

**Electronic Packaging Days 2025**

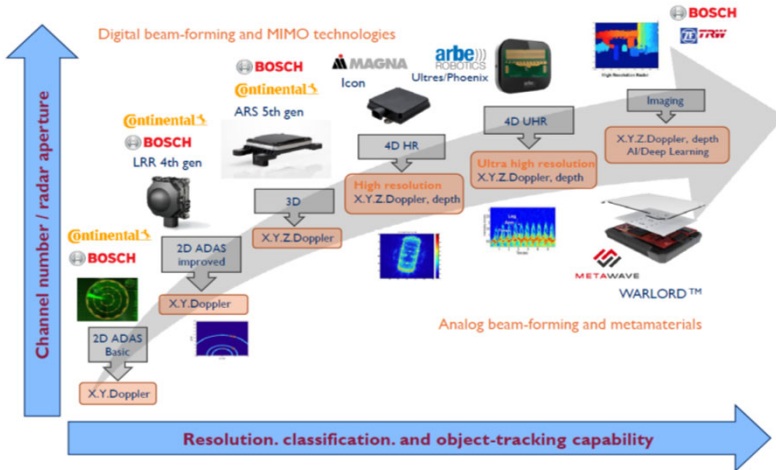
Dr.-Ing. Christian Tschoban

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# Application-Specific Design and Packaging of Radar Modules and Systems

# Trends in the field of radar module development (1/2)

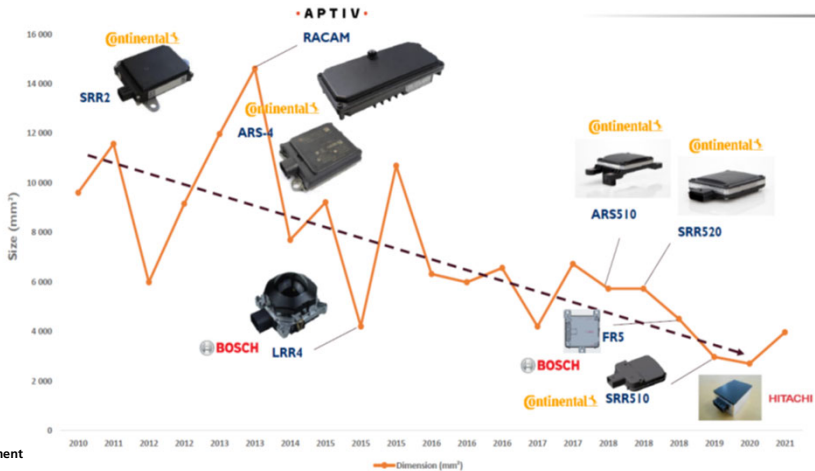
## More functionality ...



Source: Yole Développement

# Trends in the field of radar module development (1/2)

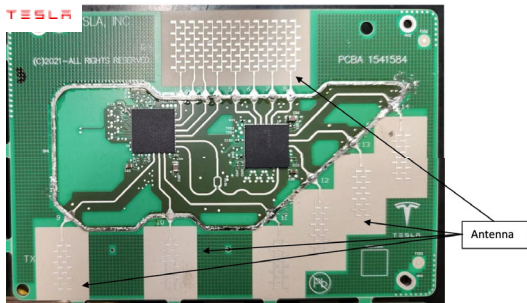
... in smaller volumes



Source: Yole Développement

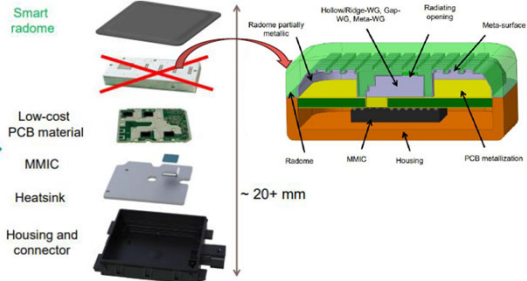
# State of the Art in Automotive Radar Modules

Packaging concept based on classical PCB technology



Source: <https://x.com/greentheonly/status/1626639883992178690/photo/3>

## HUBER+SUHNER



Source: Yole Intelligence 2024

# From an Automotive Radar Module Approach to an Industrial Driven Approach

## Packaging concept based on classical PCB

### Limitations of state of the art automotive driven approaches:

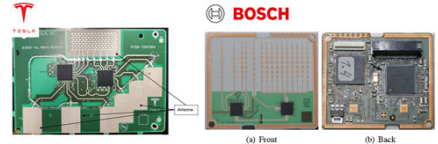
- Radar sensor has a limited angular resolution in horizontal plane
- Radar sensor has no resolution in vertical plane
- The entire radar module with its components antenna, RF front end and sensor-related signal processing is integrated into one package
- Technology selection follows RF range as a critical requirement

