for 5G.

Another important development in IMT 2020 is the role 5G will play in the IoT, and stakeholders must identify the needs of vertical markets such as e-health, energy and automotive.

The European Commission sees 5G as a crucial element in the "new industrial revolution" and a key factor in the digital single market, said **Mário Campolargo**, DG CONNECT "Net Futures" director. Value chains in Europe are still fairly traditional, but 5G in connection with the IoT and the cloud will enable a "new digitisation of our economy" that will trigger deep and lasting

transformation in all value chains and lead to a model of “product as a service.”

Europe’s strengths lie in the fact that it has a great research and development track record; is the largest global supplier of telecoms equipments; has an advanced fixed broadband infrastructure; and is security-minded. Europe also has weaknesses: its operators and cloud industry are fragmented; its over-the-top (OTT) domain are weak; and there are no smartphone players. Despite these and other problems, there are opportunities in the fact that Europe hosts leading companies in key verticals such as automotive, health and energy. There are strong societal demands backed by governments in areas such as e-health; there are no vested interests in OTT or platforms; and operators are open to virtualisation and new business models.

The EU has combined academia with industry in the 5G Public Private Partnership (5G PPP), and is looking at new use cases involving verticals. It is also considering which innovative policies can support 5G, and seeking to generate smart ecosystems based on a holistic view. The first set of 5G PPP projects began in July 2015, with 19 projects backed by around 128 million euros. Several working groups have been formed to consider architecture, spectrum, software, security and other issues. The Commission is also trying to take innovative policy approaches, beginning with an effort to bring different regions together on 5G.

Smart ecosystems for 5G raise several challenges. The first is to virtualise networks in order to trigger a new level of innovation. A second challenge is to engage the verticals, who are the “game-changers” in the new ecosystem. Thirdly, governments are important because they act as buyers of digital solutions, and 5G will bring significant improvements in the way societies manage health,

cities and energy. A fourth challenge is determining who will invest in 5G. Another issue is whether EU rules are adequate.

5G proponents face “three burning issues.” Standards must match ambitious 5G visions by, for example, including players outside traditional telecoms companies. Stakeholders should agree on the right time line for deployment and resist short-term commercial exploitation of “pre-5G versions.” Finally, spectrum regulatory constraints cannot be allowed to hinder 5G.

5G “is still at the stage of its infancy,” said **Jørgen Abild Andersen**, Organisation for Economic Co-operation and Development Committee for Digital Economy Policy chairman. 5G, which can be described as an “umbrella of mobile technologies,” is likely to provide mobile connectivity with substantially better performance than existing technologies, but it also requires that spectrum scarcity issues be resolved. Above all, “rolling out 5G will involve huge investments.”

What will spur these investments, and is there sufficient demand for 5G? GSMA figures show that 63% of global mobile usage is 2G, 32% is 3G and 5% is 4G. On that basis, 5G demand “is not likely to be compelling” at this stage, so investment in 5G will probably not be justified in this decade.

5G should be considered as an element of the entire digital economy. Today’s focus by politicians and others on full geographic mobile coverage and Internet speeds of 100 Mbps is too narrow, because mobile coverage and broadband speeds are only a means to a goal. Governments are facing the key challenges of poor innovation, low growth and high unemployment, and a flourishing digital economy can be one of the most important tools to address them. Understanding what makes

a digital economy flourish means considering all parts of the ecosystem. Success requires a holistic, “whole of government” approach in working toward a digital economy.

There are possible threats to the digital economy as well. All parts of the ecosystem are important, which is why the approach must be holistic. “Trust is crucial” and the level of security/privacy must be perceived as correct by businesses and individuals. There is a lack of data analytics skills, spectrum and standardisation.

3GPP has recently begun a standardisation process for 5G, said Chairman **Dino Flore**. Licensed spectrum remains 3GPP operators’ top priority for delivering advanced services and user experience, but the opportunistic use of unlicensed spectrum will complement the growing traffic demand. Moving forward, 3GPP has two options for offloading traffic to unlicensed spectrum: Wi-Fi via LTE/Wi-Fi interworking, or licensed assisted access to unlicensed spectrum.

