

# Eyes and Ears for the Car of the Future

**Terahertz sensors and networks  
for next generation smart  
automotive electronic systems**

## Review / Flashback

With this fourth and final issue of the Car2TERA newsletter we visit the last 4 years and summarise the project achievements.

About four years ago the H2020 project Car2TERA was launched with eight highly qualified and di-

verse industrial and academic partners from five European countries (Austria, Italy, Poland, Spain and Sweden) forged together as a consortium which would work together to achieve the ambitious goals of the project.

## Message from the Scientific and Technical Leader: Dr. Joachim Oberhammer (KTH)

Car2TERA has shown that excellent progress towards very ambitious technology goals can be achieved in a European-wide initiative. The efforts in the end phase of Car2TERA have shown extraordinary engagement by the consortium, with many partners' efforts even going rigorously over budget. Car2TERA is therefore proud to present its demonstrators: (1) a miniaturized 240 GHz in-cabin car-radar sensor with beam-shape switching and

beam-steering capabilities; and a (2) D-band plastic-microwave-fiber short-distance communication platform for future basestation interconnects. It was a great pleasure for me to guide this project as a scientific coordinator, and I am grateful for having been working with this great team and having learnt many new lessons about applying THz technology to telecommunication and sensing applications.



### Scientific Lead

Joachim Oberhammer

KTH Royal Institute of Technology  
joachim.o@kth.se

### Impact Lead

Siegfried Krainer

Infineon Technologies Austria AG  
siegfried.krainer@infineon.com

### Project Coordinator

Car2TERA Coordination Team

Technikon Forschungs- und  
Planungsgesellschaft mbH  
coordination@car2tera.eu



### Budget

€ 3.9 Million

100% EU-funded



### Consortium

9 Partners

5 countries



### Duration

48 Months

01/2019 - 12/2022

# About

From Advanced Driver Assistance Systems (ADAS) to fully Automated Vehicles, Car2TERA combines the results of recent achievements in semiconductor, micro- and nanoelectronics scientific projects. Car2TERA emerging technology and innovation took next generation cars to the next level.

In an effort to explain the impacts of Car2TERA, a video was designed which offers a quick glance on the impacts of the Project. This video was intended to be shared on social media to provide a short overview of Car2TERA. Please have a look and share with colleagues who are interested in our work.

## Objectives

- ✔ Novel car radar sensor concept
- ✔ Novel THz- over plastic data links
- ✔ Strengthen and reinforce Europe's leading position in automotive radar sensors
- ✔ Silicon-Micro machined THz system platform technologies
- ✔ Cost-effective, broadband, multi-usage SiGe monolithic-microwave integrated circuits (MIMICs).

## Demonstrator

In the last couple of months, the Car2TERA in-cabin radar sensor prototype has been brought up and gone through initial testing in the Microwave Electronics Lab at Chalmers University of Technology in Gothenburg, Sweden. After showing capabilities of sub-10 cm ranging accuracy and sensitivity to micro-motions, such as the ones generated when a human is breathing, it was deemed ready for integration with the rest of the in-cabin radar demonstrator system which was developed in parallel at Veoneer's site in Vårgårda, Sweden. In all, the demonstrator system includes the radar prototype, a radar-mounting jig and, of course, an actual car and its cabin.

The integration work was conducted at Chalmer's premises and initial demonstrator testing was performed at the end of March this year.

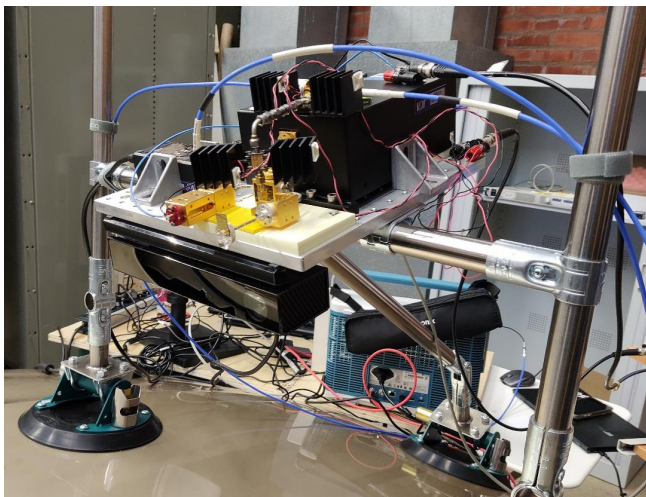


Figure 2: View of the radar from the front passenger seat. Notice that the car wind shield has been removed.

Figure 1: View of the in-cabin radar sensor prototype with a non-configurable antenna from KTH and the radar-mounting jig. The jig is attached to the hood of the car using suction cups and the metal frame can be tilted and its height adjusted so that the radar looking-angle can be configured. Also, below the radar is a Kinect time-of-flight camera which is the reference sensor system.

