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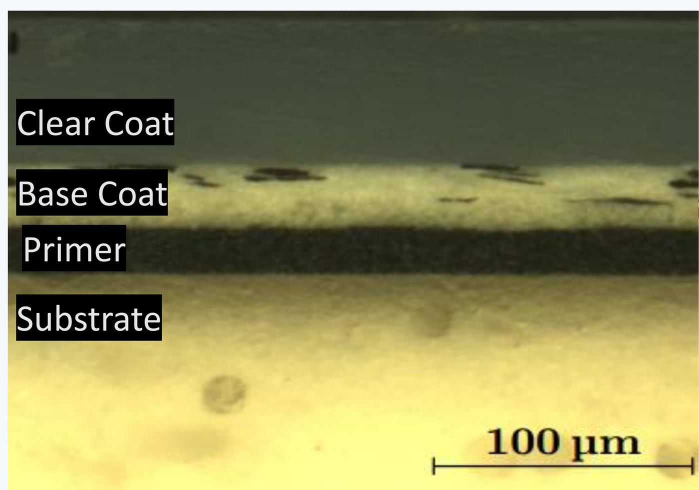
Robotic-Assisted Radar Transmission Measurements of Painted Bumper Samples to Validate TLM Simulations

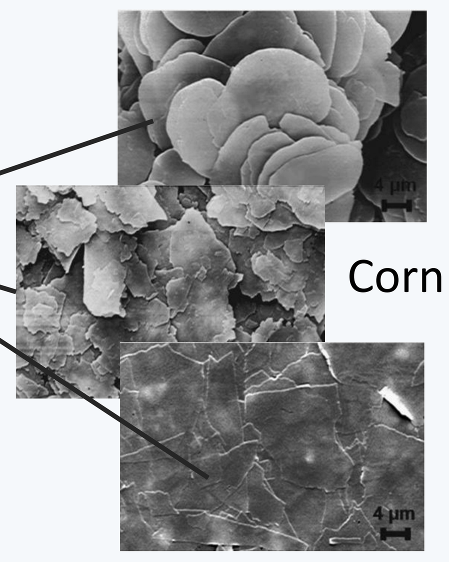
For more information visit **perisens** at **Booth C119**

This project is made in cooperation with MID4automotive * and with PPG

Introduction & Objectives

- **Goal:** Measure 76–81 GHz transmission t through painted bumpers to validate Transmission Line Model (TLM)
- **Setup:** Cobot, UR5e + Radome Measurement System RMS-C, perisens
- **Samples**: Substrates coated with generic automotive paints from PPG (non-pigmented and pigmented: mica, aluminium, iron-oxide)
- **Measurement:** Transmission t between ±60° incident (in E/H polarization)
- **Compare:** Measurements vs simulation (non-magnetic, isotropic TLM)
- **Outcome:** Good agreement with ≤ 0.07 dB amplitude & ≤0.7° phase difference

