Computer-aided design is the main tool for development of contemporary high-frequency systems. It involves representation of RF system components, such as passive elements, or active components using appropriately defined simulation models. These allow for obtaining frequency characteristics of the circuit for a given set of input parameters. Simulation-driven techniques aimed at utilization of numerical models for design of high-frequency structures belong to dominant approaches to development of modern wireless communication devices. They replaced conventional methods where structure development involved repetitive cut-and-try prototyping. Although simulation models benefit from the ability to account for complex high-frequency phenomena within the structure, they are computationally expensive. Consequently, determination of input parameters required for obtaining acceptable performance of the circuit using the simulation-driven approach is time consuming as it involves a large number of simulations. The problem can be addressed using low-cost surrogate models. However, the usefulness of available surrogate modeling tools for design of modern radio-frequency structures, characterized by a large number of input parameters as well as their wide ranges, is limited. Moreover, conventional modeling techniques (also referred to as forward modeling) can only provide response of the structure for the given set of its input parameters. Therefore, numerical optimization of the model is required in order to identify configuration of input parameters that provides desirable structure performance. From this perspective, replacement of forward models with inverse ones is desirable to facilitate direct determination of input parameters with respect to the given performance requirements.

The proposed research project aims at addressing the challenges related to rapid re-design (dimension scaling) of modern radio-frequency structures by developing advanced inverse modeling methods. Inverse models are important tools for determining input parameters of structures with respect to their performance characteristics, or physical properties of materials required for their fabrication. The goal will be achieved using analytical and physics-based inverse models, also in configuration that exploits both the simplified and accurate computer representations of structures under consideration. Correction techniques for inverse surrogate model enhancement, as well as reliable procedures for fast and accurate re-design of radio-frequency structures will also be developed. Finally, the methods and algorithms will be integrated in the form of a framework for low-cost and reliable inverse modeling, as well as comprehensively validated and benchmarked using real-world examples.

It is expected that a major contribution of the project to the discipline development will be a set of innovative algorithms for inverse modeling applicable for rapid re-design of radio-frequency structures. The anticipated results will go far beyond the current state-of-the-art and will partially define the direction of future research on fast and advanced inverse modeling methods in regard to numerically demanding engineering problems. Apart from that, it is expected that the research output related to the discussed project will contribute not only to radio-frequency engineering, but also to other fields where computationally expensive simulations play an important role in the design process. It is expected that application of proposed algorithms will substantially reduce the cost related to construction of inverse models compared to conventional techniques. The results of the proposed research project will contribute to substantial shortening of time-to-market design cycles, which is of paramount importance from the practical standpoint.