### Requirements of an industrial driven approach:

- High angular resolution in *horizontal* plane (+/- 2°)
- Sufficient resolution in *vertical* plane (+/- 3°)
- Technology selection follows safety requirements

### The industrial driven approach consists of two basic approaches:

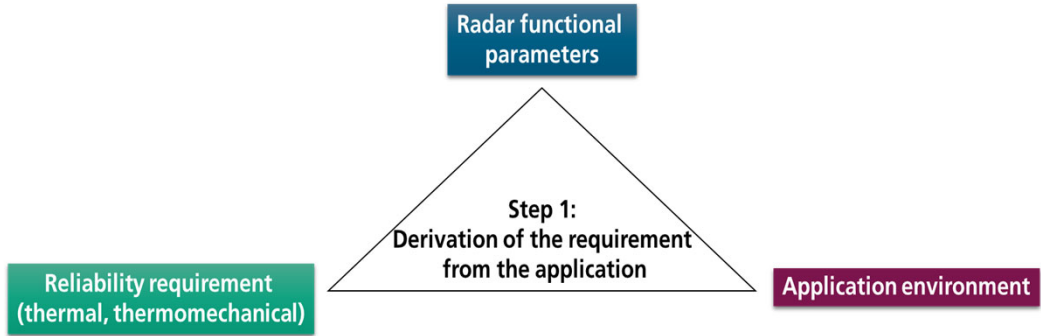
- Partitioning of the various elements of the radar sensor (antenna, RF frontend, sensor-related signal processing)
- Functional package codesign approach for the individual areas



# Methodology for a Packaging-Codesign for a high-resolution MIMO-Radar

Using the example of a radar module for autonomous vehicles in an industrial environment

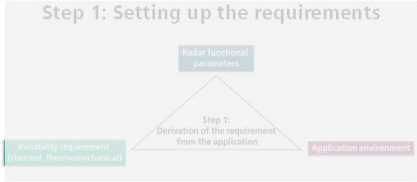
## Step 1: Setting up the requirements



# Methodology for a Packaging-Codesign for a high-resolution MIMO-Radar

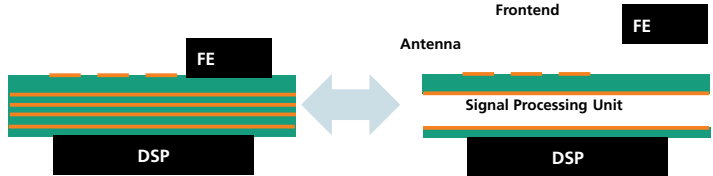
Using the example of a radar module for autonomous vehicles in an industrial environment

## Step 1: Setting up the requirements



## Step 2: Architecture Development

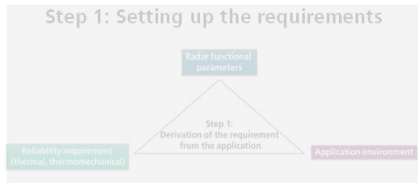
Building Blocks, Antenna concept, MIMO-concept,  
Requirements for Packaging concept



# Methodology for a Packaging-Codesign for a high-resolution MIMO-Radar

Using the example of a radar module for autonomous vehicles in an industrial environment

## Step 1: Setting up the requirements



## Step 2: Architecture Development

Building Blocks, Antenna concept, MIMO-concept, Requirements for Packaging concept



## Step 3: Packaging Technology Development and Tolerance Analysis

Possible Packaging Technology	Antenna	Frontend	Signalprocessing	Housing
PCB			● ●	
Embedding PCB		●		
LTCC				
WLP-Si				
WLP-Glass	●	●		
PLP-Mold	●			
3D-Printing				● ●

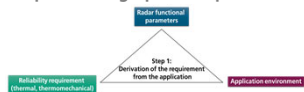
● Selected Packaging Technology Path I  
● Selected Packaging Technology Path II



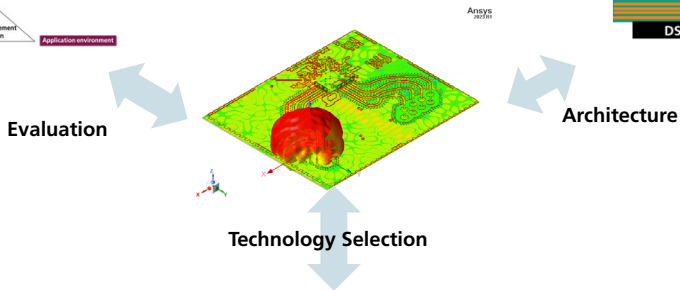
# Methodology for a Packaging-Codesign for a high-resolution MIMO-Radar

