

# MOBILE COMMUNICATIONS GROUP

## HEAD OF THE GROUP RESEARCH REPORT

The Mobile Communications Group (MCG), led by Narcís Cardona, is composed of about 30 people between professors and researchers. The MCG is aimed at developing new technologies for future standards in Mobile and Wireless Communications. The current activities of MCG are focused on four areas: 5G New Radio (5G-NR), Multicast and Broadcast Services (MBMS) over 3GPP Networks, Vehicular Communications and Body Area Communications (BAN). The Mobile Communications research Group has worked on several international projects related to 5G, most notably the METIS and METIS-II projects. The group led the 5G-Xcast project and currently leads the European projects 5G-RECORDS, INGENIOUS, FUDGE-5G, and also participates in the 5G-CARMEN, 5G-SMART, 5G-TOURS, ORCA, and WAVECOMBE projects, all of them in the development of "vertical" 5G applications. Furthermore, it can be stated that the group of MCG researchers have a consolidated experience in 5G, as shown by the organization in 2019 of the 5G Global Event. In this event, some 5G end-to-end demonstrations were performed for the first time in history. In addition, the 5G Global Event brought together all European 5G projects and 5G industry associations around the world.

## 1.- PROJECT ACTIVITIES

### 1.1.- ONGOING PROJECTS

#### **VLC-CAMPUS-5G (pilot testing field, development and demonstration of 5G mobile technologies)**

VLC-CAMPUS-5G is the project to launch a 5G technology wireless communications platform on the campus of the Universitat Politècnica de València, which supports the testing of new 5G services and equipment and promotes Valencia as a 5G city. The VLC-CAMPUS-5G project is aligned with the evolution of mobile networks towards 5G, which will bring important developments and improvements not only in terms of capacity, latency, connection density, quality and user experience, but also in terms of flexibility, efficiency, scalability and openness of the networks, which will allow offering new services.

The deployment of the VLC-CAMPUS-5G testbed is based on the expansion of the current communications' infrastructures of the UPV, by the acquisition of the necessary equipment for the emission and experimental tests of 5th generation mobile services. There is currently an ultra-dense network of femtocells configured within a private operating network, a 5G network core emulator, as well as software-configured radio units and various equipment and software licenses that together configure a network 5G laboratory.

<https://vlc-campus5g.com/>

This project is co-financed by the European Union through the operational program of the European Regional Development Fund (FEDER) of the Comunitat Valenciana 2014-2020, duration (2018-2020)

#### **Valencia 5G**

Valencia 5G is a project to validate the capabilities of 5G technology in Valencia, Spain by testing 15 use cases that involve sectors of health, industry, energy, gaming, and tourism. Valencia 5G has a budget of 10,145,234 euros and involves Orange, Huawei, Arborea Intellbird, CFZ Cobots, Global Omnium Idrica, Etra Research and Development, Red Eléctrica y de Telecomunicaciones Innovación y Tecnología and Robotnik. The project aims to contribute from three approaches: support the deployment of the first 5G networks in Spain; experiment with the network management techniques; and testing the main capabilities of the technology: ultra-reliable and low-latency communications; massive machine-to-machine communications; and extremely high speed and capacity mobile broadband. The MCG of the iTEAM will be involved in 5 out of 15 uses cases, being these: (1) Robotic Remote diagnostic. (2) Fleet management: Robotics Remote control of AGVs. (3) Robotics-Remote inspection and maintenance. (4) 5G Digital Contents. (5) Massive IoT for smart meters in supplies. The use case of robotic remote diagnostic for the skin cancer diagnostic using the 5G mobile communications network, consisting of a specialist will scan the patient remotely using robotic arms that have built-in biometric sensors that capture and process the information. On the other hand, the VLC-CAMPUS-5G of the Universitat Politècnica de València, has been chosen as one of the testing scenarios.

