Secondment Report Form

Secondee	
Host Organization	Id: TNO
	Name: Netherlands Organization for Applied Scientific Research
Research Topic(s)	Cross-polarization reduction techniques in phased arrays
	Antenna CAD tools evaluation

ACTIVITIES DURING THE SECONDMENT

The aim of this section is to describe the main activity developed during my stay at TNO, Netherlands Organization for Applied Scientific Research.

The activity can be divided in two sections:

- **Section 1**
  Scope: study and evaluate techniques to reduce the field cross-polarization components for an antenna configuration consisting of two orthogonal dipoles set along y-axis and x-axis (see Fig 1).
- **Section 2**
  Scope: evaluate the computation time performances of the ADF CAD tool when applied to the analysis of large array antennas (consisting of connected array of dipoles larger than 16x16 elements with an inter element distance of lambda/2).

The scope of the present document is limited to the CARE project.

Section 1.

Figure 1 shows the antenna configuration studied in order to investigate cross-polarization reduction techniques. Two orthogonal dipoles are centred in the origin and assumed to be half-wave long at the frequency of analysis.

The co-polar and cross-polar components are defined as the component of the electric field vector normal and parallel to a desired vector, respectively.

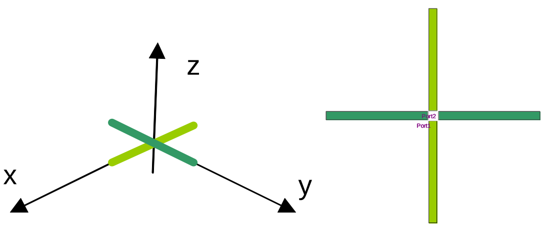


Figure 1: Crossed Dipoles

There are different definitions of Co and Cross, depending on the choice of the desired vector; for phased arrays and direct radiating antennas, the **Ludwig's third definition** is typically used, which leads to the following expressions of the co-polar and cross-polar fields radiated by the dipoles:

$$Cross_y = \cos\phi E_{y\theta} - \sin\phi E_{y\phi} = j\eta \frac{kI_0 l e^{-jkr}}{4\pi r}\left(\cos\theta \sin\phi \cos\phi - \sin\phi \cos\phi\right)$$

$$Co_y = \sin\phi E_{y\theta} + \cos\phi E_{y\phi} = j\eta \frac{kI_0 l e^{-jkr}}{4\pi r}\left(\cos\theta \sin\phi \sin\phi + \cos\phi \cos\phi\right)$$

$$Cross_x = \sin\phi E_{x\theta} + \cos\phi E_{x\phi} = j\eta \frac{kI_0 l e^{-jkr}}{4\pi r}\left(\cos\theta \cos\phi \sin\phi - \cos\phi \sin\phi\right)$$

$$Co_x = \cos\phi E_{x\theta} - \sin\phi E_{x\phi} = j\eta \frac{kI_0 l e^{-jkr}}{4\pi r}\left(\cos\theta\cos\phi\cos\phi + \sin\phi\sin\phi\right)$$

In order to reduce the cross-pol associated with the dipole along x (x-dipole), a weight **q(θ,φ)** can be multiplied to the amplitude of the dipole along y (y-dipole), as follow:

$$Co_y = q(\theta,\phi)\, j\eta \frac{kI_0 l e^{-jkr}}{4\pi r}\left(\cos\theta\sin\phi\sin\phi + \cos\phi\cos\phi\right)$$

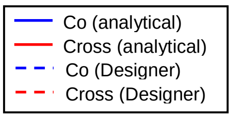
$$Cross_y = q(\theta,\phi)\, j\eta \frac{kI_0 l e^{-jkr}}{4\pi r}\left(\cos\theta\sin\phi\cos\phi - \sin\phi\cos\phi\right)$$

This weight is a function of the observation angles θ and φ. The basic idea to reduce the cross-polarization of the x-dipole is to choose the weight q(θ,φ) so that the following equation is satisfied:

$$q(\theta,\phi)Co_y = -Cross_x$$

With this choice of q(θ,φ) the co-pol of the y-dipole cancels out with the x-pol of the x-dipole. Figure 2 shows the co-polar and cross-polar components of the x-dipole as a function of θ and for φ=45°. Analytical expressions (implemented via Matlab) are compared with simulations from Ansoft Designer.