Testing efforts focused on two main features envisioned for the Car2TERA in-cabin radar concept. One is radar imaging of car occupants, which, for example, aims to infer the driver attentiveness via the driver's head tilt or to provide information of the occupants' body pose to safety systems for minimizing the damage in a crash scenario. The other feature is detecting vital signs through micro-motions, which can enable life-saving functionality in post-car crash scenarios or alert the driver if they were to forget pets or children in the car on a hot and sunny day, which could lead to severe and even life-threatening consequences.

Data collection efforts for initial testing were successful and

concluded on the 24<sup>th</sup> of March. In these efforts, participants from KTH Institute of Technology joined in and helped with integrating the fully MEMS-configurable Car2TERA antenna prototype. Due to KTH's aid combined with preparatory efforts made from Veoneer's and Chalmers' side, the testing was quick and effective and resulted in a satisfying collaboration. Results from the data collection efforts will be reported internally at the end of March 2023, and the analysis will be valuable input for making eventual finishing touches and tweaks to the in-cabin radar demonstrator system before the anticipated final demonstration in June 2023.

## Publication Update

**Multi-Gigabit RF-DAC Based Duobinary/PAM-3 Modulator in 130 nm SiGe HBT**, Frida Strombeck, Zhongxia Simon He, Herbert Zirath, IEEE Xplore, [Link to Zenodo](#)

**An MPSK Millimeter-Wave Point-to-Point Link With Radio Over Fiber Synchronous Baseband Receiver**, Weidong Zhang, Sining An, Jianpin An, E, Xiangyuan Bu, and Zhongxia Simon He, Journal of Lightwave Technology, [Link to Zenodo](#)

**Radar Cross-Section Characterization of the Car In-Cabin Environment at Sub-THz Frequencies**, Victor Pettersson, Sining An, EuRAD 2022, [Link to Zenodo](#)

**Accurate RCS Imaging of Car In-Cabin Objects at SUB-THz Frequencies**, Victor Pettersson, Sining An, IET Radar 2022 – Edinburgh, [Link to Zenodo](#)

**Integrated Circuit Design for High Data Rate Polymer Microwave Fiber Communication Department of Microtechnology and Nanoscience**, Frida Stömbeck, PhD Thesis, [Link to full text](#)

**A Wideband High-Gain Power Amplifier Operating in the D Band**, Vasileios Manouras, Ioannis Papananos, 30th IFIP/IEEE International Conference on Very Large Scale Integration, [Link to Zenodo](#)

## PMF Workshop

The **2<sup>nd</sup> International Workshop on Polymer Microwave Fiber Technology, PMF 2023 (7th- 8th March)**

organized and hosted by the KU Leuven aimed to bring together all important players in this new field, academia as well as industry and other stakeholders, in order to build a PMF community in which research, development and productization can be stimulated. The Car2TERA consortium was represented by IFAT, CHALMERS AND ERICSSON with four talks, presenting and discussing their latest results.

**Emerging Application and System Aspects of PMF Technology**

Speaker: Siegfried Krainer (Infineon, Austria)

**Efficient Wireless Coupling for PMF Data Links**

Speaker: Vasileios Liakonis (Infineon, Austria)

**D-band (110-170 GHz) receiver/transmitter chipsets for wireless and Plastic Microwave Fiber (PMF) communication for data rates up to and above 100 Gbps**

Speaker: Herbert Zirath (Chalmers University, Sweden)

**High-speed data links based on polymer microwave fiber (PMF) for 5G evolution and 6G radio systems**

Speaker: Yinggang Li (Ericsson, Sweden)

More information on the presentations can be found on the Car2TERA Blog.





## Successful Car2TERA PhD Defence: Dr. Frida Strömbeck

Title: Integrated Circuit Design for High Data Rate Polymer Microwave Fiber Communication Department of Microtechnology and Nanoscience, CHALMERS UNIVERSITY OF TECHNOLOGY Gothenburg, Sweden 2023  
Supervisor: Herbert Zirath

Coinciding with the end of the project Frida Strömbeck has successfully defended her PhD thesis on the 21<sup>st</sup> March, 2023 in Gothenburg. Her work explores the opportunities and challenges of short-range, ultra-high data rate, PMF bound communication, which is found to support 56 Gbps error-free ( $BER < 10^{-12}$ ) data and 102 Gbps with a  $BER = 2.1 \cdot 10^{-3}$ .

Abstract: The rapid development of semiconductor processes with a maximum frequency of oscillation well above 300 GHz enables new applications at frequencies above 100 GHz to be researched and developed. Such applications include wireless backhaul, wireless access, radar and radiometer sensors, wire-

less energy distribution and harvesting, etc. For shorter ranges like chip-to-chip or module-to-module (up to ten meters), millimeter-wave communication over a polymer microwave fiber (PMF) is an interesting alternative due to its potential low cost. Other advantages include flexibility, less sensitivity to temperature variations, and a more relaxed mechanical tolerance requirement. Similar to optical fiber, dispersion occurs on PMFs and will cause symbol interference. Different ways to deal with this effect were investigated, and the work proposes and presents various circuit solutions enabling high data rate communication. Two technologies are used, 250 nm InP DHBT and 130 nm SiGe BiCMOS. An energy-efficient solution using an RF-DAC and power detector for pulse amplitude modulated links are evaluated, as well as an I/Q modulated solution. I/Q (de-)modulators require more complexity, but the increased spectral efficiency can also increase the data rate further.