Using the example of a radar module for autonomous vehicles in an industrial environment

## Step 1: Setting up the requirements



## Step 4: Codesign Approach



## Step 2: Architecture Development



## Step 3: Packaging Technology Development and Tolerance Analysis

Possible Packaging Technology	Antenna	Frontend	Signalprocessing	Housing
PCB			● ● ●	
Embedding PCB		●		
LTCC				
WLP-Si				
WLP-Glass	●	●		
PLP-Mold		●		
3D-Printed				● ● ●

● Selected Packaging Technology Path 1  
● Selected Packaging Technology Path 2

# Step 1: Setting up requirements

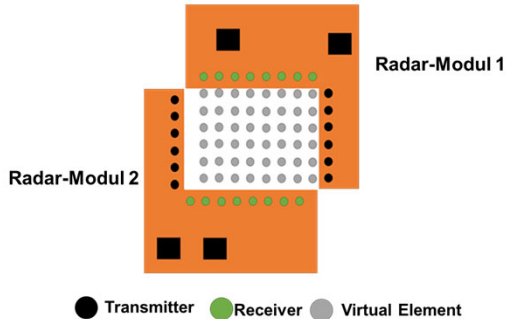
## Functional radar requirements



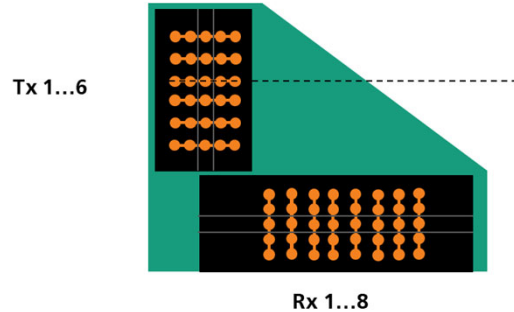
Parameter	Values
General Requirements	
Bandwith	2 GHz
Modulation	TDM
Field of View (Azimut)	$\pm 45^\circ / 90^\circ$
Field of View (Elevation)	$\pm 30^\circ$
Range	10 m
MIMO – Radar	
Angular resolution azimuth	better $4^\circ$
Angular resolution elevate	better $6^\circ$

