INVISIBLE 5G

17.º Congresso do Comité Português da URSI **"Materiais inteligentes para a radiociência"**, 24 NOV. 2023

EVOLVING 5G SMALL-CELLS TO 6G SMART RADIO ENVIRONMENTS

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17º CONGRESSO DO COMITÉ PORTUGUÊS DA URSI

MATERIAIS INTELIGENTES PARA A RADIOCIÊNCIA

5G INVISIBLE 5G

instituto de telecomunicações

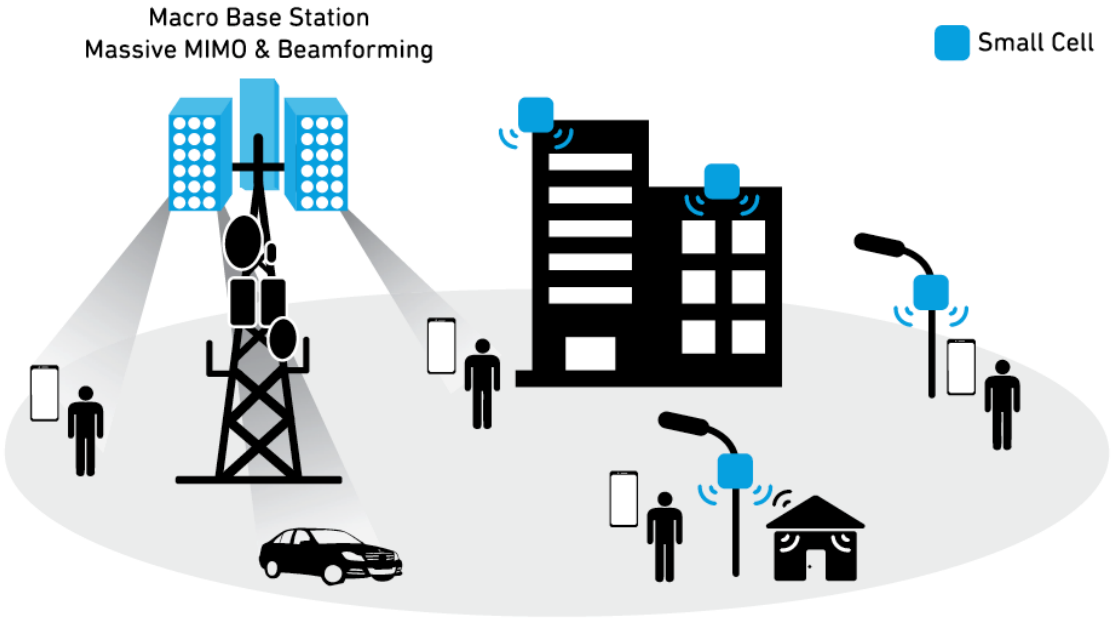
POLITÉCNICO DE LEIRIA

Outline

01. 5G Network densification
02. The role of street furniture
03. 5G SAWAPs technical requirements
04. Antenna integration and product design
05. 6G Smart Radio Environments
06. Electromagnetic Building Certification (EMBC) – ITED+
07. Final remarks

01. 5G Network densification

5G Small-cell integration

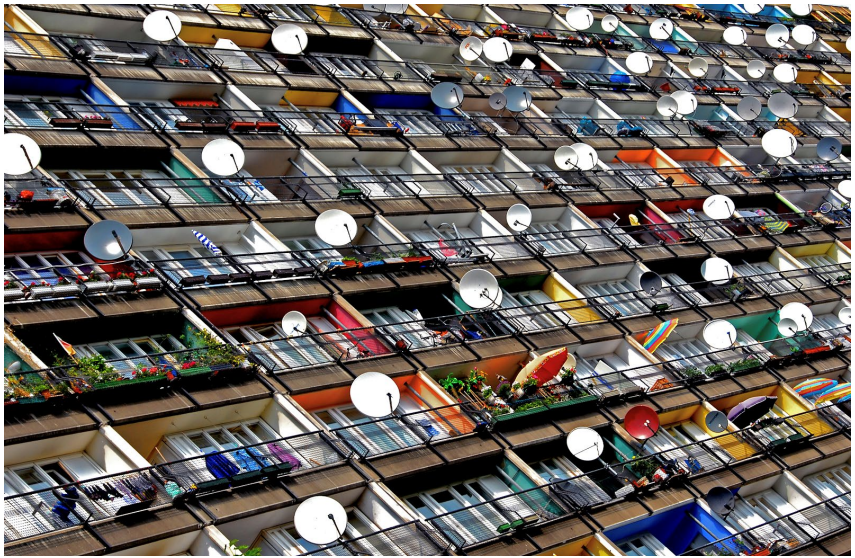


[Source: 5G RF, 2nd Qorvo Special Edition, 2020]

01. 5G Network densification

Urban pollution – negative visual impact !

[Source: http://www.one-wilshire.com/connectivity/rooftop-spaces-wireless/]



[Source: https://www.maison-travaux.fr/maison-travaux/conseils-pratiques/orienter-antenne-satellite-115483.html

02. The role of street furniture

… in expanding mobile broadband?

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NOT GOOD EXAMPLES!