This project has been funding by Red.es through European Regional Development Fund (FEDER), 18 months duration (July 2020 – December 2021)

### **AUDERE (Advanced Urban Delivery and Refuse Recovery)**

AUDERE aims to design and develop an intelligent and innovative system for urban refuse collection and last mile delivery logistics. To fulfil this objective, a fleet of autonomous vehicles (autonomous mobile robots) are equipped with 5G connectivity to carry out last mile delivery and urban waste container recovery tasks. The AUDERE system will assess the technical, economic, social, and environmental viability in a range of use cases. Therefore, AUDERE will offer high-tech solutions to the growing forward and reverse logistics needs in our cities. Trials will be performed in two scenarios. The first one is the VLC-CAMPUS-5G of the Universitat Politècnica de València, which is equipped with the infrastructure of a private 5G mobile network that allows the validation of different use cases, such as logistics, automotive, industry, media, among others. In addition, among the main advantages of VLC-CAMPUS-5G we can mention that it is a closed and controlled environment, which could be considered as a small city due to its infrastructure, commercial and sport places, banks, parks and where more than 20,000 people move daily. The second scenario is the La Pinada District, which is an eco-district, the first in Spain, that will integrate the principles of sustainable urban development, creating an attractive environment for family living, work, and enjoyment of nature. The results of this project will define new technological products that can be deployed in Smart Cities or Smart Quarters.

This project has been funded by The Valencian Innovation Agency (Agència Valenciana de la Innovació - AVI), 21 months duration (April 2020 – December 2021).

### **CROFT (Cloud Robotics and factories Of The FuTure)**

This project addresses the research required for the development of mobile robotics in the cloud based on 5th generation mobile networks for the future IoT revolution. Low latency, high capacity demands, and a large number of mobile wireless entities connected to the Internet will require a continuous Ultra Dense Network (UDN) that is likely to use mmW bands to support future factory wireless connectivity. The connection network must be multi-hop, with connectivity nodes moving throughout the factory, even with drones, to ensure line of sight conditions for successful mmW communication. The nodes can cooperate in the transmission/reception of data in a centralized or distributed way. In addition, the design of the protocol, mainly speaking of the PHY and MAC procedures, will guarantee the minimum battery consumption of the communicating machines.

The objective of the project is to research and optimize the operation of RAN architectures for 5G standards beyond NR phase 2, and to design reliable and realistic PHY and MAC procedures adapted to this new communication model composed of mesh networks and mobile nodes. The ultimate goal is to achieve an improvement in the latency, reliability and capacity of the large number of robots, drones, droids and humans that will work together in the factory of the future. In this context, the new communication paradigm of mmW and continuous UDNs together with the use of multi-hop cellular communications play a transversal role. During the project, the performance of the systems will be evaluated, simulations, RF measurements, and experiments with a large number of devices will be performed to validate the design principles used. For this purpose, the VLC-CAMPUS-5G will be exploited. In addition, this project aims to attract the talent of women to the new job opportunities that 5G will generate.

This project has been funded by the Prometeo 2020 grant from the Generalitat Valenciana to carry out R & D & I projects for research groups of excellence, 36 months duration (01/01/2020 - 30/12/2022)

### **WaveComBE (Millimetre Wave Communications in Built Environments)**

WaveComBE is an Industrial and Training Network dealing with the ultra-dense deployment of millimetre-wave (mmW) Small Cells (SCs) in conjunction with massive multiple-input multiple-output (MIMO) in 5G and beyond 5G (B5G) wireless networks. In WaveComBE the MCG is developing simulation tools to analyse the human body blocking at millimetre-wave band, as well as efficient planning tools to deploy future access points in bands around and above 30GHz. Besides beamforming techniques are being investigated for the physical layer of millimetre-wave mobile communications.