3GPP is also working on LTE carrier aggregation enhancements; elevation beamforming/full dimension MIMO; low-latency LTE; and downlink multi-use transmission using superposition coding. To support the IoT, 3GPP is improving the LTE platform for machine-type communications and working on narrowband IoT. Also on its plate is device-to-device operation and vehicle-to-“x” transmissions, the initial priority in vehicle-to-vehicle communications. 3GPP is planning to submit a technical proposal to the ITU-R IMT project. There are three emerging high-level use cases for 5G: Enhanced mobile communications; massive machine-to-machine communications; and ultra-reliable and low-latency communications.

Consensus is growing that 3GPP’s 5G work should roll out in two phases. The first phase, to be completed by the first half of 2018, should address the more urgent subset of commercial needs; the second phase, to be completed by December 2019, an IMT 2020 submission. There is no agreement on what the commercial needs are yet, but 3GPP wants to make sure the platform is forward-compatible so it can support use cases added in the second phase. Next-generation radio technology will include operations above 6 GHz, and 3GPP recently approved a study on channel modelling for spectrum there.

Audience members wondered whether enough is being done to engage the non-telecoms/ICT sector. The danger is in having too many fora talking about 5G, all claiming a holistic perspective but all starting from different places, said Campolargo. It is also important to start a dialogue with emerging economies about what 5G can do for them, said Andersen.

Session 2

Building a globally agreed vision for 5G development and deployment

This session, moderated by **Rahim Tafazolli**, director, 5GIC and Institute of Communications Systems, examined what technologies are or will be available soon for standardisation. There are “grand visions” about what 5G will deliver but Tafazolli questioned whether we are risking that by rushing into it and doing just “higher speed and higher speed” rather than new services that will help verticals and society.

The Commonwealth Telecommunications Organisation, whose 54 members are from four ITU regions, encompasses countries from developing to developed, said **Bashir Gwandu**, chairman of the Commonwealth ITU Group. Referring to the GSMA statistic of 5% 4G uptake, he noted that some parts of the world are even below that figure, and yet now the discussion is on 5G. The requirements from countries with low 4G uptake are likely different from those of nations such as Sweden or Japan, but as a community everyone must work together to find out how the sector can grow. Even countries with slow uptake must ensure that their voices are heard in the 5G debate.

Everyone expects faster mobile speeds from 5G, but it must also improve latency, which will help content delivery. But in countries in Africa, content comes from so far away that it is unclear whether 5G will be relevant. Equally, with 4G and even 3G coverage still low, the 5G time frame for Africa is unclear. Another issue is whether 5G will boost energy efficiency, and, if so, whether that will be possible in developing countries. Nevertheless,

5G is key for developing and developed nations, particularly in areas such as e-health and e-education.

China Mobile considers the evolutionary and revolutionary paths to 5G important, said Chih-Lin I, China Mobile Research Institute chief scientist of wireless technologies. Its key themes remain “green and soft,” meaning the need for more efficiency and agility. The operator is aiming for a pre-commercial 5G trial in 2018/2019, and wants to investigate open source in 5G. China Mobile’s focus is on spectrum below 6 GHz, with the C band a priority.

Everyone seems to agree that the future is more than just enhanced mobile and broadband, and is about high data rates everywhere versus high traffic capacity, very low latency and high network energy performance, said **Erik Dahlman**, Ericsson Research senior expert in radio access technologies. The 5G platform must be adaptable and allow innovation. Higher data rates should be available essentially everywhere, including rural areas and developing countries. Ericsson believes in a single solution for all services, so 5G needs a flexible, scalable, “ultra-lean” design that minimises network transmissions not directly related to user data delivery in order to achieve energy efficiency and be future-proof.