## Past Events

### EURAD – European Microwave Week 2022, Milan (Italy)

Presentation of paper in Automotive Radars above 100 GHz (Veoneer)

### NEXUS - Where Navarra meets Europe

10<sup>th</sup> November 2022, Pamplona, Spain (ANTERAL)

### 30th IFIP/IEEE International Conference on Very Large Scale Integration

3.-5.10.22, Patras, Greece (IFAT)

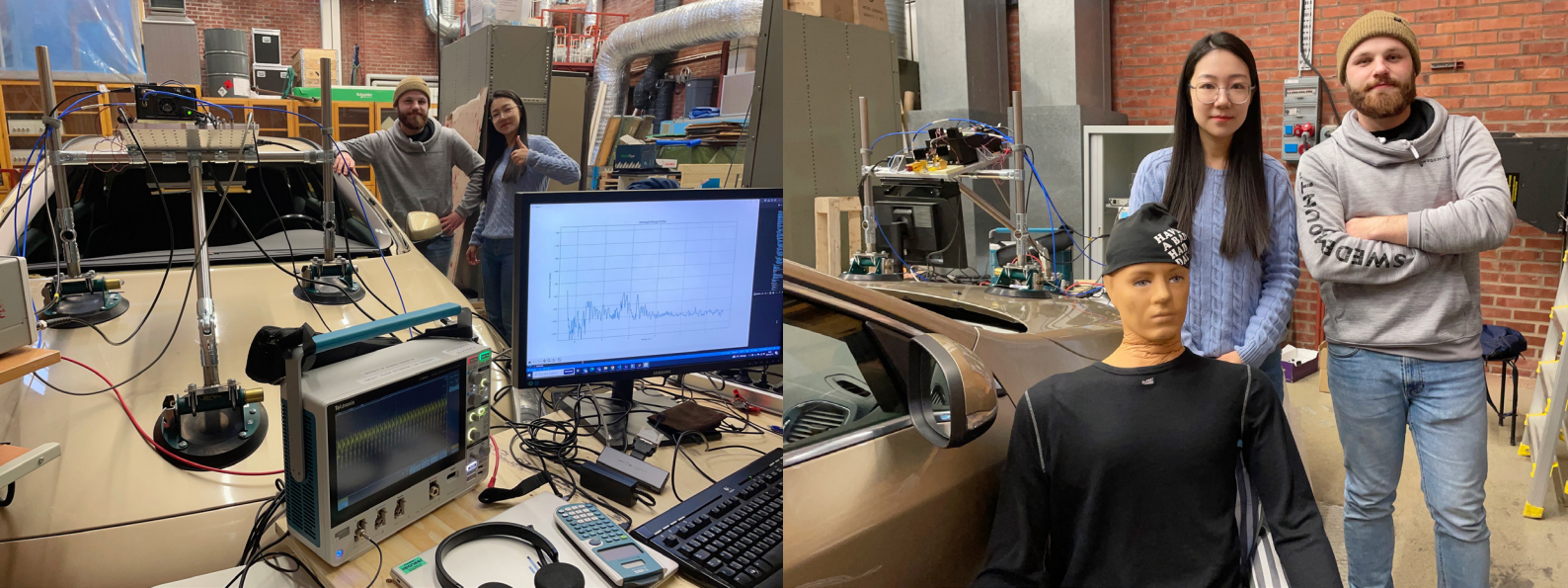
### PMF 2023 - 2nd International Workshop on Polymer Microwave Fiber Technology

PMF 8<sup>th</sup> March 2023, Leuven

### PhD defense Frida Strömbeck 21<sup>th</sup> March 2023

Gothenburg, Sweden (CHALMERS) - Frida Strömbeck defend her work on BiCMOS circuit design for PMF communication, primarily funded by the Car2tera project

Find all past and upcoming events in the Car2TERA event section: <https://car2tera.eu/events/>



Eight H2020 projects funded under call ICT-09-2017 form the Beyond5G Cluster, which aim is to offer a response to new challenges of future networks with above state of the art technologies covering all the major communication area from Gb/s to Tb/s. Car2TERA is proud to be part of this international initiative starting from 2020.

## Consortium

The Car2TERA consortium consists of eight highly qualified industrial and academic partners from various backgrounds and five different countries (Austria, Sweden, Poland, Italy and Spain), making it well positioned to achieve its objectives.



The Car2TERA project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 824962.



Car2TERA H2020



@Car2TERA\_H2020