

# Radio Channel Sounding Campaigns in EU H2020 mmMAGIC Project for 5G Channel Modeling

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**Abstract** – A summary of channel sounding campaigns in the European Horizon 2020 mmMAGIC project is presented in this paper. A comprehensive database of radio channel responses covering radio frequencies up to 100 GHz and various use cases has been established, complementing the ongoing fifth-generation channel model development.

**Index Terms** — Channel sounding, channel model, 5G, EU, mmMAGIC, Horizon 2020, 5GPPP.

## 1. Introduction

Research and development of fifth-generation (5G) wireless networks has been the significant interest of industry and academy worldwide. European activities on 5G wireless have been enormous and successful so far with many impacts on standardization and frequency regulation thanks to the 5G infrastructure public private partnership (5GPPP) initiated by the European Commission [1]. The mmMAGIC project [1] covers millimeter-wave mobile access among different projects of the 5GPPP. Having identified use cases, KPIs and requirements of the 5G wireless networks [3], the mmMAGIC project has been devoting significant efforts to 5G channel modeling [4]. The 5G channel models are required to cover the unprecedented wide frequency range up to 100 GHz and diverse types of environments such as street canyon and indoor. Despite significant efforts devoted to this issue, e.g., [5], [6], it is evident that empirical evidence supporting the 5G channel model is still insufficient. The needed empirical evidence is so large that it is necessary to have synergetic efforts combining channel sounding from many research groups. The mmMAGIC project teams up and establish comprehensive databases of measured and simulated radio channels for 5G channel models and studies of link and network design. The present paper summarizes channel sounders, channel sounding campaigns and initial findings from the data analysis performed by the mmMAGIC partners. They cover a frequency range between 2 and 82 GHz for various 5G relevant environments. Readers are encouraged to read the Deliverable D2.1 of the project, [7], and papers cited in the respective sections for details.

## 2. Channel Sounding Campaigns and Analysis

### (1) Street canyons

Urban street canyons in microcellular scenarios are one of the most important environments for 5G use cases. Aalto

University's sounding in a campus street canyon was performed with a directional radio channel sounder operating at 15, 28 and 60 GHz [8]. Angular and delay spreads at the three frequencies showed no significant dependency on the frequency. Dominated by wave-guiding effects, up to fourth-order reflections were observed within 30 dB dynamic range of measured power delay profiles.

Fraunhofer HHI carried out a measurement campaign in a street canyon of downtown Berlin at 10, 28, 41 and 82 GHz using the new multi-frequency wideband channel sounder in collaboration with Rohde & Schwarz. Statistically evaluable channel data for access scenarios were obtained. Large-scale parameters of the channel, its time variance due to a dynamic environment and the frequency dependence of the channel characteristics have been analyzed.

Ericsson research (EAB) performed channel sounding at 2.44, 14.8 and 58.68 GHz in a street canyon in Stockholm. In non-line-of-sight (NLOS) channels behind a corner of buildings, a substantial increase of propagation loss was observed. The loss was less than the knife-edge diffraction predicts around the corner, suggesting that the dominating propagation mechanisms in NLOS channels is specular and/or diffuse scattering by objects or rough exterior walls rather than diffraction. The root-mean-square (RMS) delay spreads are very similar for all frequencies in the range 20–50 ns in line-of-sight (LOS) and 75–200 ns in NLOS.

Samsung Research in UK studied channel characteristics via ray tracing simulations at frequencies such as 18, 28, 38, and 73 GHz in Daejeon, Korea. For large-scale channel characteristics, distance-dependent shadowing was observed. Furthermore, around 10 subpaths were found inside a cluster. No significant frequency dependency was observed in angular or delay spreads. The ray tracing results are used for complementing the limited number of measurements.

### (2) Open square

A scenario that emerged recently for the urban microcellular environment is an open square. Aalto University performed directional channel sounding at 15, 28 and 60 GHz using a sounder in [8]. The result shows that dominant propagation mechanisms are different from street canyons. Single-bounce reflections are much more prevailing, resulting in much larger delay spread. Angular and delay spreads were found to increase as the link distance is longer, which is an opposite trend from the street canyons.

### (3) Indoor office

Indoor hotspot is also an important environment of 5G radio network deployment, aiming at smart office, media-on-demand for example. EAB's channel sounding was in a long corridor and a large room at 2.44, 14.8 and 58.68 GHz. While small differences in excess path loss were observed at 2.44 to 14.8 GHz, the loss is higher by about 10 dB at 58.68 GHz than at the other frequencies for 100 m distance in NLOS. For a LOS channel, a clear gain due to wave-guiding is observed in the corridor at all frequencies. No clear frequency dependency is observed for delay or angle spreads in the LOS scenario.

CEA-LETI in France performed indoor double directional measurements at 60 and 82 GHz in office and conference rooms. They include measurements for human blockage modeling using a phantom representing a human torso. Having detected propagation paths in the angular and delay domains, pathloss, delay and angular spreads were derived; the results at 82 GHz measurements are summarized in [10].

### (4) Shopping mall

Shopping mall is a typical densely populated scenario where the 5G small-cells may be of significant advantage. The measurements by the University of Bristol (UoB), UK, together with Keysight, aimed at characterizing spatio-temporal channels at 63 GHz. The results indicate that reflections could have a significant impact on the overall system performance, and that exploitation of dominant reflections can greatly enhance the average cell throughput. Further measurements were made for corner diffraction and diffused scattering. Preliminary results indicate that diffraction loss is about 35 dB when compared to LOS propagation, and hence could be negligible in case a receiver is moving at short distances away from the corner. However, when the receiver is further away from the corner, the signal decay rate is much less and hence diffraction should not be ignored. The diffused components reflected from rough surfaces were found significant and led to random variation of the received signal strength. A summary of channel sounding in an indoor office, open square and shopping mall at 63 GHz is presented in [9].

### (5) Airport

Airport is covered as one of the scenarios of indoor hotspot. Aalto University performed directional channel sounding at 15, 28 and 60 GHz using the equipment in [8]. Preliminary analysis showed strong specular reflections from a multitude of different azimuth/elevation angles, making a link connection possible between different open floors.

### (6) Outdoor-to-indoor

The last environment that the mmMAGIC project concerns is outdoor-to-indoor (O2I). The measurements of EAB in Stockholm covered frequencies of 2.44, 5.8, 14.8 and 58.68 GHz. Building penetration loss ranged from 0 up to 30 dB at 2.44, 5.8 and 14.8 GHz. The highest losses around 45 dB occurred only at 58.68 GHz. The loss due to the exterior wall only, i.e. the loss in rooms having only the exterior wall

obstructing the transmitter, was in the range of 0–20 dB at all frequencies. The spread of the loss was much larger at 58.68 GHz. The RMS delay spread was found to go up with frequency.

The O2I measurements by Orange, France, were performed at 3.6, 10.5 and 17.3 GHz. The estimated penetration loss was mainly due to the concrete exterior wall and one or two inner plasterboard wall. The additive loss compared to the free space loss ranges from 10-15 dB at 3.6 GHz up to 30-35 dB at 17 GHz. The RMS delay spread were found to be less than 50 ns and not frequency-dependent.

## 3. Concluding remarks

A summary of channel sounding campaigns in the EU mmMAGIC project was presented. Details of the campaigns are described in the Deliverable D2.1 [7]. Further analyses of the measured channels are on-going for the Deliverable D2.2 in April 2017, where channel model implementation and its calibration for all the frequency bands and interested environments will be provided. Establishment of channel models for site-specific small-cell coverage design is yet another goal of the project. These works complement the on-going 5G standardization and regulatory works.

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