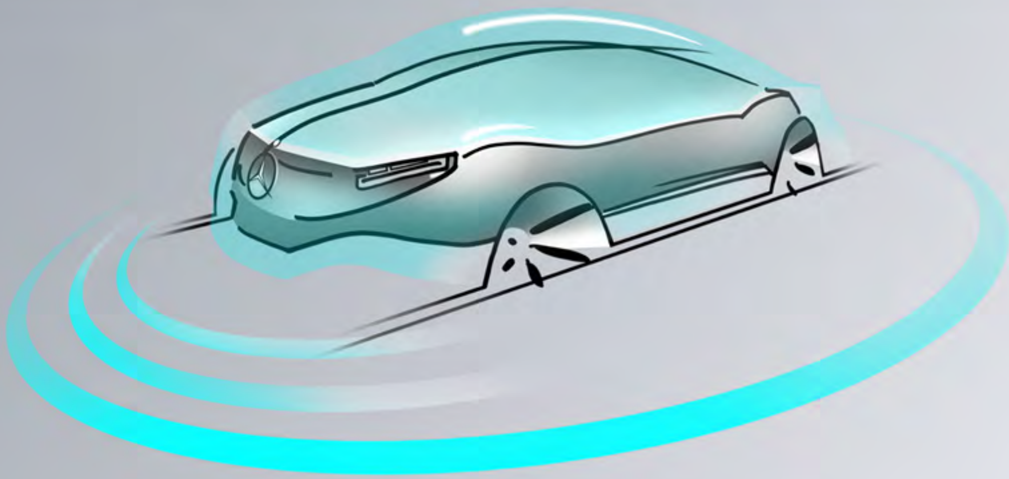


Automotive Radar and Radar Based Perception for Driverless Cars

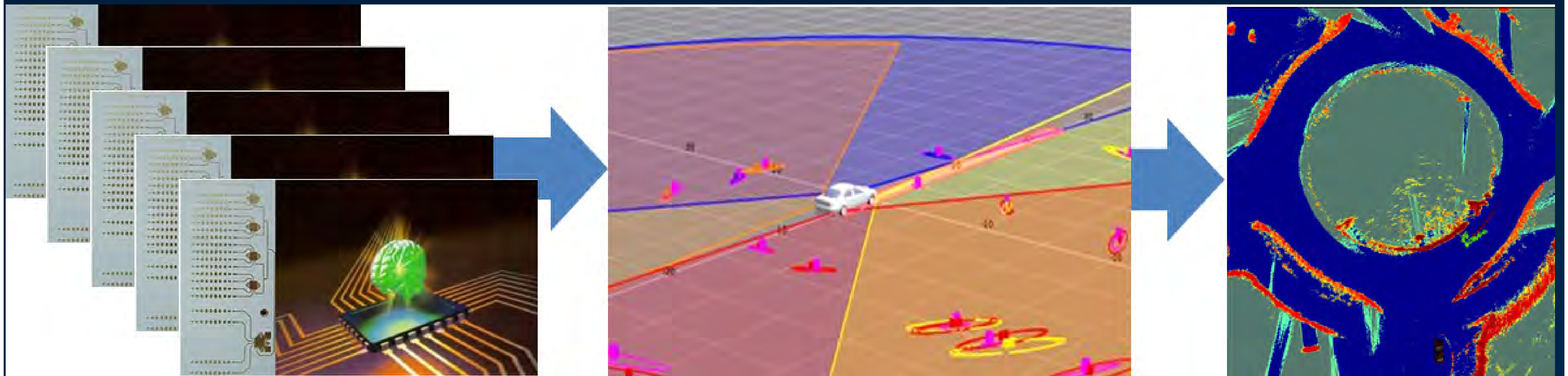
Radar Symposium February 13, 2017

Auditorium , Ben-Gurion University of the Negev

Dr. Juergen Dickmann, DAIMLER AG, Ulm, Germany

Mercedes-Benz

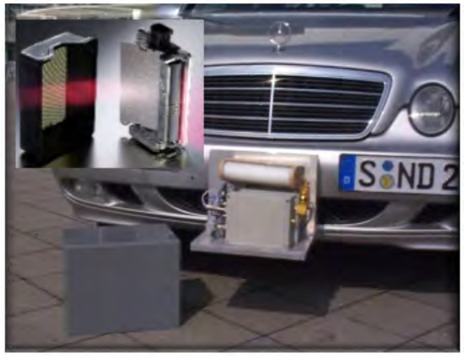
Radar Team DNA



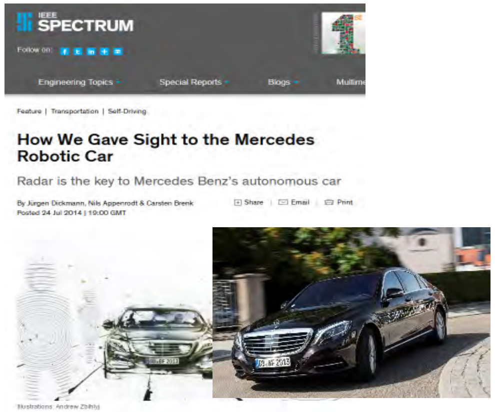
More than 15 years of field (Product) experience,
and now
"Radar is in all platforms at DAIMLER"

Radar 4 drvless driving Team-DNA

First automotive ESR



360°-76GHz Radar-Net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Engineering Topics · Special Reports · Blogs

Feature | Transportation | Self-Driving

How We Gave Sight to the Mercedes Robotic Car

Radar is the key to Mercedes Benz's autonomous car

By Jürgen Dickmann, Nils Appenrodt & Carsten Brenk
Posted 24 Jul 2014 | 19:00 GMT