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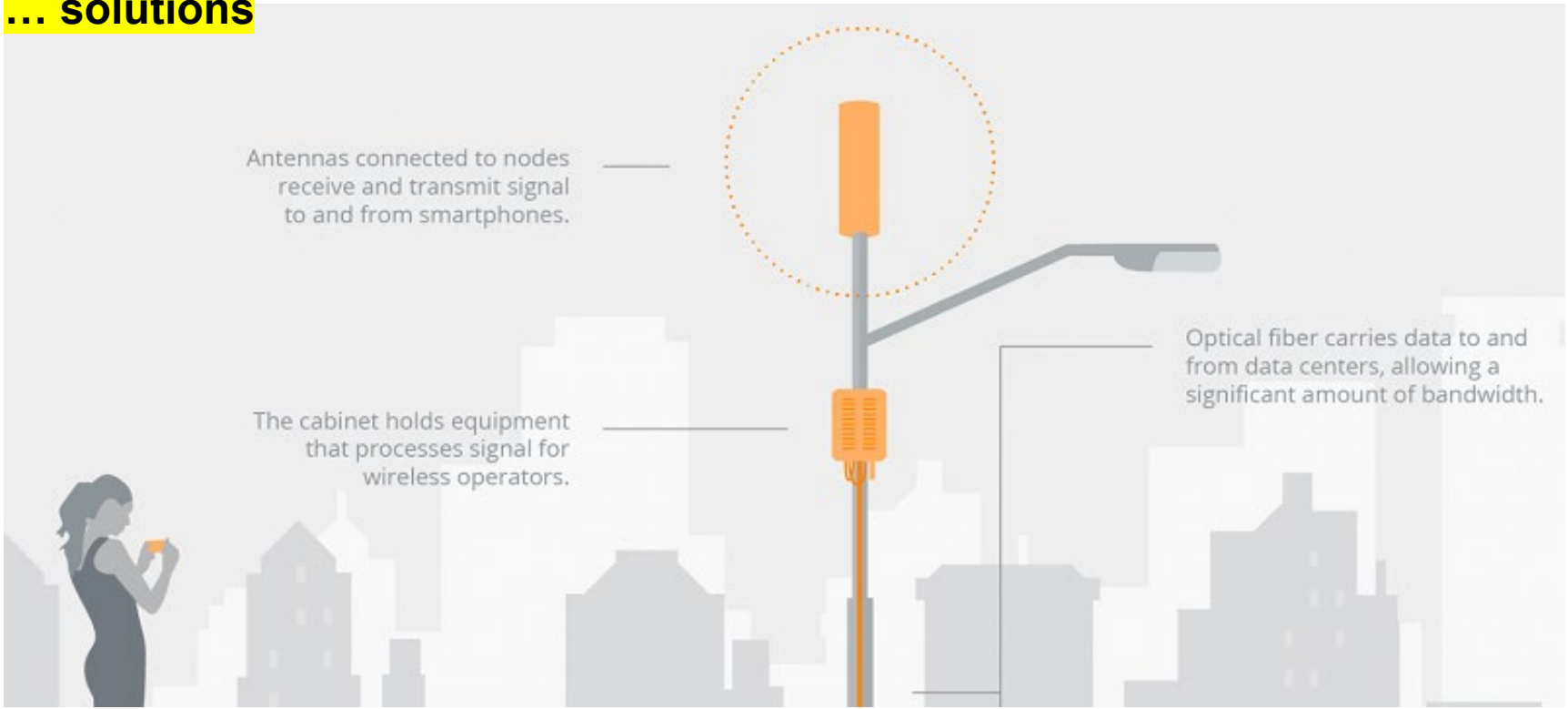
02. The role of street furniture

… solutions



02. The role of street furniture

… solutions

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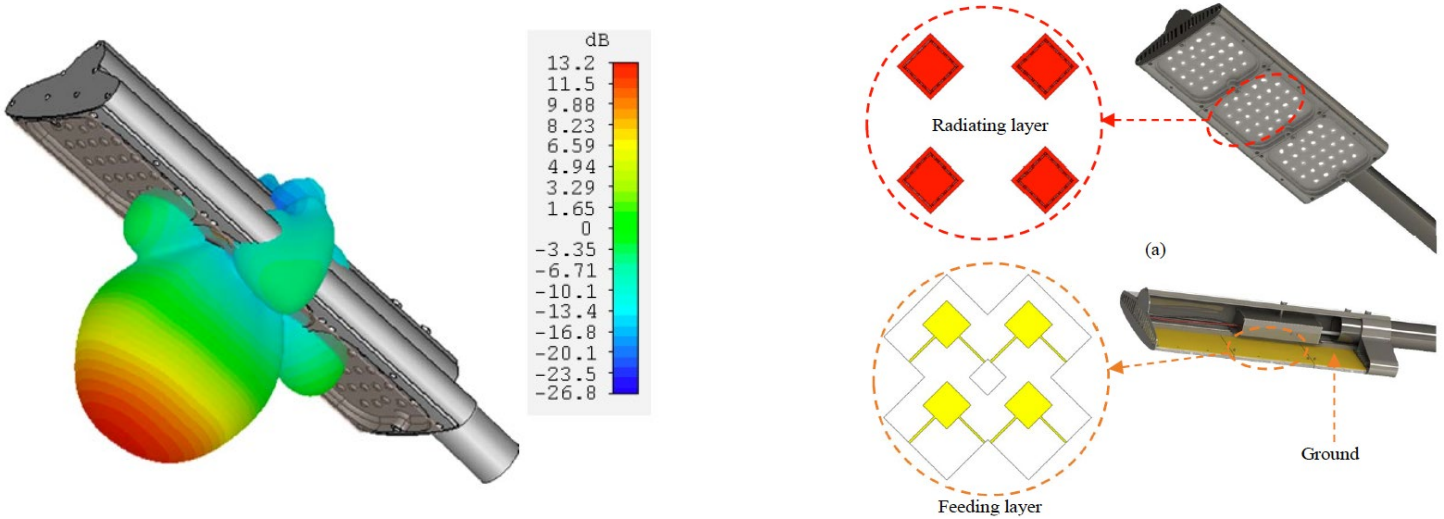
… solutions > 5G Small-cells, low power, small-form factor, highly concealed, ruggedized and easy-to-deploy



[Source: A. Alieldin et al., "A Camouflage Antenna Array Integrated with a Street Lamp for 5G Picocell Base Stations," 2019 13th European Conference on Antennas and Propagation (EuCAP), Krakow, Poland, 2019, pp. 1-4.]

