TC-2 Design Automation Committee—On the Future of RF and Microwave Design Automation—2022

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The TC-2 Design Automation Committee (formerly the MTT-1 Computer-Aided Design Committee), established in 1968 by William J. Getsinger, with one of our authors (Bandler) as a founding member, focuses on advances in all aspects of methods, software, and technologies for the modeling, simulation, and design optimization of high-frequency circuits and systems. From RF to THz, engineering innovation hinges on the availability of state-of-the-art modeling techniques and design automation methods capable of handling new mathematical representations and design methodologies as well as novel manufacturing processes and materials.

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Within the next decade, accurate and computationally efficient algorithmic design automation and optimization methods will be driven by high-frequency engineering challenges, such as the following [7]:

- EM-driven multiobjective optimization in high-dimensional and wide-range design spaces, including not only continuous but categorical, conditional, and combinatorial optimization variables
- manufacturability assessment, yield optimization, and tolerance immunity maximization for high-fidelity EM and multiphysics models, considering the unprecedented flexibility of additive manufacturing
- the optimal design of system-level measurement-based complex physical platforms subject to varying operating or environmental conditions.

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The modeling techniques that support design automation will need to keep adapting to multiphysics covering EM, thermal, mechanical stress, and other domains, leading to the generation of accurate digital twins. In addition, they will increasingly need to bridge the gap between numerically intensive solvers and design techniques, thus leveraging efficient behavioral representations and model order reduction [8].

As an example, the upcoming generation of wireless systems will entail higher complexity and more structured systems, driving the trend toward data-intensive models and scalability features from bare components to packages and modules. Variability in component design will need to be handled and suitably accounted for by accurate uncertainty quantification and propagation. More critical nonlinear relationships and component interdependencies will need to be described in an efficient way through adaptive data sampling and by exploiting deep neural networks and machine learning (ML) techniques, such as reinforcement learning. At the same time, they should be amenable to fast simulation leveraging advanced partitioning techniques and new mathematical methods [8].

Indeed, the following advances will be key to enabling the next generation of design automation tools:

- Advances in modern CPUs have been moving, for some time, toward multicore low-power designs and cloud computing. This has had a significant impact on the algorithms developed to take advantage of the hardware and will continue to do so in the future.

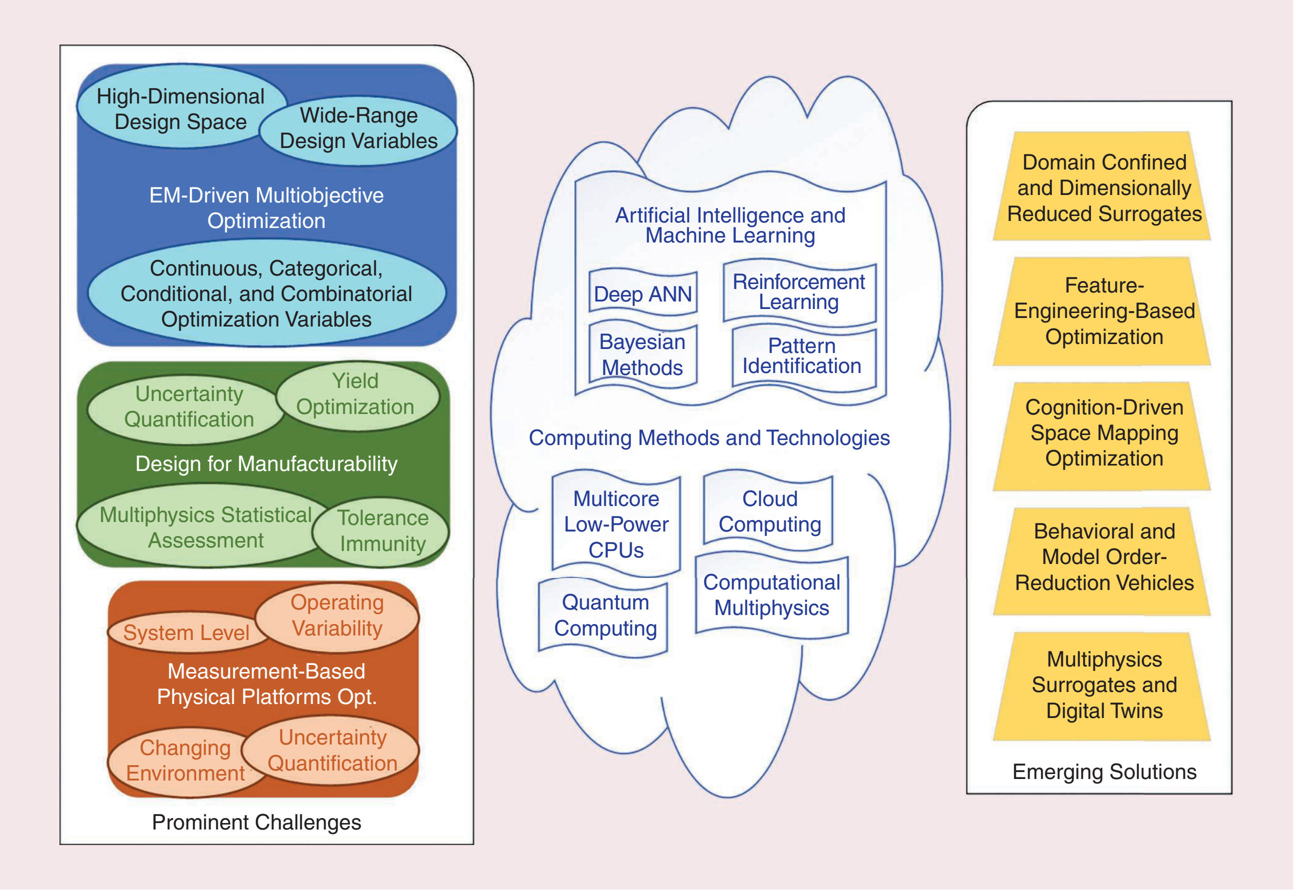

Figure 1. *The prominent challenges, advanced computational technologies, and emerging design automation solutions for RF and microwave engineering. ANN: artificial neural network.*

- Advances in artificial intelligence (AI) had led to significant investment in the development of new theories and algorithms as well as specialized hardware accelerators for the training and evaluation of ML models. The design automation field is uniquely positioned to build upon and take advantage of these new tools.
- Quantum computing technologies have the potential to further impact design automation. Exploratory research and development in formulating microwave computer-aided design into quantum computing approaches will lead to further advances in microwave design automation.

Moreover, these challenges and opportunities will be successfully addressed by promising and sophisticated optimization approaches [7], including the following emerging methodologies:

- domain-confined and dimensionally reduced surrogate-based optimization
- automated feature engineering-based optimization with automatic feature identification by AI approaches
- formal cognition-driven space mapping optimization assisted by Bayesian and ML techniques.

Figure 1 highlights imminent challenges and emerging solutions for high-frequency design automation.