3GPP is essential to 5G standardisation but ETSI has also launched several activities in that area, said Chief Technology Officer **Adrian Scrase**. The networks of the past assumed interfaces are physical, but over time, they will become more virtualised, so ETSI is looking at network functions virtualisation. Another area of study is mobile edge computing, which will allow computational power to be taken from the core and moved as close to the end-user as possible to provide lower latency. In addition, ETSI is trying for some harmonisation in the way millimetre wave bands are administered

from region to region. The time line for 5G is now clear, which is the biggest difference from last year's Huddle.

Asked the most compelling difference between 5G and 4G/evolving 4G, Chih-Lin said the dramatic increase in China Mobile's 4G traffic prompted it to look at 5G. 2G, 3G and 4G had moved on a particular path ("green and soft"), but in the future the company needed to be more flexible and agile in its energy and resource efficiency. To be sustainable, the company must look at other opportunities, such as vertical industries and platforms, which distinguishes 5G from 2-4G.

Ericsson believes that 5G likely will not differ much from 4G LTE, Dahlman said. Mobile broadband will be handled by LTE as will massive machine-to-machine communications. On the core network side, there will be cloud computing and network virtualisation, but those will probably be part of 4G, too. 5G could also be about providing good quality mobile broadband worldwide. It should be viewed as a single solution that supports all the different functions and services.

There are good arguments that LTE needs to evolve but that there is no reason for 5G, one audience member noted. 4G does not allow the delivery of gigabits per second, said Scrase. 5G is agile, efficient, tactile and immersion, said Chih-Lin. As long as more spectrum is needed for more data, the technology must evolve to 5G, said Gwandu. But Scrase cautioned that no one can assume they know their usage requirements, which is why 5G networks must be designed to be adaptable to other applications.

Audience members wondered whether sharing of licensed spectrum will be part of the 5G era. Operators like China Mobile who provided

traditional infrastructure will have to find ways to monetise their infrastructure value more efficiently and that could include spectrum sharing, said Chih-Lin. Dahlman cautioned that there is a distinction between spectrum sharing and network sharing. In time, it might be possible to have more spectrum sharing, said Gwandu, but operators do not want to expend huge sums of money to share spectrum in the immediate future. However, with more connectivity, operators or even regulators may see potential for more spectrum sharing to achieve the higher speeds 5G will make possible—but only if there are no other options.

Panellists agreed an Asian country will adopt 5G first.

Session 3

Investment and infrastructure – Creating the 5G architecture

This session, moderated by University of Piraeus Professor and Digital Systems Department Chairman **Panagiotis Demestichas**, looked at the requirements, costs, regulatory framework and investment incentives for 5G deployment.

5G will happen at some point and the satellite community wants to play a role in it, said **Kumar Singarajah**, Avanti Communications Group plc director, regulatory affairs and business development, speaking for the European Satellite Owner's Association. Avanti believes that 5G is not just mobile technology and is more than "wireless." The industry is good at efficiently transmitting data over larger areas in a cost-efficient manner, but the question is how to achieve sustainable spectrum access for satellite systems and delivery services. 5G coverage considerations suggest that low band (below 3.4 GHz and 3.8 GHz in Europe) and high band (above 31 GHz) is needed. Satellite operators believe going above 3.4 GHz will cause problems for the industry. The ITU regions have identified spectrum from around 25 GHz to 86 GHz for possible 5G use, and there appears to be consensus around 31 GHz.

5G discussions usually cover only radio access, but core networks are a key component, said **Paul Crane**, BT head of wireless network services and sustainability. The 5G concept is that if networks can provide universal mobile broadband, IoT and low latency, they can serve other nascent markets such as connected health networks. Thus, the basic concepts are a very flexible RAN joined

with a network that can be optimised to support vertical industries. Bringing verticals into the 5G requirements discussion is crucial. 5G must retain the telecoms industry's ability to interconnect. Interconnection must extend from the network player to the application player.

The European Investment Bank sees great interest in 5G as it moves into the equipment R&D phase, said Senior Economist **Anders Bohlin**. The problem is that the bank does not really know what 5G is. The financial community, banks and end-users need to know such things as what to expect from spectrum, how privacy/security will be handled, and whether the technology is standardised. The EIB is a long-term financier, which is important for R&D. But banks "always want the money back," so 5G players need a business case and a business model everyone believes in. The EIB is open to funding in the R&D phase but any final product should be standardised.