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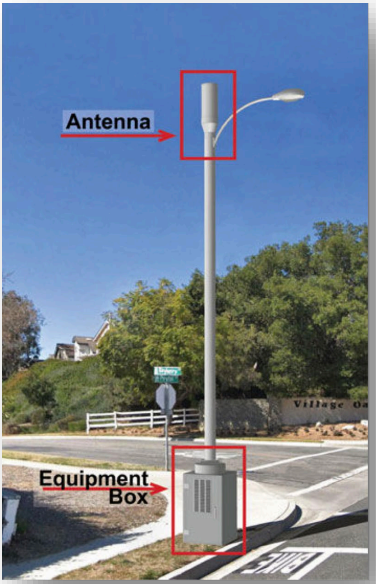
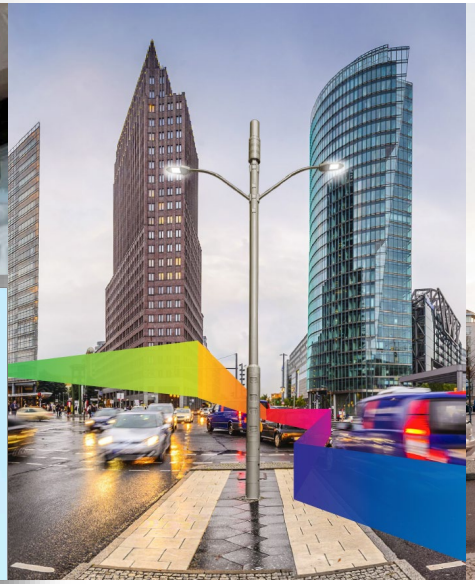
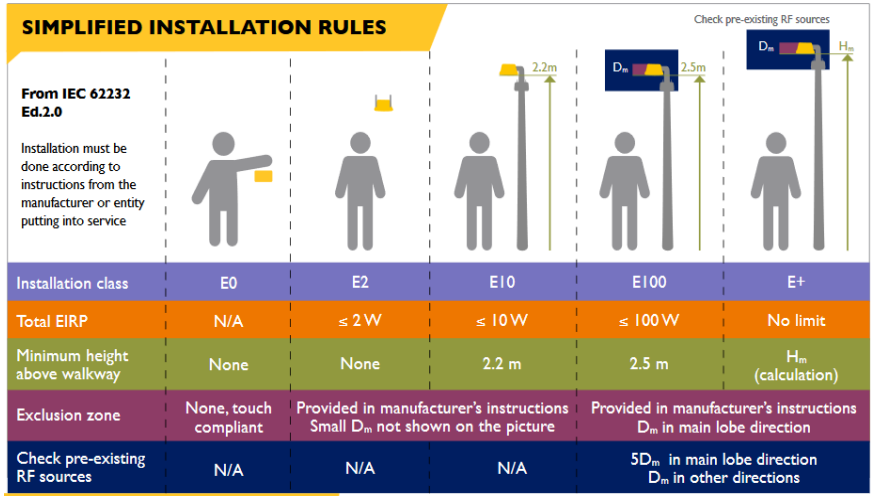




03. 5G SAWAP technical requirements

Specific requirements:

- Preferential operation Band: **3.4 - 3.8 GHz (n78)**
- Chosen Antenna type (omnidirectional, directional/sectorial) will play an important role in its practical application (in the field) and in its associated gain
- Typical **antenna gain** should be within **5 and 15 dBi**, depending on the antenna type, and should be appropriate for the small cell type to be installed



Source: Source: Small cell Forum based on information from IEC 62232 Ed 2.10, 2017.

TYPICAL MAPPING OF INSTALLATION CLASSES FOR TYPICAL SMALL CELL DEPLOYMENTS

3GPP BS Class	Config-uration	Typical Total Tx Power	Typical Gain	EIRP Range	Insta-llation Class
Medium Range BS	2 bands	20 W	7 - 13 dBi	100 - 400 W	E+
	1 band	10 W	7 - 13 dBi	50 - 200 W	E100 or E+
Local Area BS	5 bands	2.5 W	2 - 5 dBi	4 - 8 W	E10
	1 band	0.5 W	2 - 5 dBi	0.8 - 1.6 W	E0 or E2
Home BS	5 bands	100 mW	0 - 3 dBi	0.1 - 0.2 W	E0 or E2
	1 band	20 mW	0 - 3 dBi	0.02 - 0.04 W	E0

COVERAGE RANGE APPROXIMATION FOR FAVOURABLE CHANNEL CONDITIONS.

Frequency Band	Envir-onment	Coverage range (kms)		
		eMBB	URLLC	mMTC
700MHz	Rural	2.62	2.69	12.5
	Sub-Urban	0.8	0.82	7
	Urban	0.59	0.65	4.3
3.5GHz	Rural	0.62	0.65	5.65
	Sub-Urban	0.17	0.17	2.09
	Urban	0.09	0.09	0.47
26GHz	Rural	0.16	0.17	1.52
	Sub-Urban	0.13	0.13	0.97
	Urban	0.08	0.08	0.48

Source: M. N. Patwary, S. Junaid Nawaz, M. A. Rahman, S. K. Sharma, M. M. Rashid and S. J. Barnes, "The Potential Short- and Long-Term Disruptions and Transformative Impacts of 5G and Beyond Wireless Networks: Lessons Learnt From the Development of a 5G Testbed Environment," in IEEE Access, vol. 8, pp. 11352-11379, 2020.

03. 5G SAWAP technical requirements

Light Deployment Regime for Small-Area Wireless Access Points (SAWAPs)
Requirements for Article 57 of the European Electronic Communications Code

Complementary supporting information

Estimates (presented by the interested parties) of the volume requirements of a small cell in 2019 based on current technology

Estimated volumes (2019, based on current technologies)	Single SAWAP	Tri-sector SAWAP
Radio Unit (not including the Base Band Module, which is assumed to be placed in a different centralized location)	10 L	3x10 L
Antenna	3-5 L	10-15 L
Transmission/backhaul (wireless)	0,4/4-5 L	0,4/4-5 L
Power supply (auxiliary)	18 L	18 L

Source: "Key comments to the EC proposal of Implementing Regulation for SAWAPs"