The UPV is in charge of coordinating this project, led by Narcís Cardona, in consortium with The University of Sheffield, University of Durham, University of Twente and companies Ranplan Wireless Network Design Ltd. and Televis Conference, Capwaves AB together with the partner organizations, Axió Infraestructuras de Telecomunicaciones S.A.U, Telenor Group and Nokia Bell Labs.

WaveComBE provides high quality interdisciplinary and cross-sector research training for a new generation of scientists. Specifically, 11 Early Stage Researchers are hired, two of them by the UPV. During the third year of the project, two training schools were held, one of them in Valencia which was attended by all ESRs and took ad-

vantage to celebrate the Project Management Committee Meeting. This last year 15 papers have been published by the ESRs. <https://wavecombe.eu/>

This project is funded by the European Commission under the Marie Skłodowska-Curie programme. Duration: 01/10/2017 - 30/09/2021

#### **EMOTE (ElectroMagnetic prObe for early Tumour dEtection)**

*This is a joint collaborative project with Hospital La Fe, jointly funded by both public institutions. This project is devoted to the measurement of the dielectric properties of in vivo healthy and malignant tissues by using animal models (rats). In this way, it would be possible to evaluate whether the differences between healthy and tumor tissues found for humans are also repeated at in-vivo conditions. During the first semester of 2020 preliminary tests in health rats were carried out. For the second semester, trials in rats with colon, ovary and prostate cancer are being performed.*

This project has been funded by Ayudas para el Desarrollo de Proyectos de Innovación Coordinados entre la Universidad Politécnica de Valencia y el Hospital Universitario y Politécnico La Fe (call 2017). Duration: 01/01/2018 to 31/12/2020.

#### **COLODEM (Sonda Colorrectal para la Detección Electromagnética de Tumores)**

*COLODEM project is based on the development of a tool for colorectal cancer detection based on the reported difference in the electromagnetic properties of healthy and malignant colon tissues. Such tool will consist of three main parts: a flexible probe to be integrated into the colonoscope, a software algorithm for measuring and identifying the malignant tissues, and a laboratory platform for testing. This platform will be based on the electromagnetic reproduction of a human colon with presence of malignant tissues and it will be used for both the development of the probe and the detection algorithm as well as the training of the physicians. During 2020, the activities of the project have been focused on the development of 3D synthetic gel phantoms for the laboratory platform.*

This Project has been funded by Convocatoria de Ayudas a Primeros Proyectos de Investigación (PAID-06-18). Duration: 1/09/2019 to 28/02/2021

#### **5G-TOURS (SmarT mObility, media and e-health for toURists and citizenS)**

*5G-TOURS vision is to improve the life in the city for the citizens and tourists, making cities more attractive to visit, more efficient in terms of mobility and safer for everybody. 5G-TOURS builds on three themes: the touristic city (Turin), the mobility efficient city (Athens), and the safe city (Rennes). iTEAM is involved in the touristic city,*

*where visitors of museums and outdoor attractions are provided with 5G-based applications to enhance their experience while visiting the city. This includes VR/AR applications to complement the physical visit with additional content, involving interactive tactile communications. The experience of the visitors is also enhanced with robot-assisted services, telepresence to allow for remote visits, as well as live events enabled by mobile communications such as multi-party concerts. iTEAM is the leader of the broadcast use case. [www.5gtours.eu](http://www.5gtours.eu)*

This project has been funded by H2020, 36 months duration (June 2019 – May 2022)

