Aperiodic Array Antennas for Future Satellite Systems

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I. INTRODUCTION

Today, most satellite systems employ reflector antennas to generate narrow beams covering a certain area of Earth's surface from orbit. However, the performance specification of modern communication systems require an increasing demand on the multi-beam, multi-channel, dual-polarization and beam shaping capabilities, which renders the design of such complex systems to a major challenge.

A worldwide view is that Direct Radiating Arrays (DRAs) will be part of the future satellite systems. DRAs can handle these complexities, but the design solutions, based on conventional regular arrays are expensive due to a large number of required array elements (100-1000 in dense array for geosynchronous orbit) and active components, such as low noise and power amplifiers. For this reason, aperiodic or sparse arrays, where the array layout is optimized, constitute a very attractive solution for minimizing the number of elements and thus the cost.

To design aperiodic arrays, Array Signal Processing (ASP) based methods are commonly used, which are advantageous when optimizing for complex antenna beam specifications [1-2], but often assume idealized antenna elements (e.g. isotropic radiators or uniform field apertures) while ignoring antenna mutual coupling and edge truncation effects. Electro-Magnetic Simulations (EMS) overcome these drawbacks [3], but their use is limited to simplistic ASP schemes. Due to extreme computational demands, such methods are primarily used to evaluate beam performance degradation effects, but do not incorporate sparse array ASP design procedures, and hence, these approaches result in suboptimal solutions. Our aim is to enhance the current methodology by accounting for realistic elements and critical array effects in a rigorous numerical manner, while adapting advanced ASP algorithms for fulfilling the required specifications.

II. METHOD AND RESULTS

The proposed method exploits an iterative weighted ℓ_1-norm minimization method, guaranteeing the convexity of the solution while maximizing the sparsity of the array [4]. To account for realistic array effects, our method employs a rigorous full wave analysis in the iterative process accounting for the embedded element patterns of strongly excited array elements (see the block diagram of the algorithm in Fig. 1). This approach has been applied to the synthesis of large linear arrays consisting of strongly coupled dipole arrays and has yielded promising results. We are currently in the process of extending this study to larger arrays (e.g. planar circular arrays of 50-100λ diameter) and more realistic elements (such as open-ended corrugated waveguide radiators as designed by RUAG), as shown in Fig. 2.

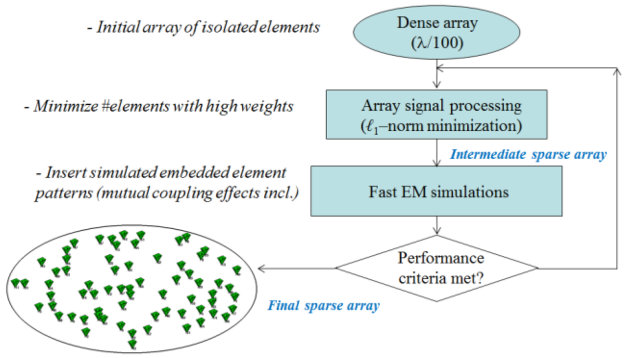

Fig. 1 *Block diagram of the proposed approach for optimal aperiodic array synthesis*

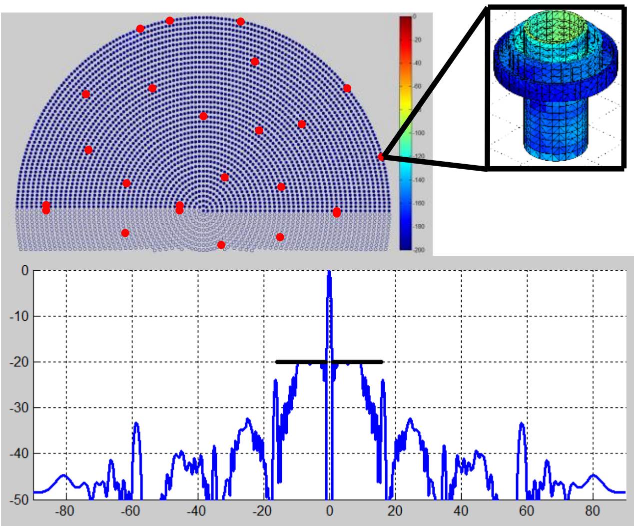

Fig. 2 *— Above: Active element positions (in red), Below: Resulting far-field pattern.*

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