04. Antenna integration and product design

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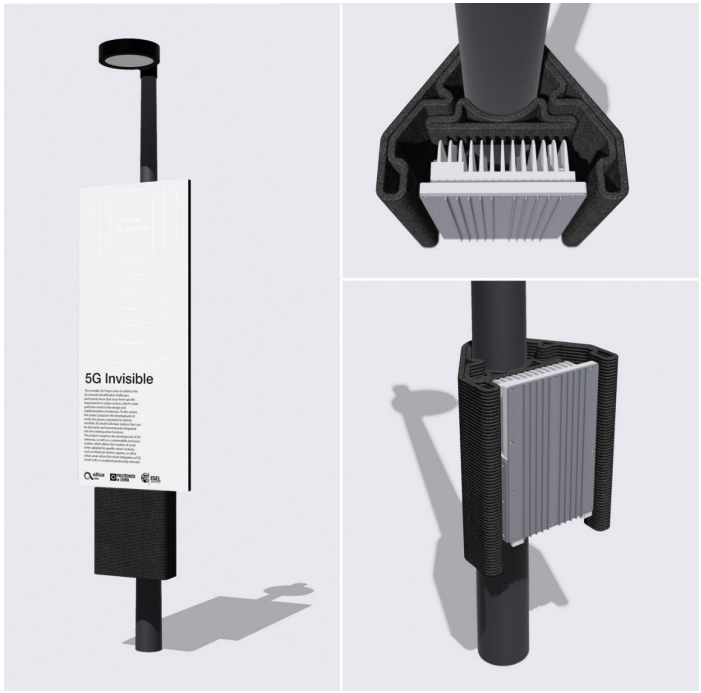
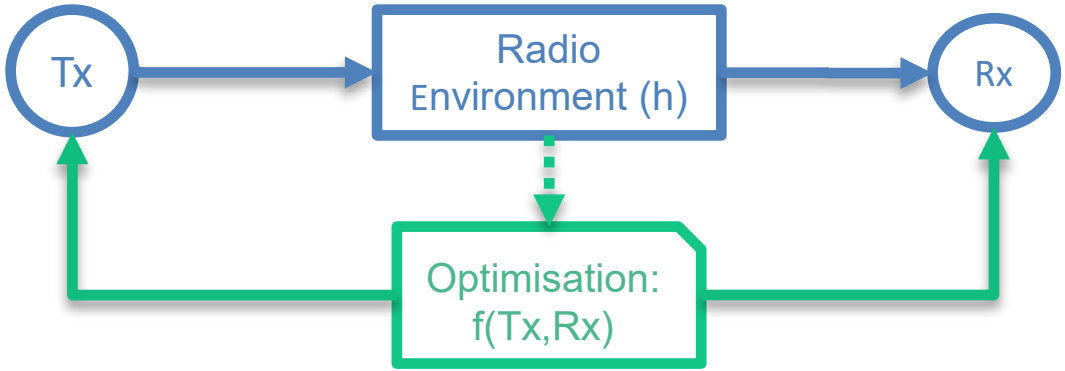


05. 6G Smart Radio environments

5G wireless networks are designed based on **end-points optimisation** for improving the network performance

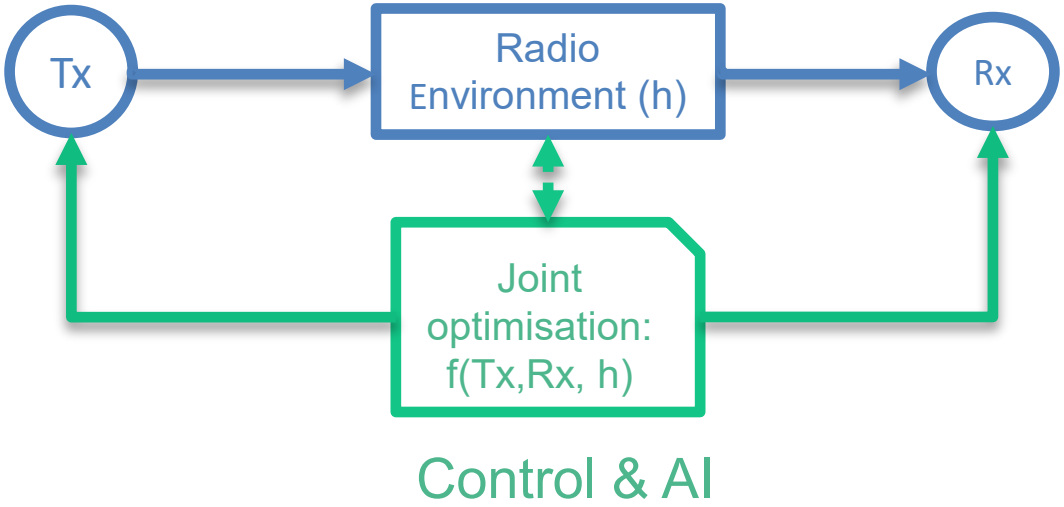


Adaptation (end-points optimisation)

Renzo, M.D., Debbah, M., Phan-Huy, DT. *et al.* Smart radio environments empowered by reconfigurable AI meta-surfaces: an idea whose time has come. *J Wireless Com Network* **2019,** 129 (2019).

05. 6G Smart Radio environments

The **radio environment** becomes **controllable** ... and intelligent



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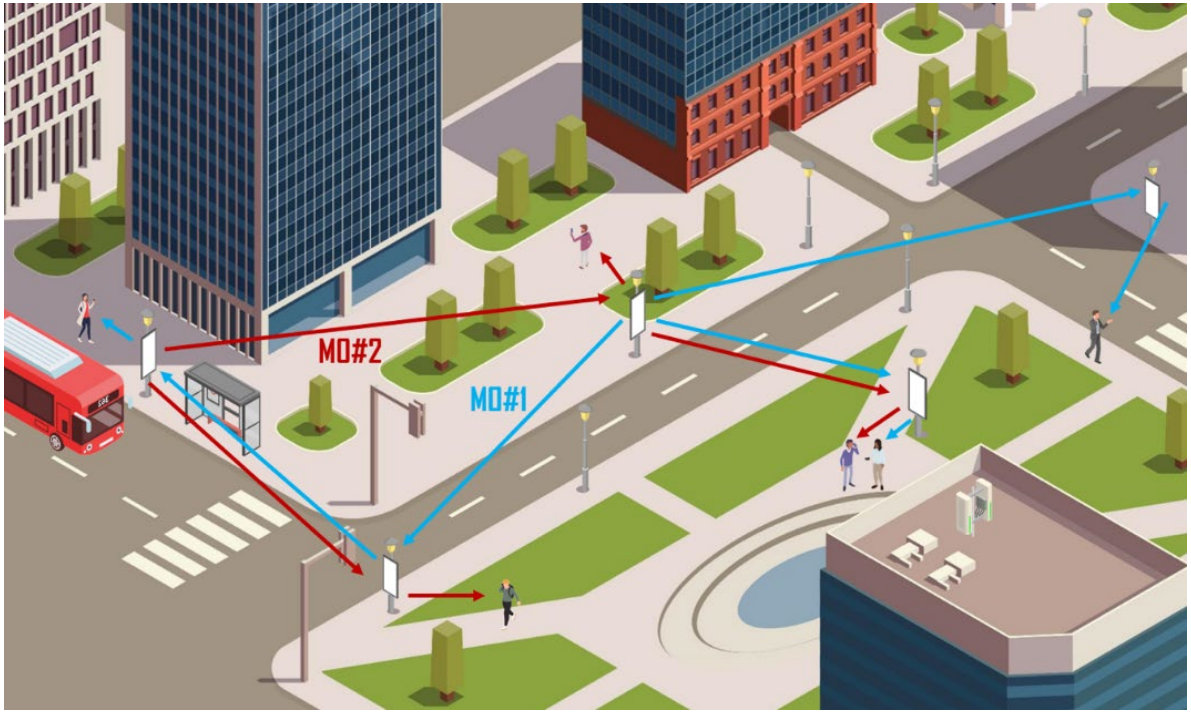