#### **5G-ROSE (5G bROadcast Software defined radio Experiment)**

*The 5G-ROSE project worked towards the transmission of 5G broadcast services over SFN virtualized networks, using opensource software. The project is very well aligned with the current trends in the world of 5G. On one side, the virtualisation of the 5G infrastructure, both core and RAN (Radio Access Network), allowing for different deployment architectures with maximum flexibility and scalability. On the other side, the adoption of so-called LTE-based 5G Terrestrial Broadcast mode, which is currently under standardization in 3GPP Release-16, and that will meet the requirements of broadcasters for the distribution of media content in 5G. 5G-ROSE has made use of the virtualised IRIS testbed at Trinity College Dublin. The project has used and contributed to the open source SDR LTE software suite srsLTE, offered by Software Radio Systems. The 5G-ROSE project consisted of three clearly differentiated, but related, broadcast experiments over a virtualised SDR (Software Defined Radio) access infrastructure. The first experiment was the development and testing of the first virtualized Multimedia Broadcast Multicast Service over Single Frequency Network (MBSFN) transmission. The second experiment dealt with the introduction of 5G physical layer Release (Rel)-16 specific components. The third part was about the combination of both unicast and broadcast transmissions by means of network slicing. <https://www.orca-project.eu/open-calls/3rd-open-call-for-experiments/>*

*This project has been funded by third Open Call for experiment of H2020 project Orchestration and Reconfiguration Control Architecture (ORCA), 6 months duration (December 2019 – May 2020)*

#### **5G-RECORDS (5G key technology enableRs for Emerging media COntent pROduction Services)**

*5G-RECORDS aims to explore the opportunities which new 5G technology components - these include the core network (5GC), radio access*

network (RAN) and end devices - bring to the professional production of audiovisual content. The project targets the development, integration, validation and demonstration of 5G components for professional content production, as part of an overall ecosystem integrating a subset of 5G network functions. The project aims to use of 5G non-public networks (NPNs) as a way to bring these new 5G components to emerging markets and new market actors, while also addressing recent emerging remote and distributed production workflows where cloud technologies cooperate with 5G. 5G-RECORDS has considered 3 use cases to embrace some of the most challenging scenarios in the framework of professional content production: live audio production, a multi-camera wireless studio and live immersive media production. iTEAM is the coordinator of the project. [www.5g-records.eu](http://www.5g-records.eu)

This project has been funded by H2020, 24 months duration (September 2020 – August 2022)

#### **FUDGE-5G (FULLY DisinteGrated private nEt-works for 5G verticals)**

FUDGE-5G will make a leap forward in realizing the notion of cloud-native 5G private networks by developing a further enhanced Service-Based Architecture (eSBA) for both control plane and user plane with “decomposed” players of the ecosystem divided into: New Radio (NR) access network infrastructure provider, eSBA platform provider, mobile 5G Core (5GC) provider, vertical application orchestration provider and vertical service provider. The forward-looking FUDGE-5G architecture will also feature “all-Ethernet” 5GLAN (Local Area Network), 5G-TSN (Time- Sensitive Networking), 5G-Multicast and intelligent vertical application orchestration features. The proposed framework enables highly customized cloud-native deployment of private 5G networks. FUDGE-5G will accelerate the (inevitable) shift to a fully software-based 5G core network by offering a disintegrated environment where components, both in control and user plane, can be deployed anywhere as micro-services (i.e., edge, on premises and cloud), being agnostic to the underlying infrastructure. This softwarization exposing 5G NR HW to third parties will enable the usage of off-the-shelf commodity HW to deliver additional cost savings, faster deployments and ultimately greater adoption for private networks. iTEAM is the coordinator of the project, and the leader of the media use case. [www.fudge-5g.eu](http://www.fudge-5g.eu)

This project has been funded by H2020, 30 months duration (September 2020 – Feb. 2023)