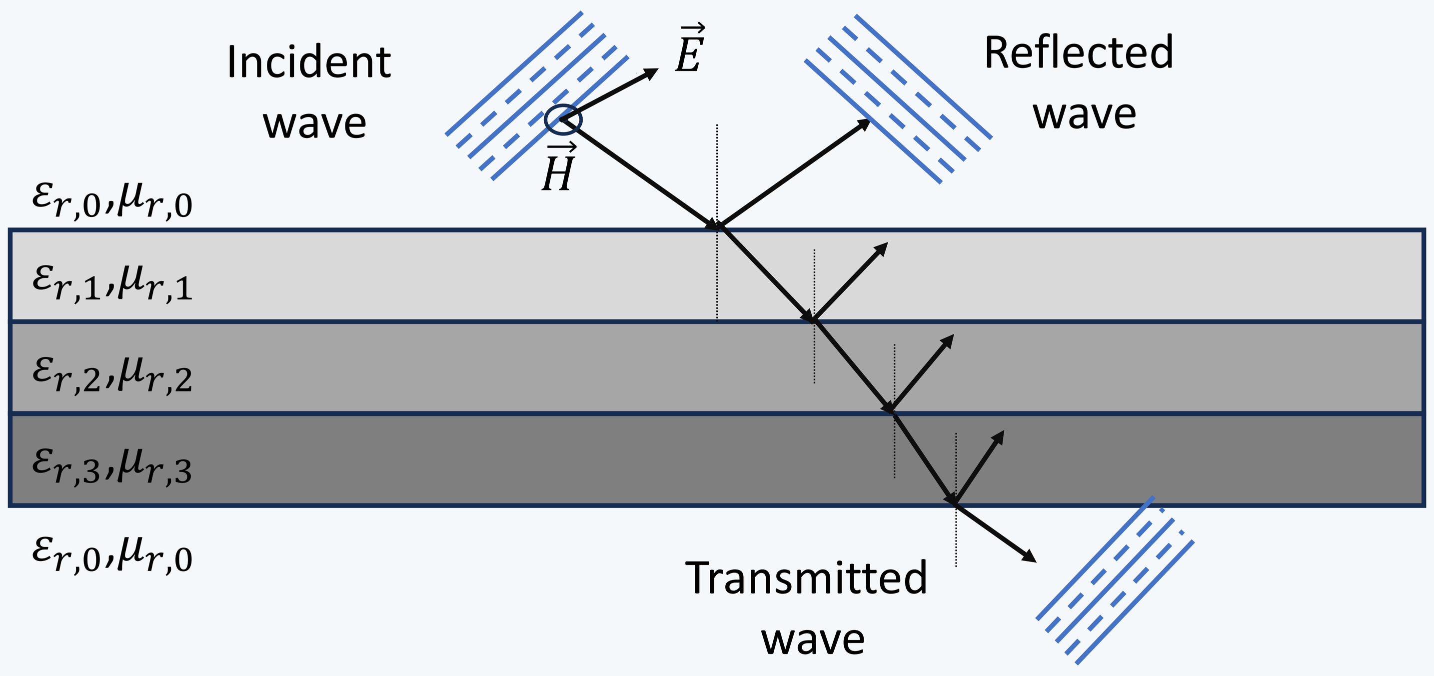




Transmission Line Model

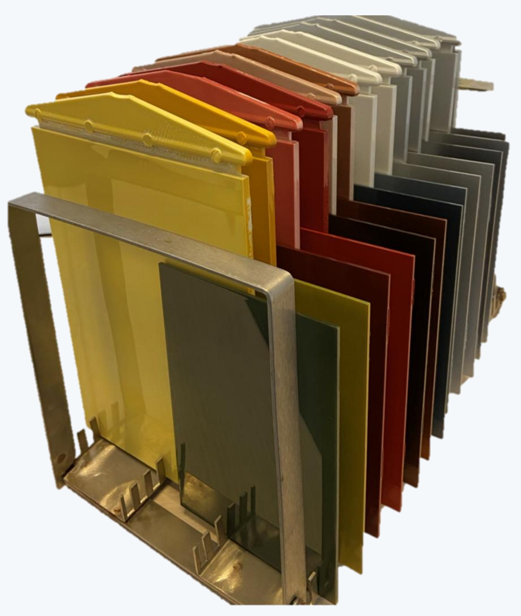
The **Transmission Line Model (TLM)** model allows us to calculate the transmission and reflection coefficient t and r by knowing the characteristics of every layer thicknesses d_i, material properties $\varepsilon_{r,i}$ and $\mu_{r,i}$ and the characteristic of the incident planar wave angle of incidence α_0, polarization ψ and frequency f.

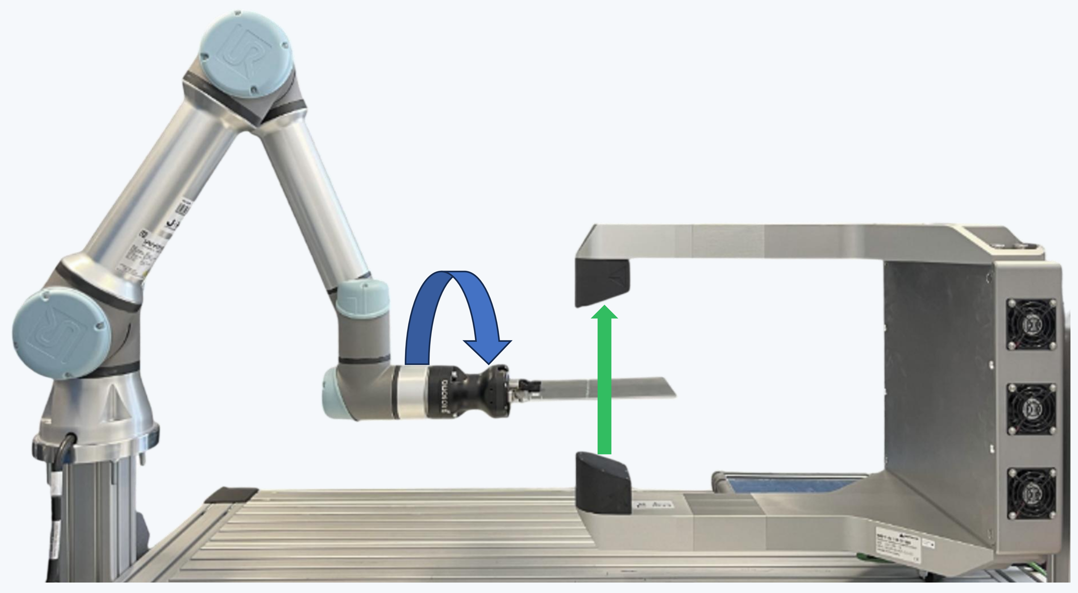
- TLM model is used as a base line in this research
- TLM model allows us, under certain conditions, to estimate the permittivity $\varepsilon_{r,i}$
- TLM model is used in the automotive industry to help find the optimal thickness to minimize reflectivity and maximize transmission of painted bumpers