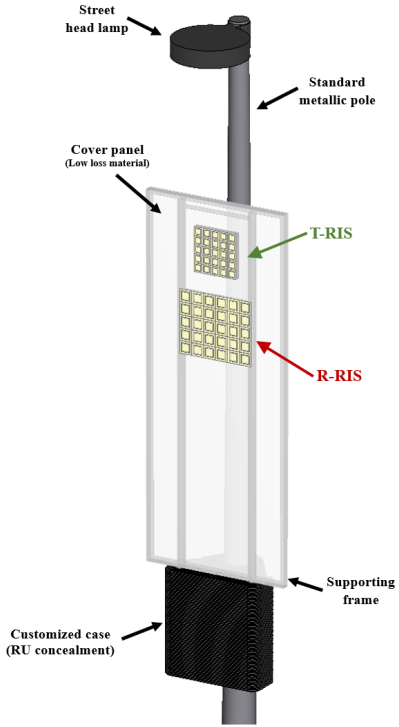

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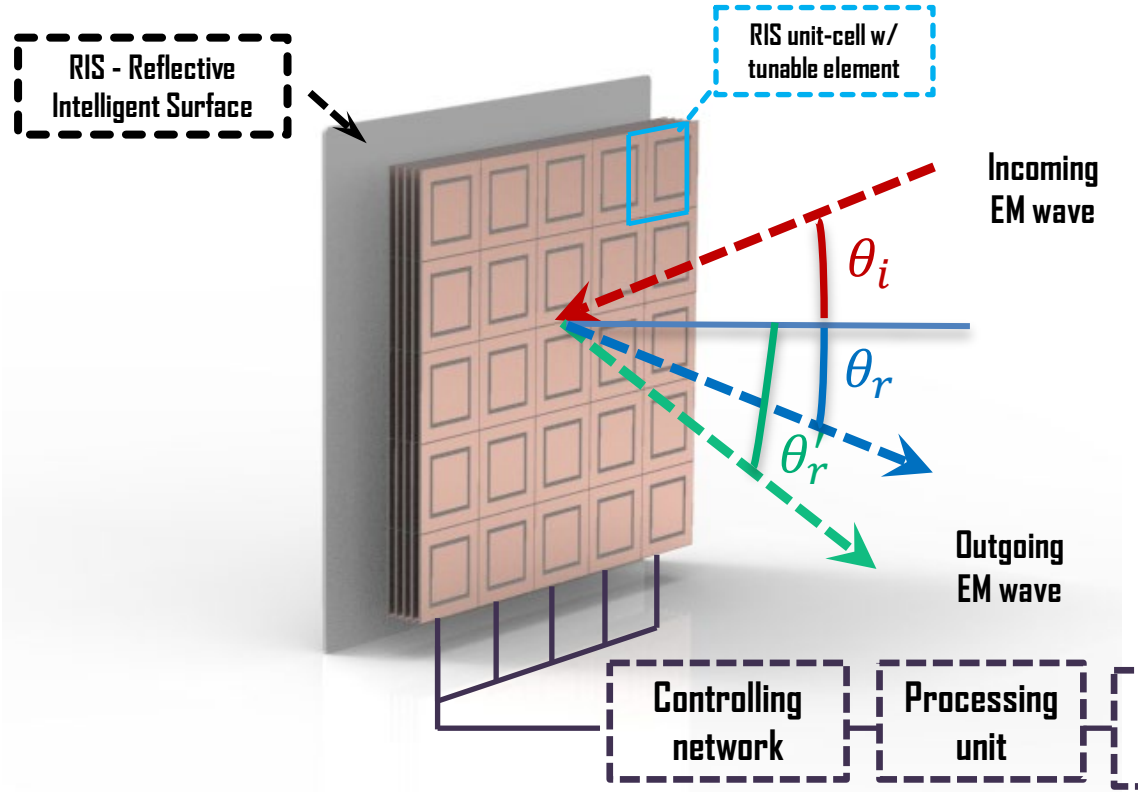
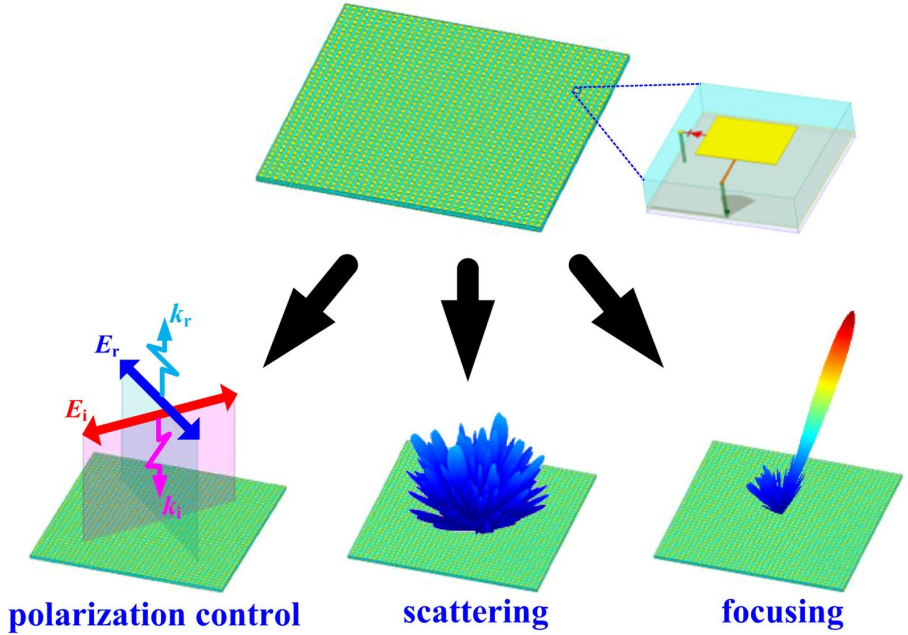


Anomalous reflection!