#### **INGENIOUS (Next-GENERATION IoT sOlutions for the Universal Supply chain)**

iNGENIOUS will exploit some of the most innovative and emerging technologies in line with the

standardised trend, contributing to the Next-Generation IoT and proposing technical and business enablers to build a complete platform for supply chain management. iNGENIOUS embraces the 5G Infrastructure Association (5G IA) and Alliance for Internet of Things Innovation (AIOTI) vision for empowering smart manufacturing and smart mobility verticals. The iNGENIOUS network layer brings new smart 5G-based IoT functionalities, federated Multi-Access Edge Computing (MEC) nodes and smart orchestration, needed for enabling the projected real-time capable use cases of the supply chain. Security and data management are fully recognized as important features in the project. iNGENIOUS will create a holistic security architecture for next-generation IoT built on neuromorphic sensors with security governed by Artificial Intelligence (AI) algorithms and tile-based hardware architectures based on security by design and isolation by default. In the application layer, iNGENIOUS new AI mechanisms will allow more precise predictions than conventional systems. Project outcomes will be validated into 4 large-scale Proof of Concept demonstration, covering 1 factory, 2 ports, and 1 ship, encompassing 6 uses cases. iTEAM is the coordinator of the project, and the leader of the media use case. [www.ingenious-iot.eu](http://www.ingenious-iot.eu)

This project has been H2020, 30 months duration (October 2020 – March 2023)

#### **5G-CARMEN (5G for Connected and Automated Road Mobility in the European union)**

This project, funded by the European Commission, has progressed with relevant impact on research community, being declared the most active project on autonomous driving by the European Commission.

The “Munich-Bologna corridor”, which covers 600 km of roads across three countries (Italy, Austria and Germany), is one of the most important corridors identified by the European Union for an initiative to improve the mobility of people and goods throughout Europe. As part of the 5G-CARMEN project, 5G technologies will be deployed along selected stretches of the motorway in the border regions. <https://5gcarmen.eu/>

This project has received funding from the European Horizon 2020 Programme for research, technological development and demonstration under grant agreement n° 825012 – 5G CARMEN. Will last 36 months until November 2021.

#### **5G-SMART (5G for smart manufacturing)**

5G-SMART unlocks the value of 5G for smart manufacturing through demonstrating, validating and evaluating its potential in real manufacturing environments. 5G-SMART trials will test the most advanced 5G integrated manufacturing applications such as digital twin, industrial robotics and machine vision based remote oper-

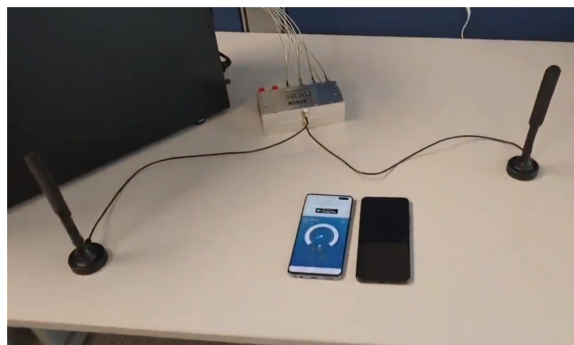
ations. 5G-SMART will undertake the first ever evaluation of ElectroMagnetic Compatibility (EMC), channel measurements and co-existence between public and private industrial networks in real manufacturing environments easing the integration of 5G. The new 5G features, developed in 5G-SMART such as time synchronisation and positioning for manufacturing use cases represent a technological leap.

5G-SMART lead by Ericsson brings together a strong consortium of partners involved in every aspect of the manufacturing ecosystem. Prof. Jose F. Monserrat, member of the iTEAM, is the Innovation Manager of the Project. This project is funded by the European Commission. <https://5gsmart.eu/>

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement no 857008. Will last 30 months until November 2021.