The 5G Forum Korea Global Alliance Committee expects to take a phased approach to 5G standards, said Chairman **Lee Hyeonwoo**. The first phase should include potential solutions for spectrum above 6 GHz. Migration to 5G might be somewhat different from the past because 4G is flexible, there is no competing standard, and there has been huge investment in 4G.

Whether 5G involves evolution or revolution, it needs active government participation for spectrum assignment and technological development, said **Jakob Henrik Juul**, Danish Energy Agency head of division. Regulators need clear time lines for 5G because it takes time to award spectrum licenses. They are focused on efficient rules, low market entry barriers and spectrum auctions. They are also concerned about protecting existing LTE rollout and about whether 5G will create a new layer of

competition. Another issue is whether 5G will present a new business model and, if so, how that might affect current subscription models.

One question is whether 5G will take sharing further and potentially reduce competition. Operators need to cut costs, and network sharing is a good way to do that but it could affect competition if it results in fewer players. How much network sharing can be allowed depends on the situation in each market.

Spectrum sharing is a way to promote better use of spectrum, said Crane. BT is looking at the higher bands for 5G sharing. The US has dedicated a third of the 3.4 GHz band to spectrum sharing, but it remains to be seen if that brings out new competitors. The approach should be considered for 5G.

Asked how panellists see the near-term (2020) prospects for 5G technology, Singarajah said that South Korea will likely showcase some 5G technology by 2018. However, he questioned whether mobile operators will be ready in the next three to five years to invest heavily in 5G products and services rather than taking a step-by-step evolutionary approach. 5G may not deploy until the 2030s. There will definitely be 5G technological demonstrations at scale but 4G is still rolling out, said Crane. Moreover, end-users still view Wi-Fi as an integral part of their experience. There will be further Wi-Fi enhancement and they won't go away in the next five years. End-users will have enhanced Wi-Fi and 4G, and the question is how to integrate them. Some countries have licensed LTE spectrum but the operators haven't yet deployed the networks, Bohlin noted. If governments auction 5G spectrum for budgetary reasons and then operators don't invest because there is no market, that will not be good for 5G.

Session 4

Making the leap forward – Overcoming the obstacles to 5G deployment

This session, moderated by Analysys Mason Principal **Janette Stewart**, addressed key challenges and issues facing 5G wireless network rollout.

4.i WRC-15 and beyond – Overcoming the spectrum challenges

Lack of spectrum should not hamper 5G development, said Andrew Hudson, UK Office of Communications spectrum policy director. It's not clear where the best spectrum for 5G will be, so Ofcom is looking at what mmWave opportunities say about the way spectrum will be used. Although it's early in the development cycle, it's important to begin assessing this. There is consensus across the regions on several bands for 5G: around 32 GHz; around 45 GHz; and 66-72 GHz. Ofcom has done work on lower frequency bands below 6 GHz, but whether those bands will extend spectrum to LTE/4G or to 5G is not a decision for the regulator.

Considering 6-60 GHz and 60-100 GHz spectrum means assessing what the bands mean for propagation loss, real-world propagation, intra-cell and inter-cell interference and sharing opportunities. Antenna dimensions, beamforming and MIMO solutions and transceiver design are also part of the equation.

5G might be introduced in existing mobile bands, said CEPT ECC Chairman **Eric Fournier**. Regulation is technology neutral, and bands already harmonised in Europe might be used there for 5G. The research and industry sectors want 5G spectrum in higher bands, and there

is worldwide consensus that WRC-15 should launch studies for identification of 5G spectrum in those bands. The European Common Position for WRC-15 is that bands from 24.5 GHz to 86 GHz should be studied –although each poses compatibility challenges - but that the 27.5-29.5 GHz band should not because it supports satellite broadband communications. The key debate at WRC-15 will be on what happens with spectrum below 30 GHz or 40 GHz.

