# Near Field Phase Retrieval for UAV-based Antenna Measurements

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## 1 Abstract

We consider an array working in receiving mode at the frequency of 175 MHz. An Unmanned Aerial Vehicle (UAV) equipped with a continuous wave transmitter is exploited in order to perform a near field scan. While UAV flies in the near field of the array, voltages at each antenna element are acquired by means of digital system. The aim of this work is to retrieve the phase information. This is not trivial because the RF transmitter on the UAV is not phase-locked to the receiver on the ground. This work will enable us to perform a near field to far field transformation in order to compute the radiation pattern of the whole array.


## 2 Introduction

In last years, UAV-based systems for antenna measurement have been successfully used for in-situ characterization of antennas [1]. Ideally, during measurements, one would like to acquire the field in both amplitude and phase, as in anechoic chamber tests for example. However, for antenna measurements based on Unmanned Aerial Vehicles (UAVs) the phase retrieval can be not easy to perform because the source and the receiver are generally not phase-locked, i.e. they do not have the same working frequency. Some researchers [2] proposed phase-less techniques, with the disadvantage to deal with a double number of measurements and a non-linear minimization problem. In our work we want to maintain the phase information in the field reconstruction. We exploit an additional antenna placed far from the array in order to recover the phase of the desired field. Once recovered the near field of the array, we could subsequently perform a near to far field transform.

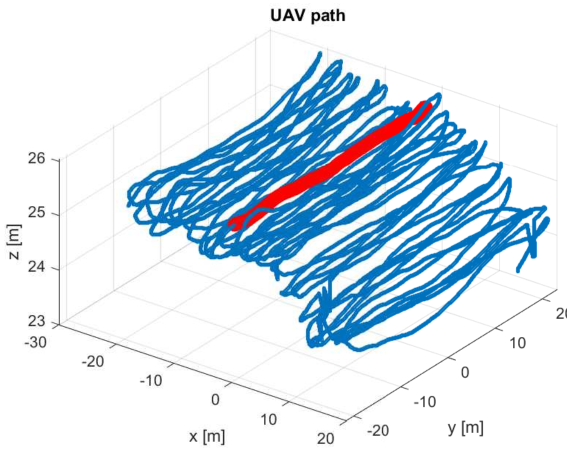


Figure 1: Example of UAV trajectory during a near-field scan (blue curve). Trajectory selected for comparison between reconstructed and simulated phases (red markers).

## 3 Preliminary Experimental Results

When the array is electrically big (big with respect to $\lambda$), UAV can not reach the Fraunhofer distance $2D^2/\lambda$, where $D$ is the diameter of the array and $\lambda$ the wavelength. Then the radiation pattern of the array is not directly measurable and the UAV can only fly in the near field zone of the array. Experimental data we use comes from the Pre Aperture Array Verification System (Pre -AAVS1) of the Square Kilometre Array located at the Mullard Observatory in Cambridge (UK). This array is composed by 16 log-periodic antennas and it has a diameter $D = 8m$, with a considered wavelength of $\lambda = 1.7m$. In this first test, we recovered the differential phase

$$\Delta\varphi_{as} = \varphi_a - \varphi_s \tag{1}$$

of the central antenna of the array, where $\varphi_a$ is the phase of the received voltage measured at the central antenna port, whereas $\varphi_s$ is the phase of the transmitted signal from the UAV (which is unknown), by exploiting the signal received from a reference antenna [3].
We placed the reference antenna far from the array, in order to be considered as an isolated element that is not interacting with the array.
The programmed flight of the UAV was a regular raster along $y$-axis, but as we can see from Fig. 1, it is far from being regular.
Under these hypotheses, we computed the differential phase $\Delta\varphi_{as}$ shown in Fig. 2. In Fig. 3 we compare our reconstructed phase $\Delta\varphi_{as}$ with the simulated phase of the field along the central trajectory only (red line in Fig. 1). The agreement is satisfactory.

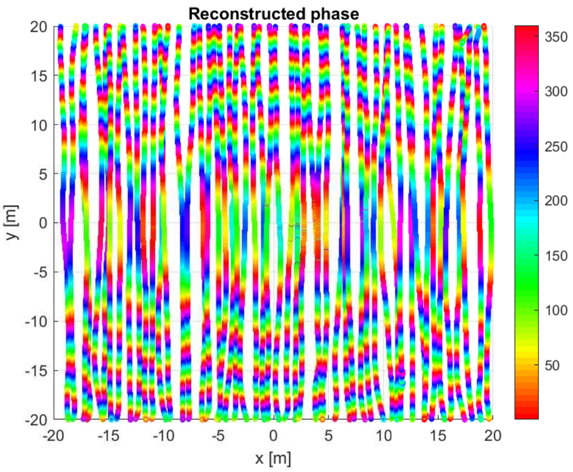


Figure 2: Near-field phase reconstruction ($y$-component) for the array element that is closer to the center. The 3-D trajectory of the source is shown in Fig. 1.

## 4 Conclusions

We reported the near field phase for a single element of an array working in receiving mode at 175 MHz. Similar results have been obtained for the other elements. Future developments concern the exploitation of a near-to-far field transform to obtain the far-field patterns. Due to the irregularity of the UAV path (see Fig. 1), inverse source approaches [4] will be considered in view of their capability to deal with arbitrary scan paths.

## References

[1] G. Virone et al. - *Strong Mutual Coupling Effects on LOFAR: Modeling and In Situ Validation*, IEEE Transactions on Antennas and Propagation, vol. 66(5), May 2018.

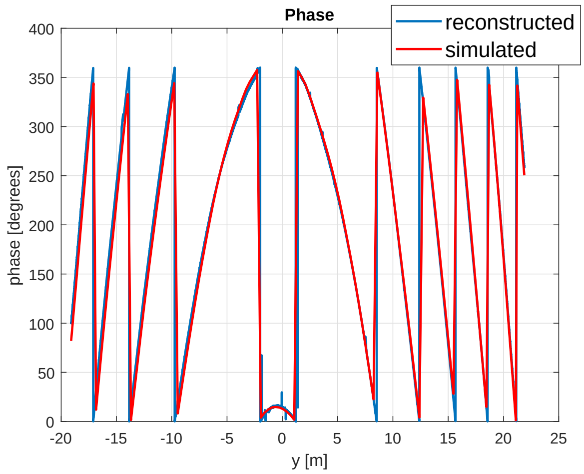


Figure 3: reconstructed (blue curve) and simulated phase (red curve) of $y-$component of the AUT near-field along the red trajectory in Fig. 1.

[2] M. G. Fernandez et al. - *Antenna Diagnostics and Characterization using Unmanned Aerial Vehicles*, IEEE Access (Volume: 5), 2017.

[3] L. Ciorba et al. - *Near-Field Phase Reconstruction for UAV-based Antenna Measurements*, 13th European Conference on Antennas and Propagation (EuCAP), 2019.

[4] J. L. Araque Quijano and G. Vecchi - *Field and Source Equivalence in Source Reconstruction on 3D Surfaces*, Progress In Electromagnetics Research (PIER), 103, pp. 67-100, 2010.