05. 6G Smart Radio environments

Multiple functions for this metasurface



Yang, H., Cao, X., Yang, F. et al. A programmable metasurface with dynamic polarization, scattering and focusing control. Sci Rep 6, 35692 (2016). https://doi.org/10.1038/srep35692

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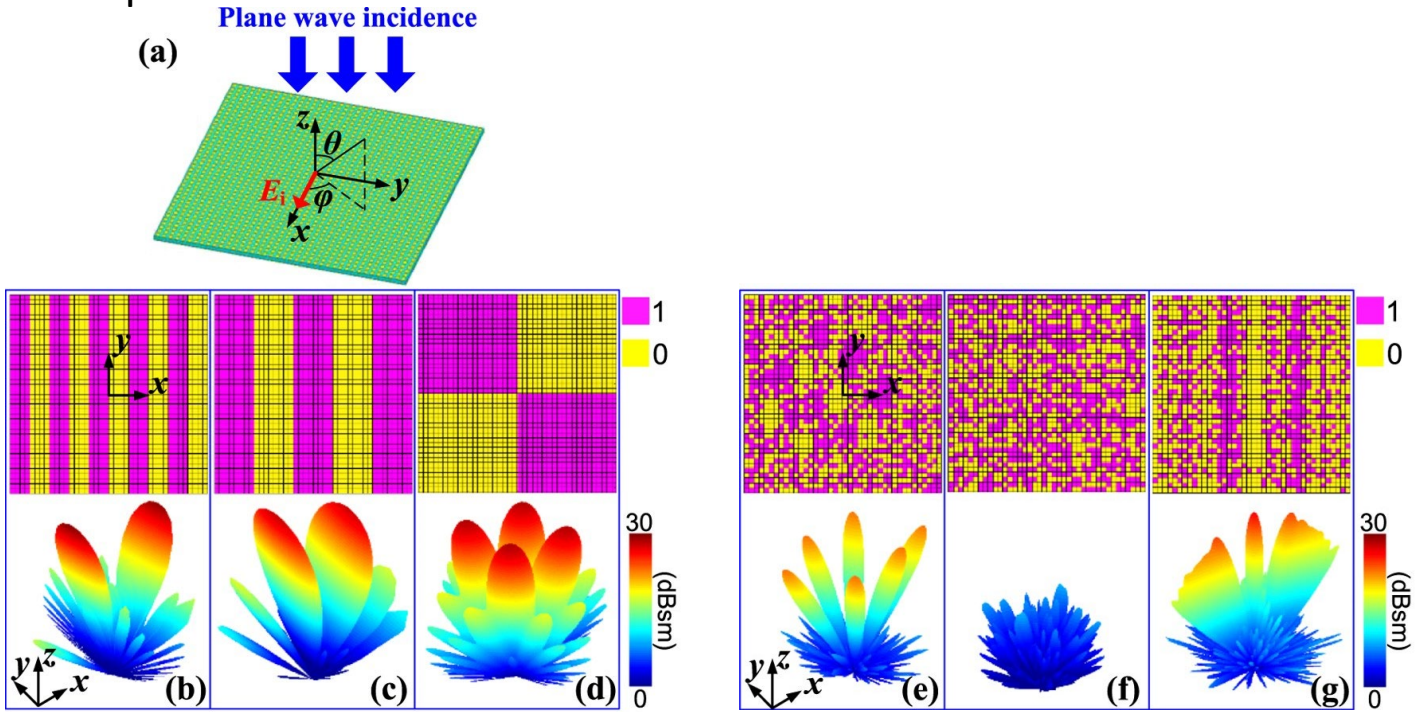

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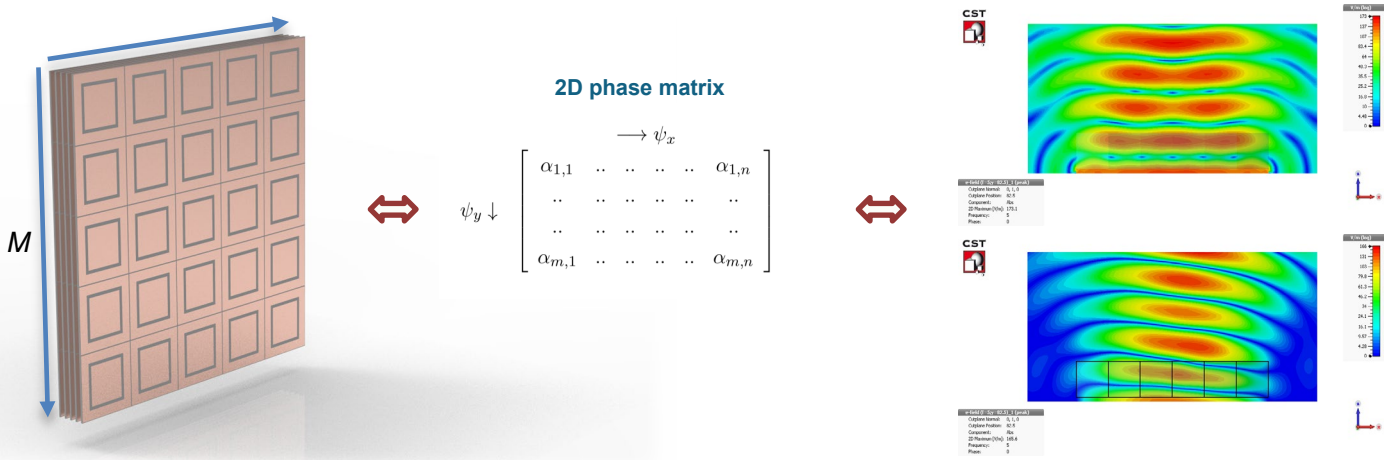
Metamaterial-inspired reconfigurable surface design



J. R. Reis et al., *"FSS-Inspired Transmitarray for Two-Dimensional Antenna Beamsteering,"* in IEEE Transactions on Antennas and Propagation, vol. 64, no. 6, pp. 2197-2206, June 2016, doi: 10.1109/TAP.2016.2543802.