**2.- RESEARCH RESULTS**

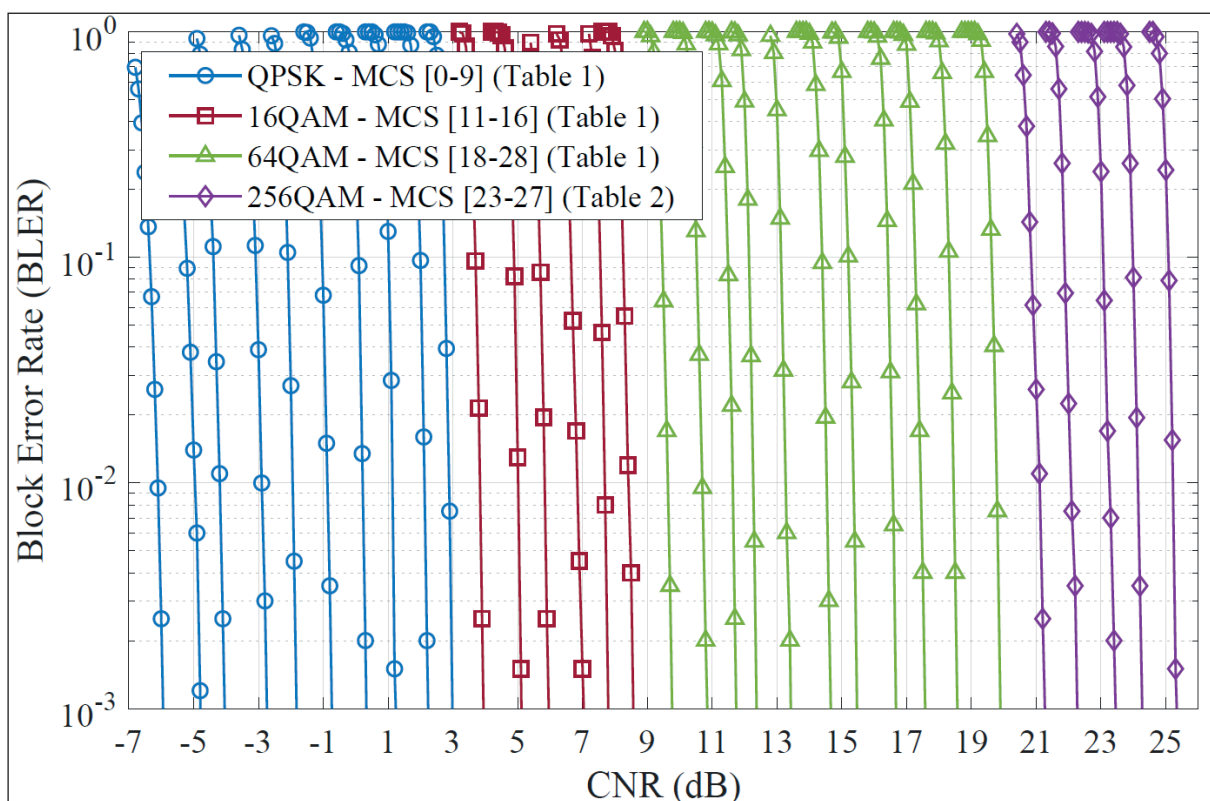
Throughout this year, the deployment of a private open source 5G network by the mobile communications group has been completed. With a bandwidth of 20 MHz, more than 300 Mbps are reached, which is an important performance milestone compared to 4G. It is also worth highlighting the participation of Prof. Jose



Mobile connected to the private 5G network based on open source "VLC-CAMPUS-5G"

F. Monserrat in the report prepared by the World Bank and entitled *Envisioning 5G Enabled Transport*. This report discusses if the development and rollout of fifth-generation (5G) mobile broadband has the potential to not only support, but accelerate these revolutionary changes as today's digital transport solutions evolve and entirely new opportunities become viable.

The Figure below shows the Simulated 5G New Radio (NR) physical layer performance for different Modulation and Coding Schemes (MCS) in AWGN channel. These results have been obtained by the Mobile Communications Group of the



Simulated 5G New Radio (NR) physical layer performance for different Modulation and Coding Schemes (MCS) in AWGN channel.