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Autonomous BUS

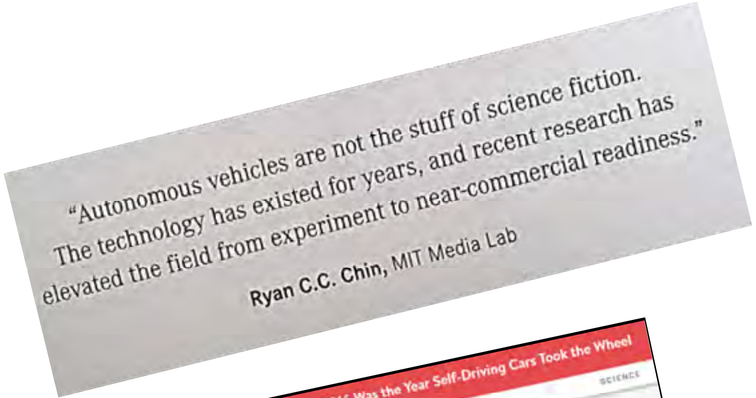
Autonomous Tuck

Sites of the drvless-activities

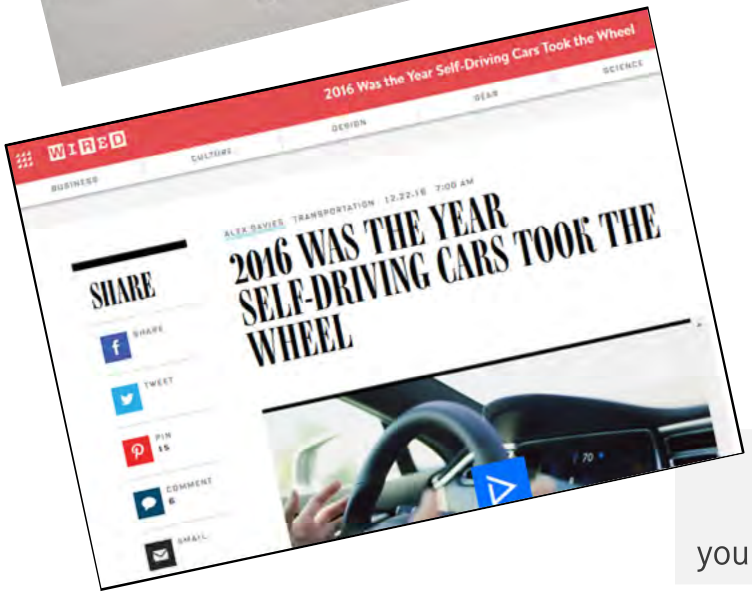
Automated driving
and
Active Safety

Introduction

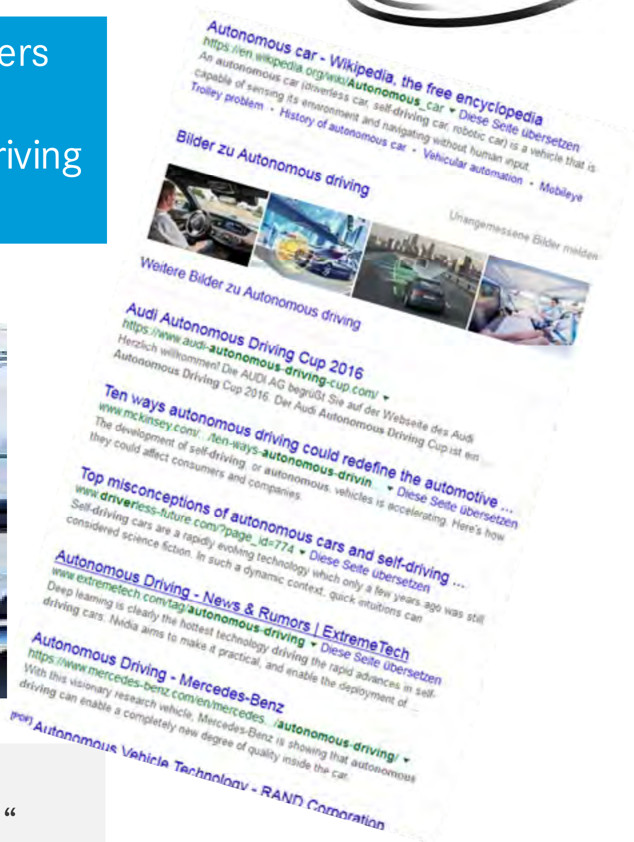
Driver less driving: A Trend at Hype peak?


"Autonomous vehicles are not the stuff of science fiction. The technology has existed for