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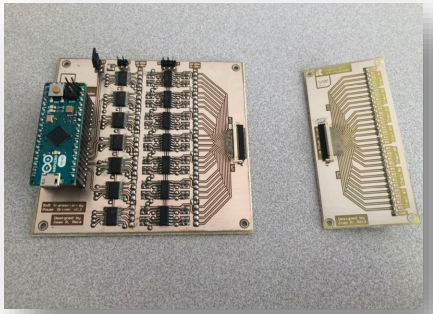
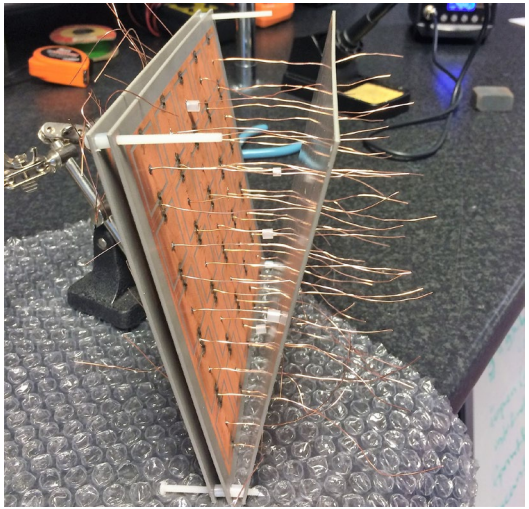
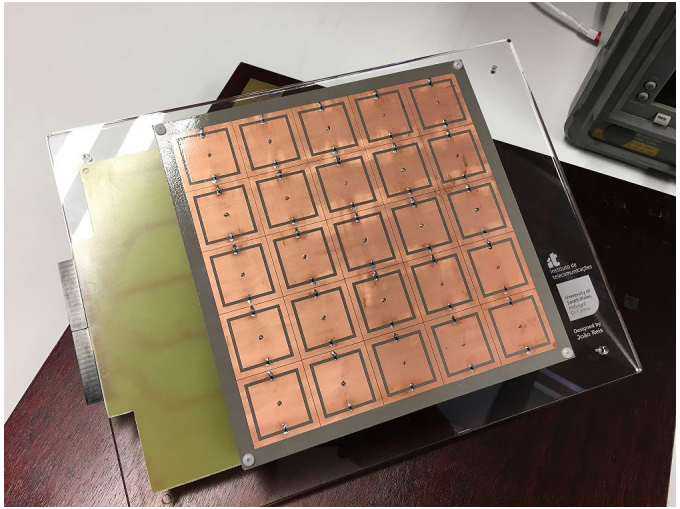




Assembling the prototype.



Finished prototype.

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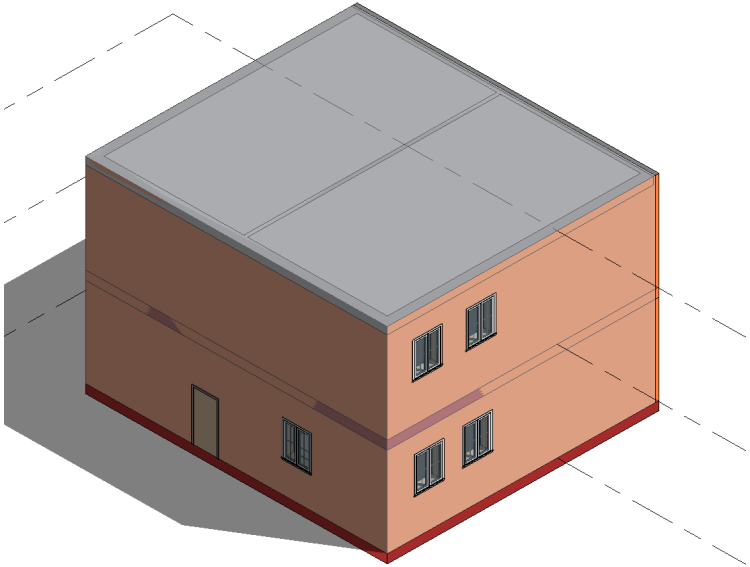
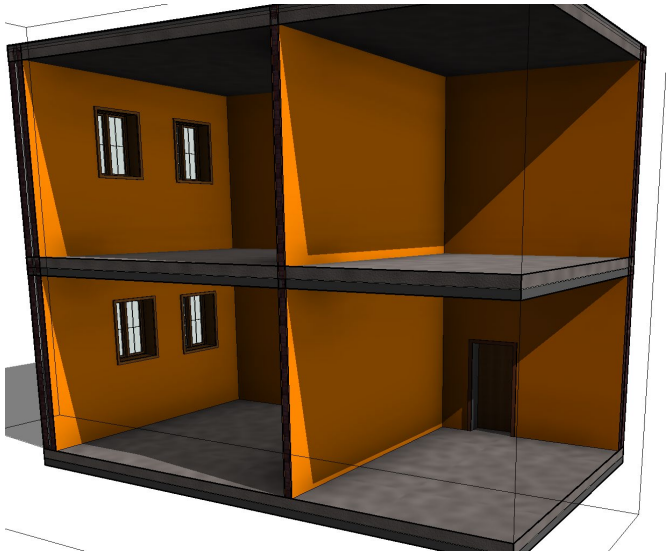
06. Electromagnetic Building Certification – ITED+

A Building Information Modelling (BIM) Plug-in for Future Electromagnetic Building Certification (EMBC)?





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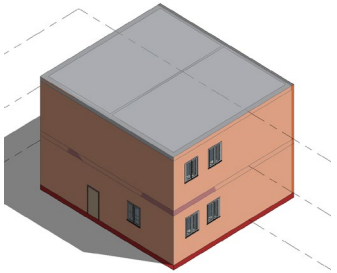