A clear majority of mobile carriers (63%) is still providing 2G services, with 32% offering 3G and 5% 4G, said **Wladimir Bocquet**, GSMA head of policy planning, government and regulatory affairs. From now until 2020, operators will spend a large amount of capex on 4G, so it is important to ensure that the right standards, spectrum and understandings are in place to put consumers first.

There is “no formal definition or approach agreed” for 5G but there are two broad visions/drivers. At the service level, it will offer extremely reliable, near-universal coverage of high-speed mobile 2G, 3G and 4G mobile broadband. More generally, it will achieve much higher data rates, lower latency and full connectivity. This is exclusively next-generation radio access technology.

New mobile bands must be identified at WRC-15 or it will be too late for 5G because it can take a decade to obtain new spectrum at a WRC. Also needed is an appropriate response to the emerging high-level use cases for 5G, such as enhanced mobile broadband and massive machine-type communications. Policymakers should consider that 5G is likely to require significant additional capacity spectrum, and that it will need coverage spectrum to provide nationwide services. Sub-1 GHz spectrum is vital for digital inclusion. In addition, a wider range of mobile licensing regimes

is possible with 5G, such as exclusive and flexible shared licensing.

5G will be a unified, scalable and flexible platform which will empower new user experiences in networks with lower cost of deployment and operation, with a more consistent user experience, higher capacity and better energy efficiency, said **Luigi Ardito**, Qualcomm Government Affairs director – Europe, Middle East and Africa, speaking on behalf of DIGITALEUROPE. 5G will require spectrum below 6 GHz for mobile services, but also spectrum from 6 GHz to 70 GHz. It must be harmonised and contiguous spectrum of sufficient bandwidth to deliver 5G services. Spectrum is also needed for backhaul, and must be as harmonised as possible to drive economies of scale.

DIGITALEUROPE has proposed the ITU study the 6-20 GHz, 20-40 or 45 GHz and 45-70 GHz bands. Bands under 20 GHz are under-represented in WRC-15 proposals. CEPT should not take a vocal position against other regions seeking to include the 27.5-29.5 GHz band for study, and should continue to remain neutral on other bands below 30 GHz.

Panellists disagreed over how broad the WRC-15 agenda item on 5G spectrum should be. Ofcom's concern is that including a wide range of spectrum bands will mean so much work on studies that a positive outcome will be unlikely, said Hudson. "Lots of people might have to give a little bit" so that the work can be done quickly. CEPT also prefers a more focused agenda item, said Fournier. With WRC-15 a month away, he urged the audience to "make your case" now for additional bands.

Bocquet noted that bands between 6 GHz and 20 GHz offer opportunities. The conference discussion shows the need for a better understanding of what

5G is intended to achieve. 5G proponents should not take too broad an approach but should make sure that they don't arrive at a consensus they regret in four years. DIGITALEUROPE understands how impractical a broad agenda item is but shares GSMA's view about 6-20 GHz for 5G, Ardito said. 5G will need low frequency spectrum as much as high frequency, which will mean refarming, Hudson said. Fournier agreed that spectrum below 6 GHz would be useful for 5G, but said the push for 6-20 GHz is "strange" because of antenna issues.

As to whether excluding certain bands now might end up prejudging the WRC-19 agenda item, Hudson said it's not regulators' job "to make everyone happy" but to "debate the important questions." There must be some evidence-based choice as to what to use the spectrum for and what society wants. The debate will be "uncomfortable." Parties should agree on what spectrum they want for 5G; there is "no black and white," said Bocquet.

4.ii Overcoming other issues and challenges

Achieving higher speed, lower latency, and a high degree of reliability – Research challenges in developing 5G for mission critical machine communications

Huawei European Research Centre Vice-President **David Soldani** described 5G vertical industry accelerator tests and trials in Munich which examined use cases of connectivity to cars, drones, robots and other devices around mission critical machines. The goal is to use many types of sensors that create a fully immersive experience. 5G requires very high speed connectivity. The Centre has also developed a concept of "slicing," one physical infrastructure upon which many operators can provide difference services. It has developed a simple tool to allow network

operators to connect to the network according to specific service-level agreements.

