Secondment Report Form

Secondee	**TOMISLAV DEBOGOVIĆ**
Host Organization	Id: **CTTC**
	Name: **Centre Tecnològic de Telecomunicacions de Catalunya**
Research Topic(s)	Antennas for remote sensing and radio astronomy
	Array antennas incl. reflectarrays
	Reconfigurable antennas
	Space application antennas (communication & navigation)

ACTIVITIES DURING THE SECONDMENT

The secondee, in collaboration with the host institution, successfully demonstrated the partially reflective surface antenna with dynamic beamwidth control [1]. During this secondment, four novel abilities of this type of antennas were investigated:

1. Independent beamwidth control in two orthogonal polarizations.
2. Circular polarization operation.
3. Possibility of beam steering and operation in wider frequency band.
4. Reduction of losses of the antenna.

1. Independent beamwidth control in two orthogonal polarizations

Antenna consists of a partially reflective surface (PRS) above a source antenna S, as shown in Fig. 1a). Fig. 1b) shows the source antenna. It is a square patch antenna with two ports, which enable independent excitation of two orthogonal polarizations. In direction normal to the patch, these are x and y-polarization. The cell of the PRS is shown in Fig. 1c). Reflection for the x and y-polarized wave is independently controlled with capacitors C_x and C_y, respectively. This can be observed in Fig. 2 which shows the reflection of the PRS for x- and y-polarized normally incident wave.

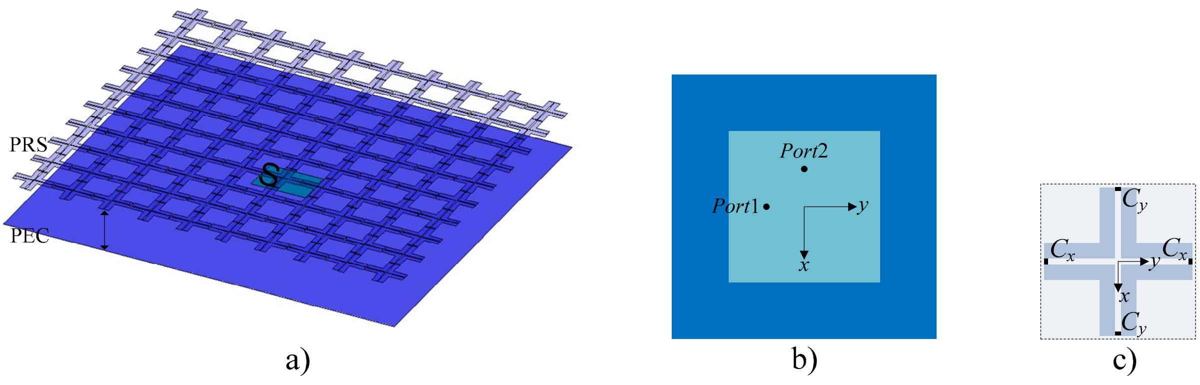
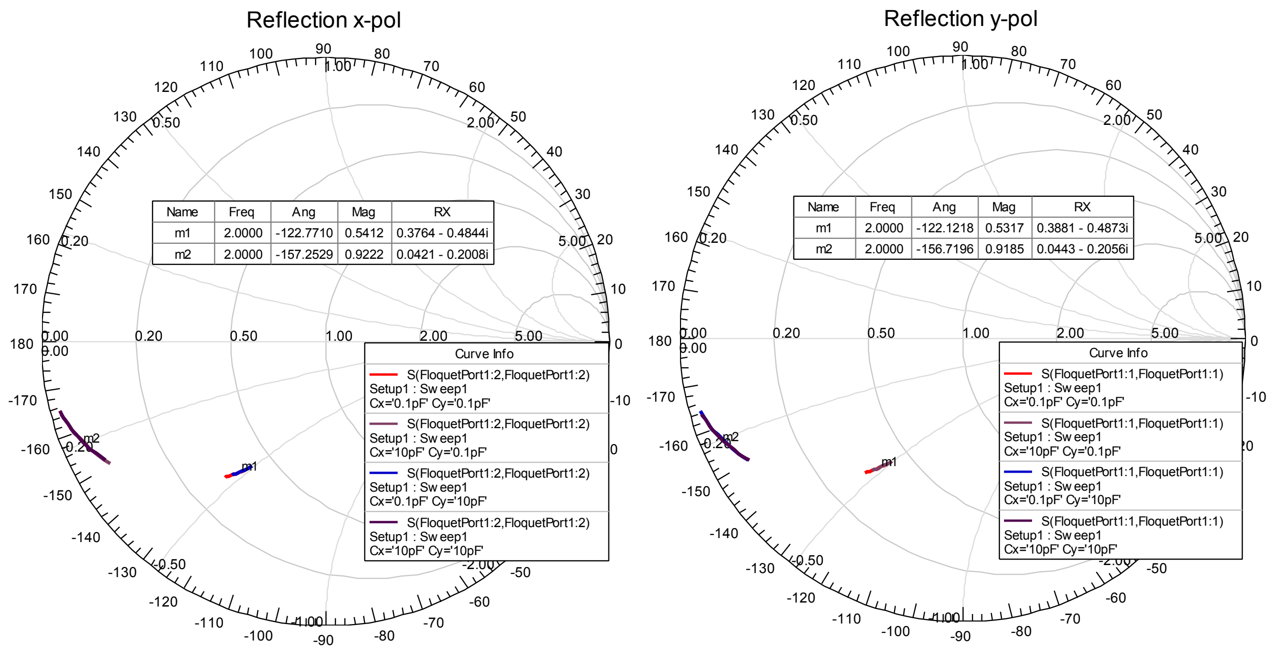