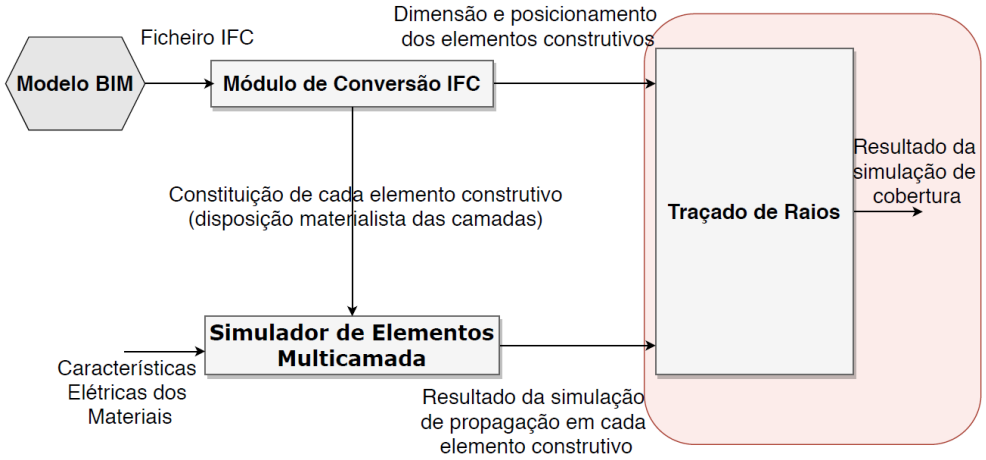

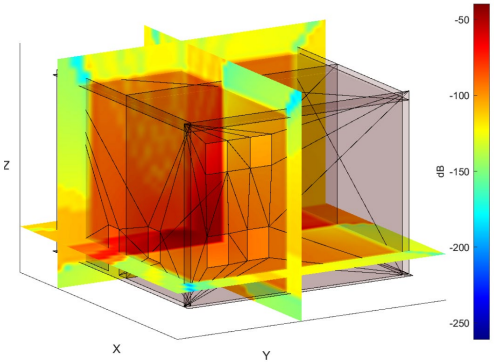

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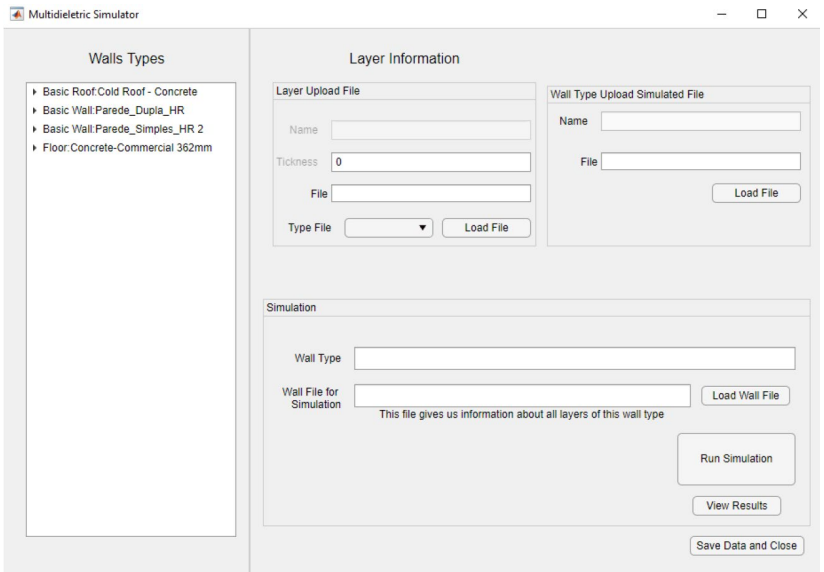

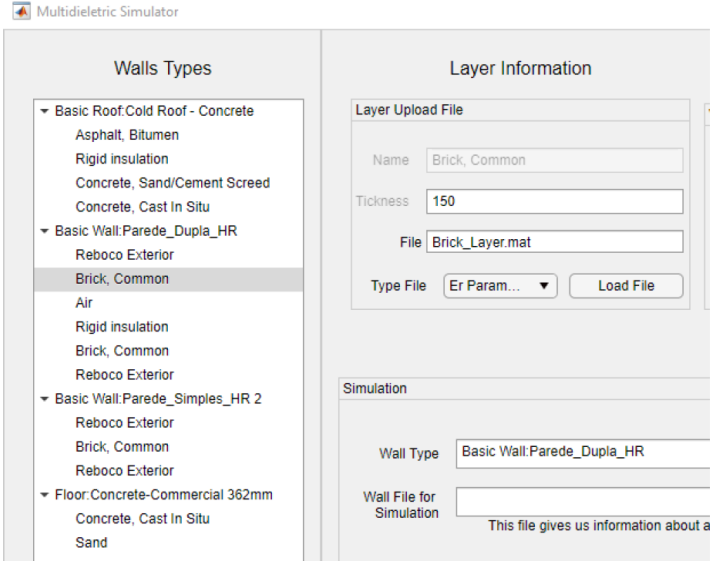

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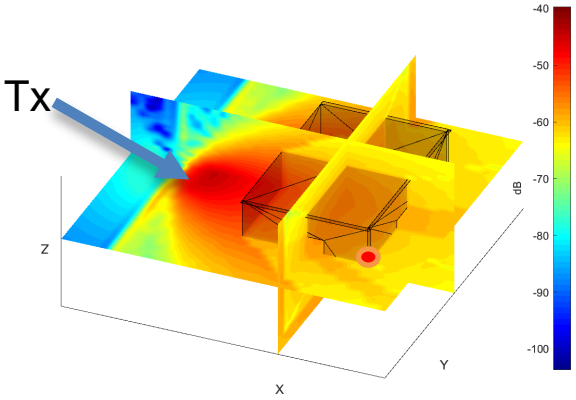
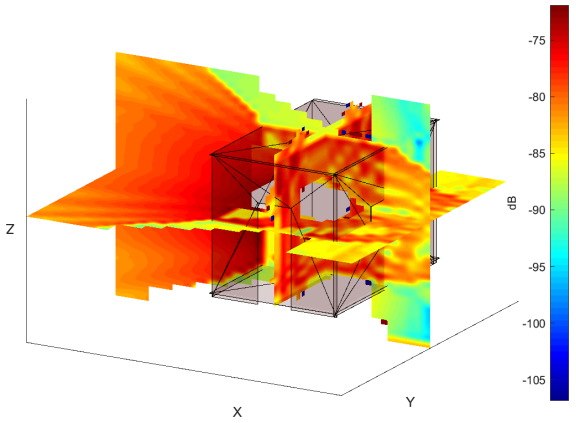
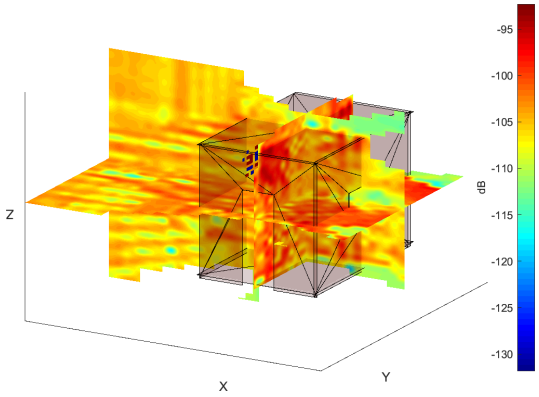


Direct/through component



1st order reflection



2nd order reflection

07. Final remarks

- Intelligent materials are key for deployment of 5G communication systems and beyond > **considered as a new antenna technology!**;
- Urban integration of reconfigurable antennas and intelligent surfaces required for smart radio environments > **higher levels of concealment!**;
- Regulatory aspects > **Electromagnetic Building Certification** (EMBC), and integration with BIM tools.

Thank you!

Questions, please?

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