θ=45°; φ=45° ; q(45,45)=0.1716



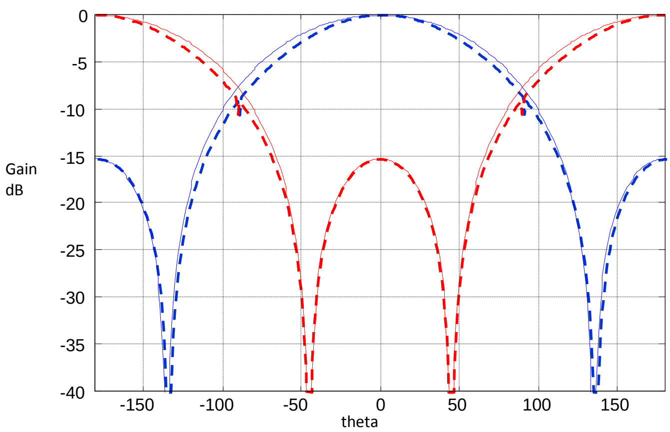


Figure 2: Cross-pol and co-polar - q(45,45)=0.1716

The value q(θ,φ) is calculated for θ=45° and φ=45°, and thus the **cross component shows a null** for the angle (45°,45°). Figure 3 refers to q(70°,45°), so the cross-pol of the x-dipole vanishes at θ=70° and φ=45°.

$$\theta = 70^o \quad \phi = 45^o$$

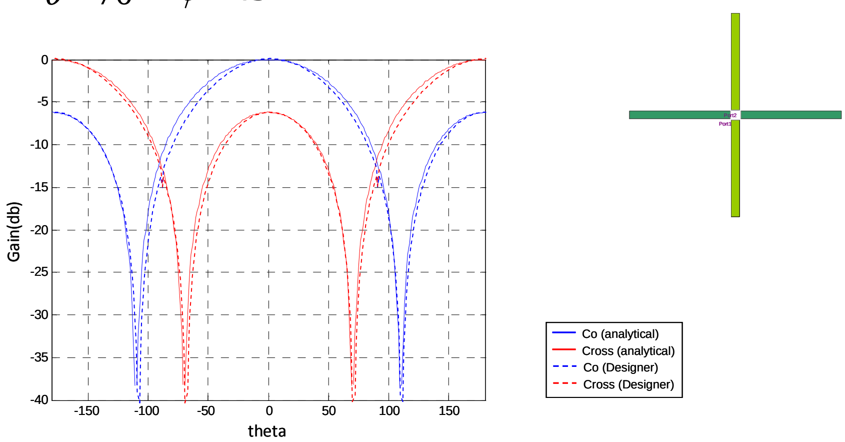


Figure 3: Cross-pol and co-polar - q(70,45)=0.1716

Two orthogonal dipoles with shifted phase centres can also be considered (Figure 4).
In this case, in order to eliminate the cross-polar component of the x-dipole, the weight q(θ,φ) has to be multiplied for a phase term accounting for the distance between the dipole centers:

$$e^{j\frac{2\pi}{\lambda}\frac{d_x}{2}\sin\theta\cos\phi}\;e^{j\frac{2\pi}{\lambda}\frac{d_y}{2}\sin\theta\sin\phi}$$

Figure 5 shows co and cross components for θ=45° and φ=45°.
Also in this case the cross polar component has a null at (45°,45°).

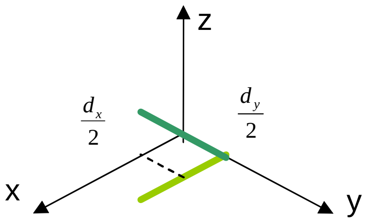


Figure 4: Shifted dipoles

θ=45°; φ=45°; q(45,45)=0.1716

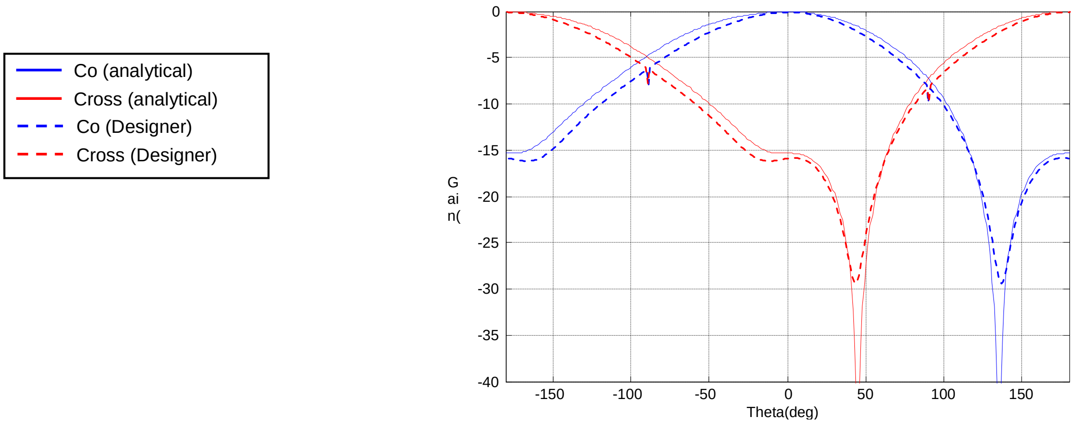
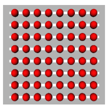