Facing up to the threats of Cyber Attacks in a 5G world

Cybersecurity challenges are not restricted to 5G but arise from the connected world in general, said Symantec Government Affairs Manager **Zoltan Precsenyi**. Smart wearables, smart grids, connected watches, connected cars and telematics such as anti-theft systems are all vulnerable, as is the e-health space. Symantec believes that every type of attack or vulnerability seen on computers is possible in the IoT and with greater connectivity. Key trends are the resurgence of endpoints in the rapid shift to mobile and the IoT, and increasingly “fuzzy” perimeters. There is also rapid cloud adoption, the emergence of security as a service model, and governments awaking to the cybersecurity agenda, which often involves legislation that does not always resolve security issues.

The 5G community should “be very careful what we wish for” with regard to possible future EU legislation. Self-regulation should be a credible alternative to government mandates.

DAY TWO

Session 5

The disruptive nature of 5G – Revolutionary New Use Cases and implications for industry

This session, moderated by Wireless Test and Innovation Centre, UK Chairman **Stuart Revell**, addressed new services and applications 5G might enable, what users might be able to do on a 5G network that is not currently possible, and how companies can take advantage of the new environment.

Introduction and Presentation of White Paper

Revell discussed the Future Technologies Network (techUK) white paper on 5G innovation opportunities, an industry-academia collaboration. The paper arose from the 2014 Huddle, where it became clear that to achieve 5G goals there would have to be one network with all of the services running on it. But because that is not practical, parties looked at radio access technology and the “digital fabric.” The paper recommends the creation of a 5G and IoT innovative network; test beds and trials enabling 5G’ digital fabric and technological validation; and the creation of a UK ecosystem to develop a leading position for international 5G standards activity.

Power consumption is the main challenge. Another very disruptive issue is that the 5G vision – seamless services with the perception of sufficient bandwidth and coverage in any context – means that individual security, policy and control will rest with the user

or device, a completely different approach from traditional networks. Coverage and capacity are “killer applications.” Revell illustrated several 5G use cases involving the sensing and accessing of weather, air quality and traffic management information. While the technology exists today for such sensing, the information can't be put together without more work on systems integration and interoperability.

Presentation – IMT-202 Promotion Group and FuTURE Forum

Ming Lei, representing the FuTURE Forum, discussed China's two main 5G groups – the IMT-2020 5G Promotion Group (PG), which targets standardisation and promotes Chinese competence in 5G R&D, and FuTURE Forum, an international non-profit seeking to develop and open, neutral, international platform to promote R&D. The IMT-2020 PG, whose vision is aligned with that of the ITU, has established relations with major international organisations such as the 5G PPP. It believes that future 5G networks can be logically decoupled into three planes: control, access and forwarding. On candidate bands for 5G the IMT-2020 PG is aligned with the international community. It believes that spectrum below 6 GHz will be the core band, with 6-100 GHz spectrum being introduced in 2019 and beyond. The FuTURE Forum is preparing version 2.0 of its 5G white paper which examines, among other things, various aspects of security.

Panel Discussion

5G “is all about use cases,” said **Christian Kloch**, TDC vice president, mobile strategy and technology. The IoT is a new concept for many operators and requires collaboration with other industries. All industry players must understand what 5G can do for them.

5G is the telecoms industry's "last chance" to stretch its services and compete with big players like Google, said **Pasi Kempainen**, NNE Pharmaplan senior consultant. 5G's disruption isn't in the radio access part but in the services infrastructure. Facebook, Google and others will "eat your lunch" in the future on services if operators don't deal with their services infrastructure.

In 20 years, mobile communications have fundamentally changed society, creating very successful companies such as Facebook, Google, Uber and Airbnb, Ming said. But it's an unknown territory of which no one has experience. The IoT exposes the weakness of the tech industry, which is highly segmented. It will profoundly change the landscape and drive new disruptive business.