## Step 2: Architecture Development

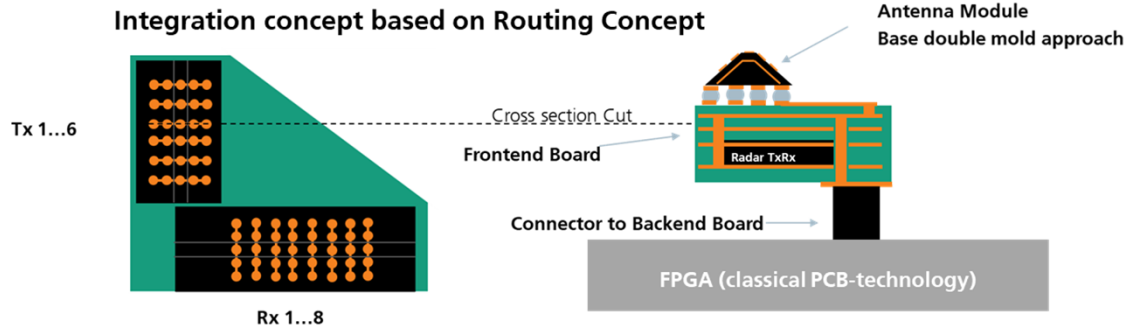
### Hardware and MIMO-Concept



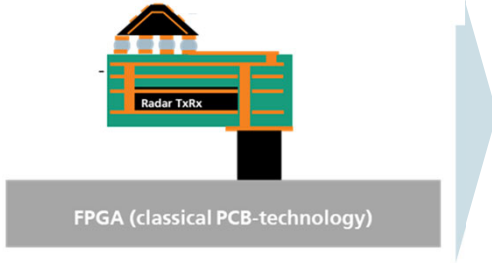
### Integration concept



## Step 2: Architecture Development



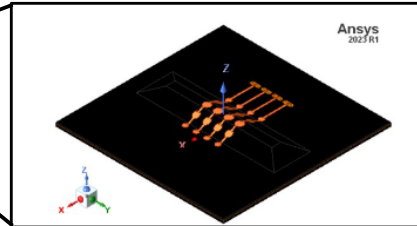
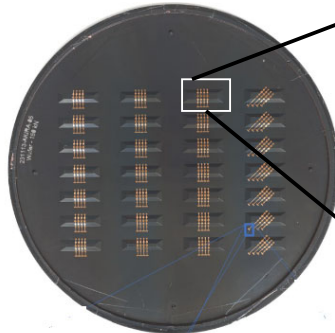
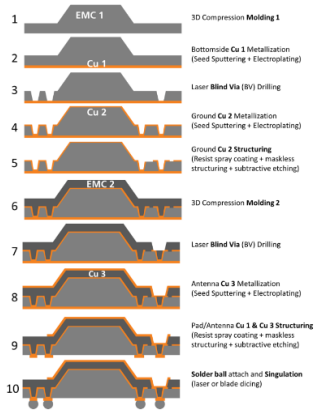
## Step 3: Technology Selection



Possible Packaging Technology	Antenna	Frontend	Signalprocessing	Housing
PCB			●	
Embedding PCB		●		
LTCC				
WLP-Si				
WLP-Glass				
PLP-Mold	●			
3D-Printing				●

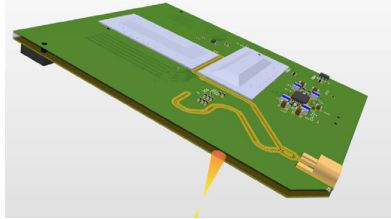
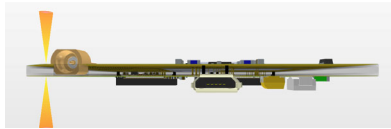
# Step 3: Packaging Technology Development

## 3D antenna on package for 180° field of view

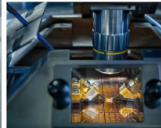
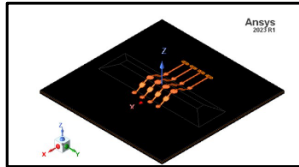


**Source:** M. Dreissigacker *et al.*, "On the Design and Fabrication of SMT-Compatible 3D-Freeform Antennas Based on Compression Molding and Direct Cu-Metallization," 2024 IEEE 10th Electronics System-Integration Technology Conference (ESTC), Berlin, Germany, 2024

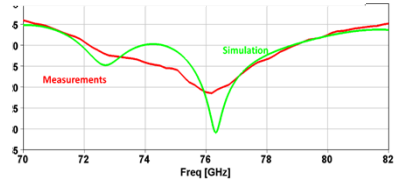
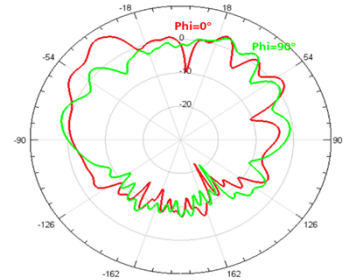
# Step 4: Functional Codesign Approach



Final Design Frontend with integrated 3D-Antennas



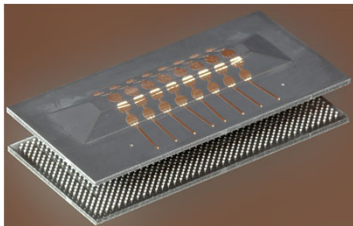
Evaluation 3D-Antennas development base on Codesign Approach



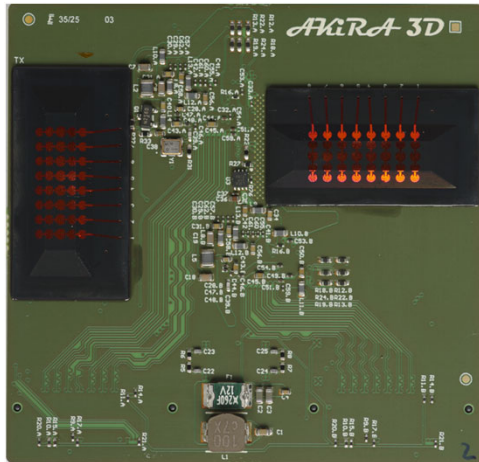
# SUMMARY AND ACKNOWLEDGMENT

## Summary and Outlook

- Fraunhofer IZM develops leading-edge **compact** radar sensors
- by using **latest packaging** technologies to get more functionality and performance
- and applying latest approaches in **function-packaging co-design**.



Parameter	Values
General Requirements	
Bandwith	2 GHz ✓
Modulation	TDM ✓
Field of View (Azimut)	$\pm 45^\circ/90^\circ$ ✓
Field of View (Elevation)	$\pm 30^\circ$ ✓
Range	10 m ✓
MIMO – Radar	
Angular resolution azimuth	better $4^\circ$ ✓
Angular resolution elevate	better $6^\circ$ ✓



Thank you for sharing my interest ...



... and not falling asleep!

## Contact

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