*iTEAM with its own 5G NR physical layer simulator. The simulation results have been used within the 5G PPP IMT-2020 Evaluation Group to perform a detailed analysis and performance evaluation of 5G NR against a set of Key Performance Indicators (KPI), as defined in the International Mobile Telecommunications 2020 (IMT-2020) guidelines by the International Telecommunication Union (ITU), providing an independent evaluation of the Third Generation Partnership Project (3GPP) contribution. <https://5g-ppp.eu/5g-ppp-imt-2020-evaluation-group/>*

## 2.1.- FEATURED PUBLICATIONS

**“5G New Radio Evaluation Against IMT-2020 Key Performance Indicators”.** Manuel Fuentes, Jose Luis Carcel, Christiane Dietrich, Lang Yu, Eduardo Garro, Volker Pauli, Fotis I. Lazarakis, Ole Grøndalen, Ömer Bulakci, Jian Yu, Werner Mohr and David Gomez-Barquero. *IEEE Access* **8: 110880-110896 (2020), DOI: 10.1109/ACCESS.2020.3001641**

*This work provides a detailed analysis and performance evaluation of 5G New Radio (NR) against a set of Key Performance Indicators (KPI), as defined in the International Mobile Telecommunications 2020 (IMT-2020) guidelines, and provides an overview about the fulfillment of their associated requirements. The objective of this work is to provide an independent evaluation, complementing the Third Generation Partnership Project (3GPP) contribution. From the original group of sixteen KPIs, eleven of them have been carefully selected, paying special attention to eMBB services. Results show that 5G NR achieves all considered requirements, therefore fulfilling the specific market's needs for years to come.*

**“5G V2V Communication With Antenna Selection Based on Context Awareness: Signaling and Performance Study”.** Sandra Roger, David Martín-Sacristán, David Garcia-Roger, Jose F. Monserrat, Apostolos Kousaridas, Panagiotis Spapis and Serkan Ayaz. *IEEE Transactions on Intelligent Transportation Systems*, **14 pages, 09 September 2020.-DOI: 10.1109/TITS.2020.3019530**

*Enhanced vehicle-to-everything (eV2X) communications include ultra-high reliable fifth-generation (5G) fully-autonomous driving vehicular applications. Depending on the communication context, antenna subgroups at specialized positions may perform better. We propose a context-aware antenna selection procedure enhancing multi-antenna eV2X, extending current 5G radio resource control and radio resource management signaling. The context exchange signaling overhead is analyzed in comparison to the exchange of reference signals. Simulation results for a platooning use case show the ad-*

*vantages of antenna selection.*

**“V2X Support in 3GPP Specifications: from 4G to 5G and Beyond”.** David Garcia-Roger, Edgar E. González, David Martín-Sacristán and Jose F. Monserrat. *IEEE Access*, **accepted 28 August 2020.**

*The connected car is gaining momentum as a research, standardization and industrial development concept. Vehicles may use many wireless connectivity options: conventional cellular technology, a base station or infrastructure element, but also directly to each other using different standards from the IEEE and 3GPP. This article reviews with detail and rigor the system architecture aspects involved in the support of vehicular communications by the 3GPP 5G standard, focusing on its most recent iteration: Release 16.*

**“Analysis of an open-ended coaxial method for detection of colorectal cancer obtained through colonoscopy biopsies. Preliminary results”.** A. Nevárez, A. Fornés-Leal, A Parra-Escrig, C. García-Pardo, M. Frasson, N. Cardona and V. Pons-Beltrán. *Endoscopy*, **Vol. 52. Issue S01, pp 122, April 2020.**

*Many technological advances have been made to optimize the detection of colorectal cancer (CRC) lesions. Research has shown that the electromagnetic properties of healthy and cancerous tissues differ in many biological samples. We aim to analyse differences in healthy and pathological colon tissues gathered from colonoscopy biopsies. Results have shown that measurements of electromagnetic properties could aid in the detection of colorectal pathologies. The variability of the results is quite large and hence the system should be improved prior to a potential implementation.*