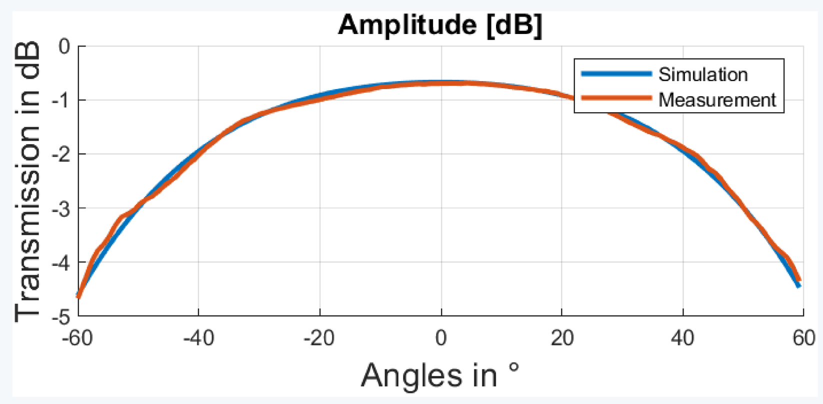


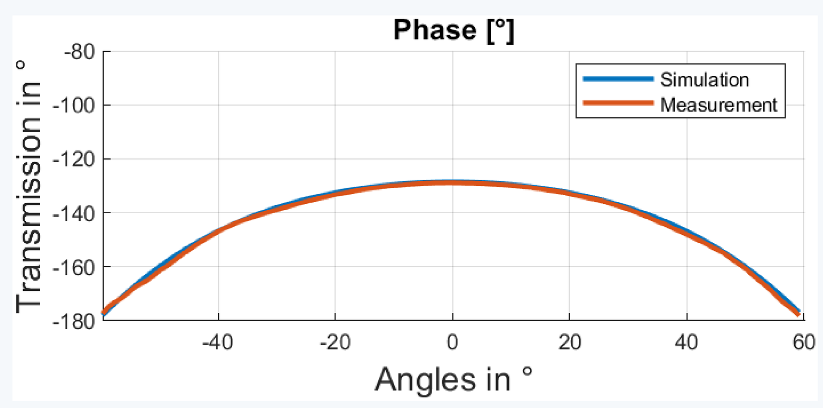
Measurement Process

(A) Preparing and selecting samples by PPG → (B) Determining the permittivity using RMS-D, perisens → (C) Measuring over angle using a cobot and an RMS-C, perisens → (D) Comparing measurement and simulation results









Results & Conclusion

Base coat description (weight percentage in liquid paint)	Base coat thickness (µm)	Base coat relative permittivity		1way-transmission Mean Absolute Error (E-Field/H-Field)	
		ε_r'	tan δ	dB	deg
Paint without effect pigment (reference)	**10**	**2.45**	**0.700**	**0.04 / 0.02**	**0.40 / 0.27**
Silver dollar aluminium coarse D50: 36 µm (2.21 %)	11	23.12	0.060	0.07 / 0.03	0.35 / 0.24
Corn flake aluminium coarse D50: 22 µm (2.02 %)	10	29.25	0.090	0.07 / 0.03	0.44 / 0.38
PVD aluminium pigment (1,86 %)	11	16.83	0.083	0.05 / 0.02	0.37 / 0.36
Mica silver fine (1.57 %)	12	3.68	0.383	0.06 / 0.03	0.37 / 0.23
Iron glimmer (1.86 %)	14	10.96	0.109	0.06 / 0.03	0.48 / 0.5
Iron oxide yellow opaque (3 %)	12	5.15	0.542	0.03 / 0.02	0.36 / 0.38
Iron oxide red opaque (3 %)	11	3.07	0.402	0.06 / 0.03	0.61 / 0.52
Iron oxide coated aluminium pigment (1.57 %)	12	11.18	0.127	0.05 / 0.04	0.30 / 0.35

- Robot based measurement of 10 samples with different base coat materials having **permittivity** ranging **from 2.4 to 29**
- **Good agreement of measured and simulated transmission** for pure substrate, metallic paints and mica paints
- Mean absolute error ≤0.07 dB amplitude & ≤0.7° phase error for incident angles of ±60° for all tested samples
- The Transmission Line Model assumptions of **isotropy** and **non-magnetism** are not affected by alumina, mica or iron oxide pigments

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