# DETERMINISTIC AND STOCHASTIC EXPOSURE ASSESSMENT OF CHILDREN AND PREGNANT WOMEN AT EMERGING 5G FREQUENCIES: THE PROJECT CHILD 5G

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## ABSTRACT
The CHILD 5G project, supported by ANSES, contributes to improve the existing knowledge regarding the exposure of the whole population to one or multiple electromagnetic (EM) sources operating in the 5G bands in the near- or far- field with respect to the user. This includes the study of the power absorption and resulting heating as a function of age and, for specific conditions such as pregnancy, by deterministic and stochastic computational methods. This multifaced approach provides accurate children and pregnant women exposure assessment considering representative 5G exposures scenario and use cases.

## INTRODUCTION
5G exploits a large spectrum, ranging from frequencies below 1 GHz and the mid-band range (up to 6 GHz) to millimeter-wave (mm-Wave) frequencies [1], [2]. The adoption of the mm-Wave frequencies for mobile communications is a point of discontinuity with respect to legacy 2G/3G/4G generations. So, the 5G systems integration with the current 2G to 4G mobile networks changes the environmental radiofrequency (RF) exposure spectrum. This context raised the need to assess and analyze physical interactions at 5G frequencies with humans, particularly for potentially more sensible subjects, like children and pregnant women.
Until recent years, little attention has been paid to the assessment of human exposure at microwave frequencies above 6 GHz. With 5G networks, this evolves and ICNIRP has updated the RF exposure guidelines [3]. However, at the research level, this topic is still in an infancy phase. Preliminary data on children exposure depending on the tissue permittivity, skin thickness, and blood flow variations at 26 GHz are available [4]. However, an in-depth exposure assessment considering realistic exposure conditions, body models, new use cases and their variability is still to be performed. CHILD 5G project intends to fill these gaps of knowledge.
The main goal of CHILD 5G project is to analyze how the physical and geometrical parameters variations induced by age and pregnancy impact the power deposition and resulting heating in near-surface tissues in realistic exposure scenarios. This analysis is performed in the mm-Wave band with a special attention to the frequencies that are used for 5G and future generations. The electromagnetic (EM) and thermal problems are solved with a deterministic and a stochastic approach to consider all the most representative exposure scenarios, involving the contextual presence of multiple EM sources and the use of different excitation signals.

## METHODS
CHILD 5G project addresses the following open questions:
- Exposure assessment in 5G bands and analysis of the difference in terms of EM power absorption and heat rise, as a function of age and for specific conditions, such as pregnancy.
- Cumulative exposure in realistic scenarios in presence of multiple wireless devices (e.g., mobile phones, tablets, connected watches) positioned in the near- and/or far- field of the user.
- Development of deterministic and stochastic approaches for the evaluation of the power absorption and heat rise.

The work program is divided in four steps.
1) Exposure scenario identification: This task defines the exposure scenarios in terms of numerical models and EM sources. Tissue models with increasing complexity (from multilayer to anatomical) and with age-

dependent properties are used to characterize the exposure and compare the absorption in children and pregnant women to adults. Plane wave sources together with reconfigurable antenna arrays are used to simulate far- and near-field exposure representing a set of selected realistic exposure scenarios.
2) Deterministic and stochastic dosimetry: This task develops deterministic and stochastic techniques for the analysis and characterization of multiple realistic exposure scenario building surrogate models able to estimate the distribution of EM exposure quantities of interest, considering variability of the exposure scenario.
3) Thermal study: The aim is to numerically analyze how the temperature rise evolves in different exposure scenarios and population. Along with the geometrical and permittivity variations, this task also considers the evolution of thermal parameters (i.e., heat conductivity, heat capacity and blood flow) with age.
4) Data gathering: Finally, this task aims to integrate data generated in the framework of the CHILD 5G project with previous analysis.

## WORK IN PROGRESS

The ongoing research focuses on assessment and characterization of children and pregnant women exposure to wireless mobile devices and access points operating at 5G mm-Wave frequencies. EM and thermal analysis is performed on human models of increasing complexity accounting for the interindividual variability (including skin thickness, humidity, physiological condition), the age dependence of the dielectric and thermal properties, and anatomy. The detailed results will be presented and discussed during the conference.


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