Figure 5: Cross-pol and co-polar - q(45,45)=0.1716

Section 2

I studied and designed a connected array in free space, constituted by 256 dipoles with an inter element distance of lambda/2.
In order of reduce the calculation time with respect to other commercial EM solvers, the Antennas Designer Framework (ADF) can be used.
ADF is an antenna workbench, developed by IDS Company, where the user finds a suite of different modelling tools (*multi-methods environment*), both general purpose and specialised, able to co-operate in the formation of complex modelling procedures (*combined methods procedures*).



Blue line: real part; Red line: imaginary part)

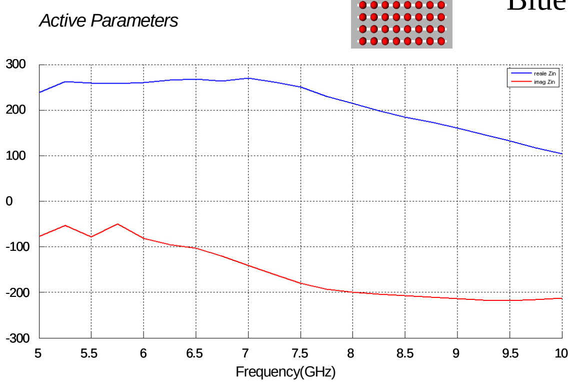


Figure 6: ADF – Active impedance

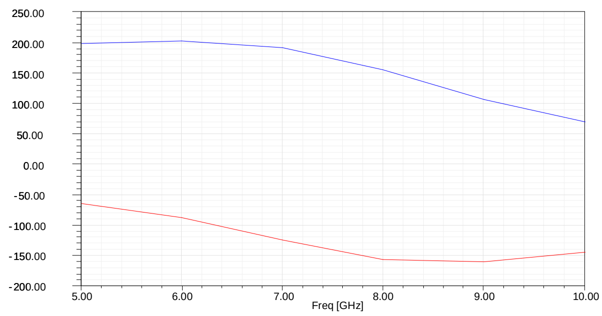


Figure 7: HFSS - Active impedance

Comparing the active impedance of a central element of the array obtained via ADF and Ansoft HFSS (Figures 6 and 7), the same dynamic can be observed.
In the ADF case, **the simulation time is lower**: *CPU Time: 37 min for frequency.*

These results can be deepened.

MAIN RESULTS OF THE STAY

Number of Publications: __1___

Number of Documents/ Reports: _____

Number of Case Studies & Demonstrators: _____

Other(s):
(1)____expected at EuCAP2011 (TBC)_
(2)____________________________________
(3)____________________________________

* Attach all relevant documentation that specifies your results

FORECAST ACTIVITIES

In order to improve CARE's secondment program, please fill this short questionnaire. Use the space at the end to expand your answers, if needed. Our aim is to improve the general experience for secondees in future.

Disagree ⮜ ⮞ Agree

GENERAL

My objectives were achieved.	**1** ☐	**2** ☐	**3** ☒	**4** ☐
The research topics were relevant to my work.	**1** ☐	**2** ☐	**3** ☒	**4** ☐
I benefited from being part of a wider research culture.	**1** ☐	**2** ☐	**3** ☒	**4** ☐

HOST ORGANIZATION

I am satisfied with the quality and quantity of supervision I received.	**1** ☐	**2** ☐	**3** ☐	**4** ☒
I had access to adequate resources to support my research..	**1** ☐	**2** ☐	**3** ☒	**4** ☐

SECONDMENT PROGRAM

I would recommend this secondment programme to others.	**1** ☐	**2** ☐	**3** ☐	**4** ☒
I believe the skills I have learned will help me to improve my job/research.	**1** ☐	**2** ☐	**3** ☐	**4** ☒
I would apply to another programme similar to CARE.	**1** ☐	**2** ☐	**3** ☐	**4** ☒
In general, how would you classify the CARE Secondment Programme?	**1** ☐	**2** ☐	**3** ☒	**4** ☐

Other questions/comments to be potentially considered:
The secondment experience resulted very positive from the technical and the coordination point of view.
In particular, the TNO matched the expectation in being ax extraordinary technical place where to study the state-of-the-art techniques in antenna array design.
Finally, I would like to express my thanks to the entire TNO staff that supported my secondment.

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SIGNATURES

Candidate **Claudia Casali** **Date**:
(year/month/day)

Signature ____