**“Doppler Characterization in Ultra Wideband BAN Channels During Breathing”.** R. Garcia-Serna, C. Garcia-Pardo, J.M. Molina-Garcia-Pardo, L. Juan-Llácer, N. Cardona. *IEEE Trans. On Antennas and Propagation*, **vol. 68, Issue 2, pp. 1066-1073, Nov. 2019, DOI: 10.1109/TAP.2019.2951849.**

*Monitoring the physical parameters from devices inside the body, using ultra wideband (UWB) technology, enables the development of high bandwidth demanding applications in real time. The relative movement of the nodes deployed in the body, due to breathing, can give rise to a frequency shifting effect, increasing the fading level in the propagation channel during transmissions. In this article, therefore, we present a study of the frequency effects on the propagation channel derived from the relative movement between two nodes of a wireless body area network (WBAN), at least one of them placed inside the human body, caused by breathing. The*

study is performed on the basis of the Doppler spectrum characterization in terms of the shape fitting and frequency spread parameter derivation. Continuous wave (CW) signals have been used to cover the UWB range at four selected frequencies: 3.1, 4.8, 6, and 8.5 GHz, and a liquid phantom has been employed for emulating the dielectric properties of the high water content tissues at the considered UWB frequencies.

**“UWB Channel Characterization for Wireless Capsule Endoscopy Localization”.** C. Garcia-Pardo, M. Barbi, S. Pérez-Simbor, N. Cardona. 2020 IEEE International Conference on Communications Workshops, June 2020, DOI: 10.1109/ICCWorkshops49005.2020.9145270.

Wireless capsule endoscopy (WCE) is a medical device for the inspection of some parts of the gastrointestinal (GI) tract. Currently, WCE transmits to the outside low resolution video, although high quality images would be necessary for improving the detection of diseases. Ultra wideband (UWB) frequency band is a good candidate to achieve such requirement due to its large available bandwidth. Besides, the knowledge of the exact location of WCE would also help physicians to locate the suspicious tissue so diagnosis time could be shortened. Received Signal Strength (RSS) based localization is one of the simplest localization techniques. However, RSS localization requires a good knowledge of the path loss model, what is not easy for in-body communications. The objective of this paper is to provide a review of the problem of modelling the path loss for WCE in UWB as well as give implementation guidelines for WCE localization.

## 2.2.- PATENTS

**Method for transeiving broadcast signal using combination of multiple antenna schemes with layered division multiplexing and apparatus for the same.** Sung-Ik Park, LIM Bo-Mi, KWON Sun-Hyoung, Heung-Mook Kim, Jae-Hyun Seo, Jae-Young Lee, Nam-Ho Hur, JUNG Hoi-Yoon, David Gomez-Barquero and Eduardo Garro. Reference: US10454536. Entity: ETRI. Granted.

**Methods, telematics server and base station for supporting vehicular communications in a cellular network.** Calabuig Gaspar, Jordi; Calabuig Soler, Daniel; Monserrat del Río, Jose Francisco and Gozávez Serrano, David. Reference: US10455367. Entity: BMW AG. Granted.

**Vehicle-based femtocell with prioritization of data packets on the basis of the required internet service quality.** Monserrat del Río, Jose Francisco and Peter Fertl. Reference: US10277303. Entity: BMW AG. Granted

## 2.2.- AWARDS

**Scott Helt Memorial Award to recognize the best paper published in the IEEE Transactions on Broadcasting 2019.** Physical Layer Performance Evaluation of LTE-Advanced Pro Broadcast and ATSC 3.0 Systems. IEEE Trans. Broadcast. 65(3): 477-488 (2019). (Manuel Fuentes, De Mi, Hongzhi Chen, Eduardo Garro, Jose Luis Carcel, David Vargas, Belkacem Mouhouche and David Gomez-Barquero)

**Extraordinary Doctoral Thesis Award of the Social Council of the UPV.** Advanced Layered Division Multiplexing Technologies for Next-Gen Broadcast. (Eduardo Garro Crevillén)