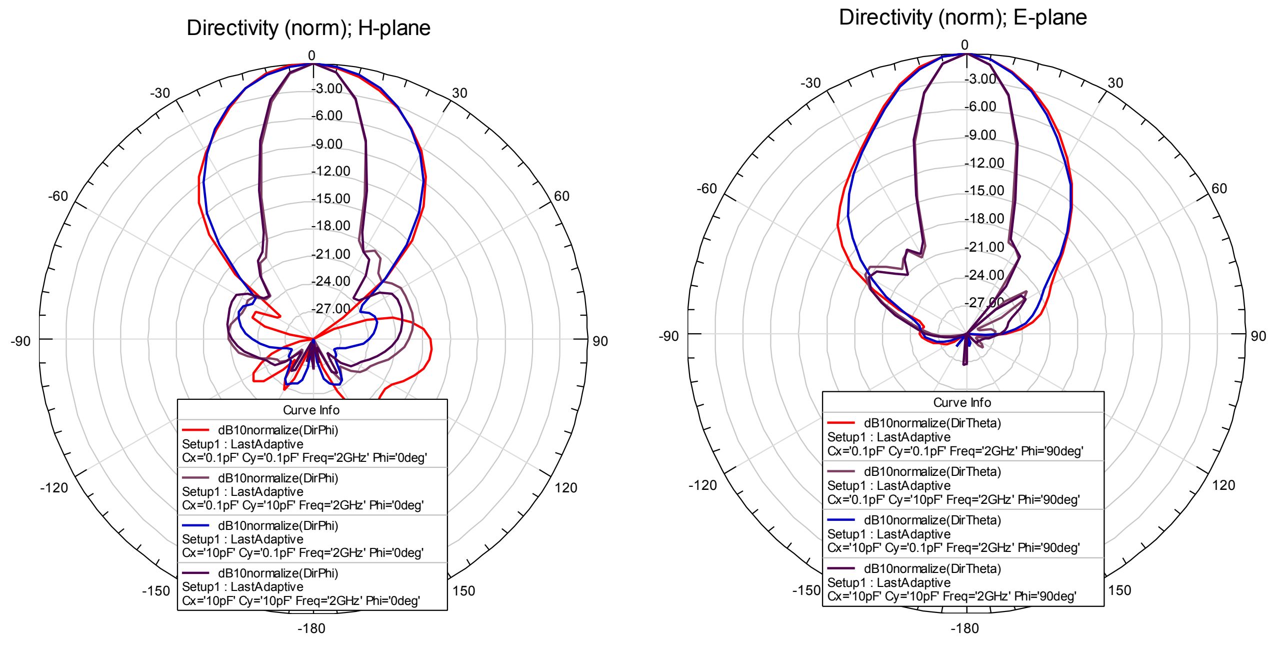
Fig. 1. PRS antenna with independent beamwidth control: a) the assembled antenna; b) the source; c) the cell.



a) b)

Fig. 2. PRS reflection coefficient: a) *x*-polarization; b) *y*-polarization.

