Wireless Internet access is a ubiquitous technology of today's world required both for business operation and to provide entertainment and social interactions for individuals. It is forecasted that the required Internet access link throughput will increase three-fold from 2018 to 2023. This can be provided by the 5G network by simultaneously increasing the density of base stations, increasing spectral efficiency, and increasing the utilized bandwidth. However, the relationship between these factors and the costs induced is complex. The first approximation is revealed by the Shannon formula. The wireless link capacity can be increased by raising bandwidth or transmission power. However, it leads to an increase in consumed power. While in the past most research aimed at increasing the bitrate, over the last few years energy efficiency (defined as the ratio of bitrate and consumed power) optimization has gained momentum. In this aspect, it is important to reliably model the consumed power that depends on many factors.

Although huge advancement is observed in this field over recent years, most researchers assume perfect and linear modeling of electronic components constituting the radio frontend, e.g., power amplifiers (PAs). In reality, a linear increase of mean transmit power results in a linear increase of consumed power and no signal distortion only when high back-off (difference between clipping level and mean transmit power) is used. Unfortunately, this frontend model cannot be used for highly energy-efficient systems. For reliable modeling of a wireless system close to its energy efficiency limit, a nonlinear frontend characteristic and its influence on many system metrics has to be considered, e.g., the increased transmission power results in increased interference power generated both in the transmission band and outside the transmission band, widening the system bandwidth. At the same time, the transmitted signal, as a result of PA nonlinear characteristics, has its distribution changed, resulting in a nonlinear increase in power consumption. These problems with nonlinearity modeling can be extended to some other components of the wireless transceiver, e.g., Analog-Digital Converters (ADCs) or battery characteristics. As such, nonlinear frontend models should be considered at various stages of wireless transceiver design, e.g., power allocation strategies or reception algorithms.

The hypothesis of this project is: **Ultra spectrally- and energy-efficient 6G system requires a cross-layer design considering radio front-end nonlinearity.** The project is divided into 4 tasks. Task 1 aims at nonlinearity and power consumption modeling in a wireless transceiver. While there exist separate models of nonlinear distortion and power consumption of a wireless transceiver, the combined model does not exist, especially for contemporary frontend architecture. This modeling will be based both on literature study/simulations and measurements. This will help to provide a short-term power consumption model important for battery-powered device optimization. Task 2 deals with the design of a multicarrier transceiver considering front-end nonlinearity. This includes optimization of the transmitted signal, reception algorithms, and link adaptation, e.g., power allocation. Task 3 studies the design of Massive Multiple Input Multiple Output (M-MIMO) systems considering frontends nonlinearities. Various solutions varying from changing Analog-Digital Converters resolution to antennas deactivation will be tested to improve network performance. Task 4 aims at combining solutions proposed in Tasks 2 and 3 to obtain synergy in nonlinearity-aware multicarrier, M-MIMO wireless system design. The project results will show that nonlinear frontend models can be used both in conventional algorithm design, e.g., based on convex optimization with constraints, and while using Machine Learning tools. The project results will be published mainly in international journals and presented during international conferences. As the M-MIMO and multicarrier technologies are present in 5G and are foreseen to be present in 6G as well, it is expected that the results will be highly useful for the scientific community in the present and in the future.