There is a converging view that 5G is a new kind of network that enables new services, connecting new industries and devices and empowering new user experiences, said **Wassim Chourbaji**, Qualcomm Vice President, government affairs Europe, Middle East and North Africa. But with a time frame of 2020, the key challenge is to move toward actual deployment. To do that, industry and policymakers should address several issues. Who will invest in 5G? Mobile revenues in the EU5 countries are falling. Operators need predictable policy, and Europe in particular should be "more bold" in making spectrum available and harmonising as much of it as possible. Business models are also an issue: The companies "who will make money are the ones who are controlling the data." And 5G needs standards, not proprietary technologies.

As for when 5G might be commercially available, Kloch said right now is when players should start close collaboration with industry on what the use cases actually are. He expects that over the next couple of years people will have a better idea of

how to use the networks and commoditise them. But verticals will only move to digital if it boosts productivity, Chourbaji noted. If they don't move, others will, so in five years they may no longer exist. Network services should be developing all the time, said Kempainen. Companies can start building the services and enablers for the IoT for customers today, and then when the radio access network is ready, "there you go."

One audience member wondered how telecoms companies deploying 5G will handle the situation where verticals have their own networks, and whether some sort of revenue-sharing arrangement is possible. Revell agreed that one concept is that the many networks in which businesses have already invested capex might not be interested in 5G. Corporations look for the most flexible, agile platforms for service delivery, which are operator-agnostic, said Kempainen. 5G is an opportunity for the telecoms industry to "go higher in the value chain" and offer better services. Not every IoT needs to be brought into 5G, said Ming.

Asked for one take-away for industry to address, Revell said it's to engage the verticals via trials and test beds. The sooner 5G is nailed down, the sooner the infrastructure can be developed, said Kloch. Chourbaji urged a holistic approach encompassing policies, business models and technology. Don't let 5G limit the start of service enabled, said Kempainen. Be excited about the IoT but also be careful, added Ming.

Session 6

5G Business Cases – new business models and commercial opportunities across different sectors

This session, chaired by **Mischa Dohler**, chair professor in wireless communications, King's College London, focused on what 5G's impact across a broad range of sectors will mean for traditional and new businesses and on new business models and potential commercial opportunities.

6.i Maximising the value of 5G for businesses everywhere

Introductory Presentation – Developing sustainable new business models across vertical markets

Consumers are the final customer in the mobile sector, but 5G will bring about a "massive shift" from B2C to B2B, said Dohler. It will mean serving the "people in the factory and the factory." But there is a big difference between 5G need and demand; everyone is now analysing the former but there is no guarantee there will be an actual demand. The biggest need is for global coverage, where products can be sold anywhere via end-to-end equipment. Accountability for such things as sensor failure is a very strong legal component of 5G.

Because 5G is a B2B world, vendors such as Ericsson and Nokia are the companies that speak its language while mobile operators speak to consumers. Once vendors have locked themselves into verticals they will be in a strong position to bring in the operators. For fixed operators, 5G

offers B2B opportunities but it won't be a "cash cow" for them. However, with the "tactile Internet," data will move to the edge, which the operators own, and where they will be in the OTT space.

6.ii SECTOR CASE STUDY: Maximising the potential of 5G in the Automotive Industry

A Presentation of the 5G PPP Whitepaper

Soldani, speaking on behalf of the 5G PPP, introduced a white paper that examines the use cases for 5G in the automotive sector, such as for automated driving, traffic efficiency and transport and logistics. Its main conclusions were that latency and security are key issues, and that a possible business model is pay-as-you-drive mobility. The paper concludes that there is a need to model the reality; start testing the different scenarios; and redesign how the protocols are managed. It recommends standardisation; the adoption of policies that foster a technological approach; and the reduction of sector-specific rules to create a level playing field across the market place and the entire digital value chain.