Fig. 3 shows normalized radiation patterns when Port1 is excited, in H- and E-plane. In can be noticed that in this case only C_y affects the beamwidth. Also, coupling between ports is < -20 dB. Therefore, independent beamwidth control is achieved in two orthogonal polarizations.



a) b)

Fig. 3. Normalized directivity of the PRS antenna with independent beamwidth control (Port1 excited): a) H-plane; b) E-plane.

2. Circular polarization operation

Operation in circular polarization can be seen as a special case of independent beamwidth control in two orthogonal operations. If one feeds the source antenna with signals in phase quadrature, the result will be circular polarization. The only difference is that in this case $C_x = C_y = C$. Fig. 4 shows the axial ratio of the radiated electromagnetic wave.

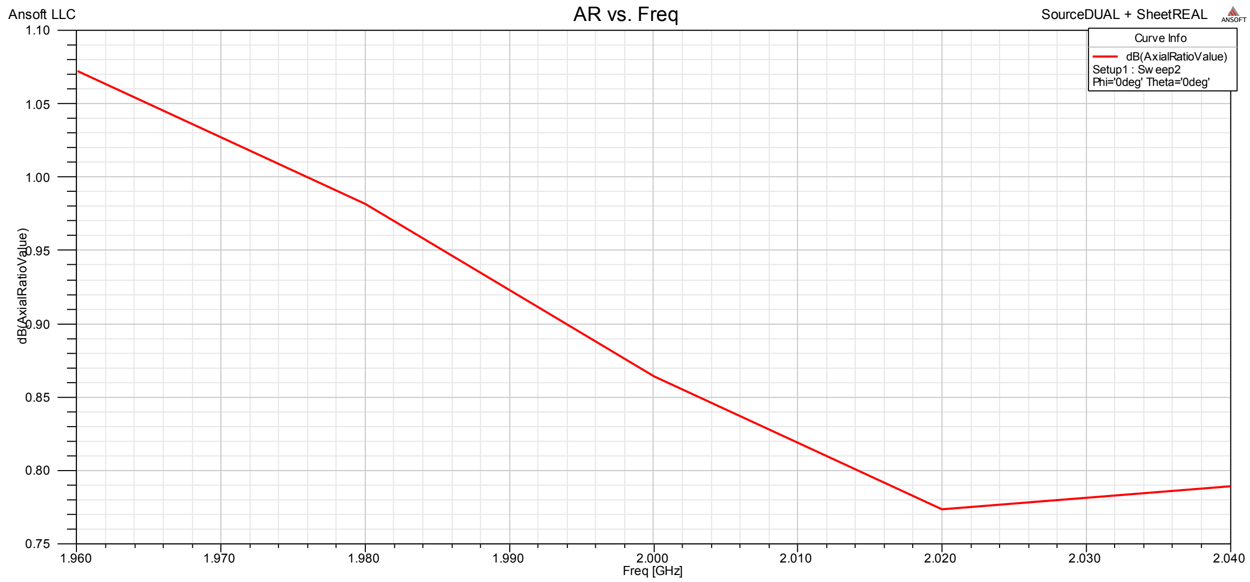
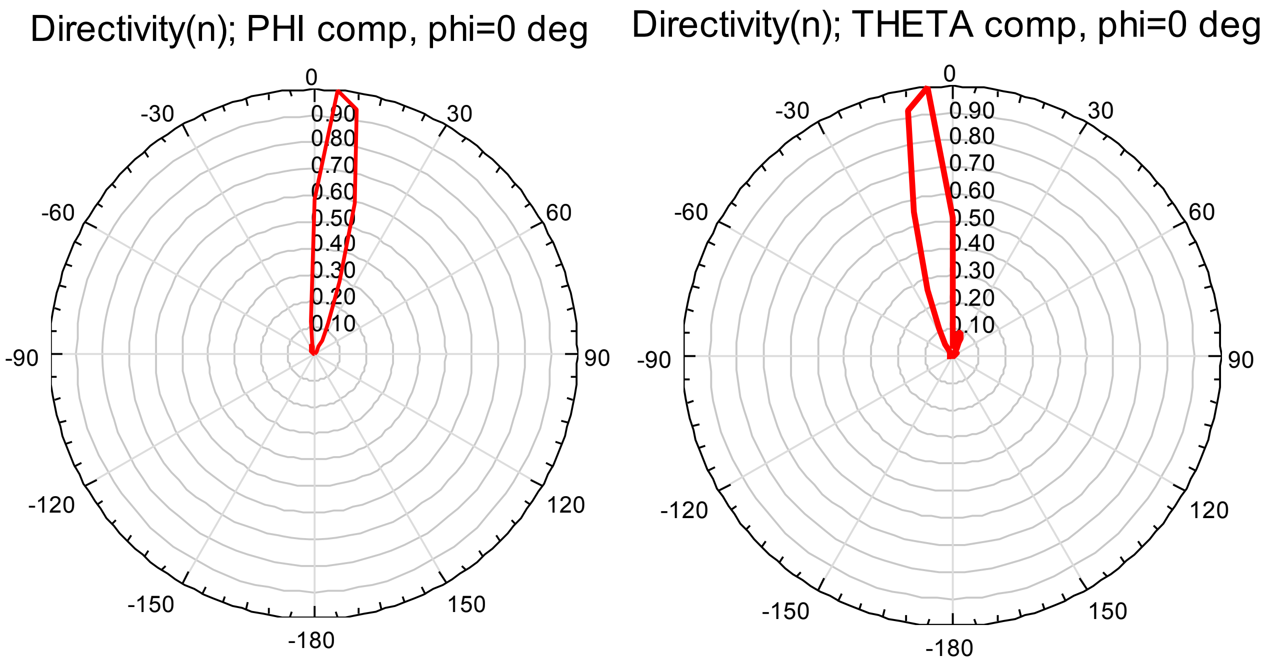


