Application of the Compressive-Sensing Approach to the Design of Sparse Arrays for SATCOM Applications

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I. INTRODUCTION

Current SATCOM systems employ multiple reflectors with a one-feed-per-beam configuration to synthesize narrow spot-beams. However, these systems are very complex and offer very limited reconfigurability. Active antenna arrays are attractive solutions [1], although are often expensive due to the large number of elements and electronic components involved. Aperiodic array antennas can substantially reduce the number of elements and costs with respect to regular arrays but their design is challenging [2]. Several synthesis methods have been proposed, yet aperiodic array design techniques are not as mature as those in use for their regular array counterparts. These methods are often either: (i) accurate but computationally expensive (e.g. Genetic Algorithms [3]), or; (ii) efficient but simplified (e.g. Density Tapered method [4]).

Compressive Sensing (CS) has been recently applied to the synthesis of sparse antenna arrays. The method can optimize large maximally sparse antenna array problems in a fast, deterministic and flexible way [5]. In previous research publications, the authors have (i) extended the original formulation to the multi-beam scenario; (ii) exploited array layout symmetry and modular design; and (iii) hybridized the original iterative optimization procedure with a full-wave EM analysis, so as to include the effects of mutual coupling into the design process and studied for arrays of strongly coupled antennas elements, such as dipoles, as well as large planar arrays of pipe horns [6, 7]. Additionally the authors have addressed multi element type design [8] and, more recently, are investigating reconfigurable arrays (i.e. arrays designed to provide a set of arbitrary-shaped beams) and isophoric arrays (i.e. arrays with a single excitation amplitude). The main directions are summarized in Fig. 1.

II. RESULTS

In this paper the authors will present a comprehensive overview of the results when applying the proposed framework to the synthesis of sparse arrays for SATCOM applications. The main objective is to provide a practical and quantitative understanding of the array design (such as number of elements, control points, array aperture, etc.) as well as the capabilities of the array (such as directivity, scanning, shaped beams, etc.) with respect to common design aspects and specifications. Some of the aspect that will be discussed are: (i) the effects of the choice of element type, size and mixed elements (ii) multi-spot beam capabilities with quantized phase shifters and reconfigurability; (iii) symmetrical layouts, modular designs and excitation amplitude levels; (iv) Mutual coupling effects and cross polarization optimization. An example of a summary of the quantitative results for SATCOM application is shown in Table 1.

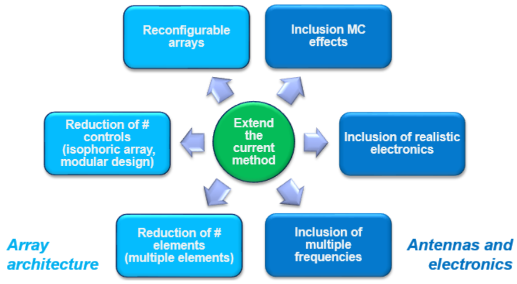

Figure 1. *Main extension to current approach.*

	Performance factors		Design complexity	
	SLL	Scan loss	# Elements	# Controls
Multi element types [ICEAA 2015,published]	=	-0.6 dB	-10%	-10%
Isophoric [TAP 2016;prepared for submission]	~	-	+5%	1
Realistic antenna & electronics effects [AWPL 2015;published]	compliant	-	~	~
Symmetry [TAP 2015;submitted]	=	=	+4%	-75%

Table 1. *Summary of some of the quantitative capabilities of the proposed design framework.*

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