A Telecoms Manufacturer's Perspective

Nokia Networks sees many opportunities in 5G for the automotive industry, said Principal Engineer **Preben Mogensen**. There are three domains for 5G in the automotive sector: mobile broadband, massive machine-to-machine applications, and critical machine communications. He discussed the requirements for the different use cases. Nokia want 5G to be a framework which is then applied to the automotive industry. That will require high data rates, connective mobility and telemetry—being able to support many devices at low cost. Automotive opportunities can begin using LTE. The resilience of the system is an issue, because traffic management shouldn't break down if a base station or backhaul

fails. 5G should be designed for all future use cases of the automotive sector, but should not specifically maximise 5G for that industry.

A Road Operator's Perspective

The connected car is about vehicles talking to other vehicles and to the infrastructure, said **Peter Vermaat**, principal ITS consultant, Transport Research Laboratory. There has already been a lot of research on connected applications/services in the industry. Around 200 million cars can connect to infrastructure these days, nearly always via cellular networks. The transport industry has heard that 5G "will solve all our problems" but is cynical because the same was said about about 3G and 4G and nothing happened. 5G proponents will have to overcome that scepticism.

The types of applications available can generally be divided into several categories: safety; efficiency, such as dynamic routing; convenience, the "money-spinner" applications; financial, such as road use charging; and gathering floating vehicle data in real time. "Automation" has been hyped, since the vehicle that can drive autonomously in all situations won't happen until 2017.

Connected-car requirements are strongly dependent on the kinds of services being considered. Vehicle-to-infrastructure is best achieved through the cellular network or short-range network such as ITS-G5, which provides high speed, ultra low latency, high reliability short-wave connectivity. The auto industry strongly supports vehicle-to-vehicle communications. Future services will probably require both. Safety services are the most important to car makers, but they rely on low latency and high reliability. In terms of the communications needed, it's very unlikely that a single type of communication will be sufficient.

A Cross Industry Perspective

Vodafone believes that 5G will be mainly characterised by a new air interface and new core or family of cores, said **Ilaria Thibault**, principal researcher and subject matter expert, 5G technologies. Mobile broadband will continue to evolve, while 5G should address the demands coming from new verticals, of which the automotive sector is one.

Mobile operators already offer machine-to-machine (telematics) and infotainment packages service in vehicle-to-infrastructure communications. There are also standards that address safety-related use cases in vehicle-to-anything communications. 5G can be considered an autonomous vehicle-to-anything-type network. Spectrum allocations in the US and Europe have triggered two standards, and 3GPP is also looking to include vehicle-to-anything LTE advanced, but there is still no business case behind those technologies. Unless safety applications are combined with infotainment or other packages, there won't be business case. But the network shouldn't be over-engineered when vehicles already have inherent limitations. Instead, the network should try to leverage the capabilities of vehicles to strengthen other properties instead of just focusing on inherently unreliable wireless communications. It's also important to concentrate on the commercial viability of the new services under consideration.

One audience member wondered why autonomous driving is becoming a big issue now. Technology allows more assisted driving, said Mogensen. The demand and the technology have come together, said Dohler. There is also a need to generate jobs and go beyond traditional business models, said Soldani. 5G will make autonomous driving happen, he said. Google is driving the issue to some extent,

said Vermaat, because it has developed its car publicly in a way that the auto industry hasn't

Autonomous driving isn't new, and things like cruise control have been around for years. The industry uses the term "automated driving", which implies that a car drive itself, but that's very far away, he said. The technology will come, but not without a strong push from a government or a good business case, said Thibault.

Session 7

Bringing it all together – Summaries and conclusions

Conclusions and final discussions

Concluding, **Knud Erik Skouby**, director, Center for Communication, Media and Information Technologies, Aalborg University, said it was “extremely difficult” to deliver takeaways from the conference. But compared with last year’s Huddle, this year spectrum “has a much more prominent place,” possibly because WRC-15 is imminent and 5G implementation is getting closer. This year also saw more discussion about the 5G user’s perspective – whether consumers or verticals --rather than just that of the telecoms industry. The new services 5G can deliver also lead into a discussion of security issues.

Jefferies, summing up, said that talks with some participants showed that perhaps the community hasn’t completely got its ideas together about 5G and must be careful not to over-hype the technology as being everything to everybody.