Fig. 4. Axial ratio in normal direction.

3. Possibility of beam steering and operation in wider frequency band

It is known from the PRS antenna theory that higher reflectivity of the PRS causes larger directivity enhancement of the source. However, in the same time it causes narrower frequency bandwidth. One possible approach, adopted here, is to use a source with higher directivity, combined with the PRS of lower reflectivity.

The source of higher directivity used here is an array of two patch antennas shown in Fig. 1b), at the distance of 2/3 λ. As the reflectivity of the PRS is not very high, it still does not cause too high mutual coupling between the elements of the array below. Therefore, by phasing of the input signals it is possible to obtain beam steering. Furthermore, thanks to the dual-pol array elements, steering can be achieved independently in two polarizations. Fig. 5 shows normalized radiation patterns of this antenna, independently steered.



a) b)

Fig. 5. Normalized directivity of the PRS antenna with phased array as a source: a) x-polarization; b) y-polarization.

4. Reduction of losses of the antenna

The losses of the PRS antennas above are negligible, as these antennas contain no lossy parts. In reality, however, the capacitors realized with varactor diodes, combined with the lossy substrate, can significantly deteriorate the gain of the antenna [1]. By investigating this issue more thoroughly, it was concluded that the switch substituting capacitances, which has C_{off} = 10 fF and R_{on} = 1 Ω would have no appreciable impact on the antenna loss. The only real switch with this performance is a MEMS switch. Therefore, the production of a PRS cell containing this type of switches is initiated.

[1] T. Debogovic, J. Perruisseau-Carrier, J. Bartolic, "Partially reflective surface antenna with dynamic beamwidth control," *IEEE Antennas Wireless Prop. Lett.*, vol. 9, pp. 1157-1160, 2010.

MAIN RESULTS OF THE STAY

Very important results were achieved during this stay. However, as the stay was short, further research in the topic is necessary. Particularly, fabrication and measurement of the MEMS device will take approximately 6 months. Then, it is envisioned that the results will be published as written below:

	Other(s):
Number of Publications: 1-2	(1)________________________________
	________________________________
Number of Documents/ Reports: 1	(2)________________________________
	________________________________
Number of Case Studies & Demonstrators: 5	(3)________________________________
	________________________________

* Attach all relevant documentation that specifies your results

FORECAST ACTIVITIES

The secondee`s co-supervisor is dr. Julien Perruisseau-Carrier. Therefore, the collaboration between the University of Zagreb and CTTC is already very intense. Also, due to the similar field of research, further collaboration with other universities and industry is envisioned (primarily with EPFL (Switzerland) and Thales Alenia Space (France)).

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: ________________________________

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SIGNATURES

Candidate **Date**: 2011/02/28
(year/month/day)

Signature ________________________________