years, and recent research has elevated the field from experiment to near-commercial readiness."
Ryan C.C. Chin, MIT Media Lab

2016 Start-ups, new players
and Car-OEMs
flooded the autonomous driving
arena



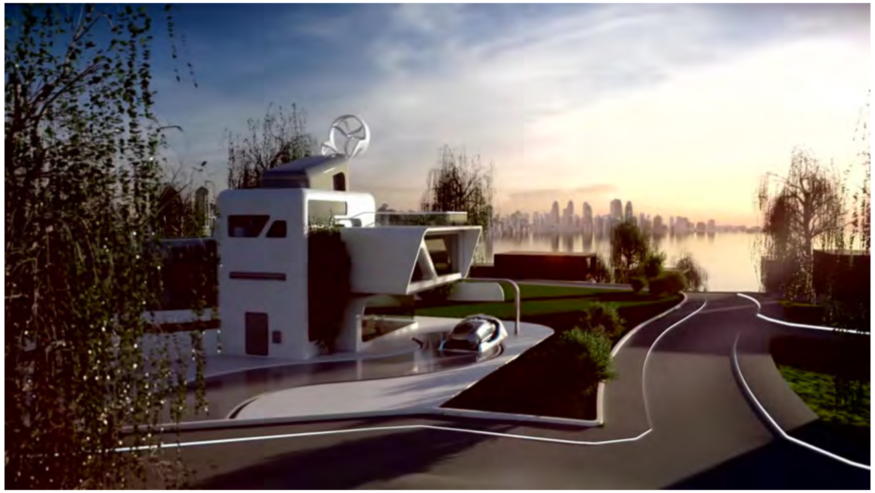
… and they all
heavily use Radar



If you are in „Wikipedia“
and things like „How Stuff works,“
you have reached public societal awareness

Drvless driving – How we approached it

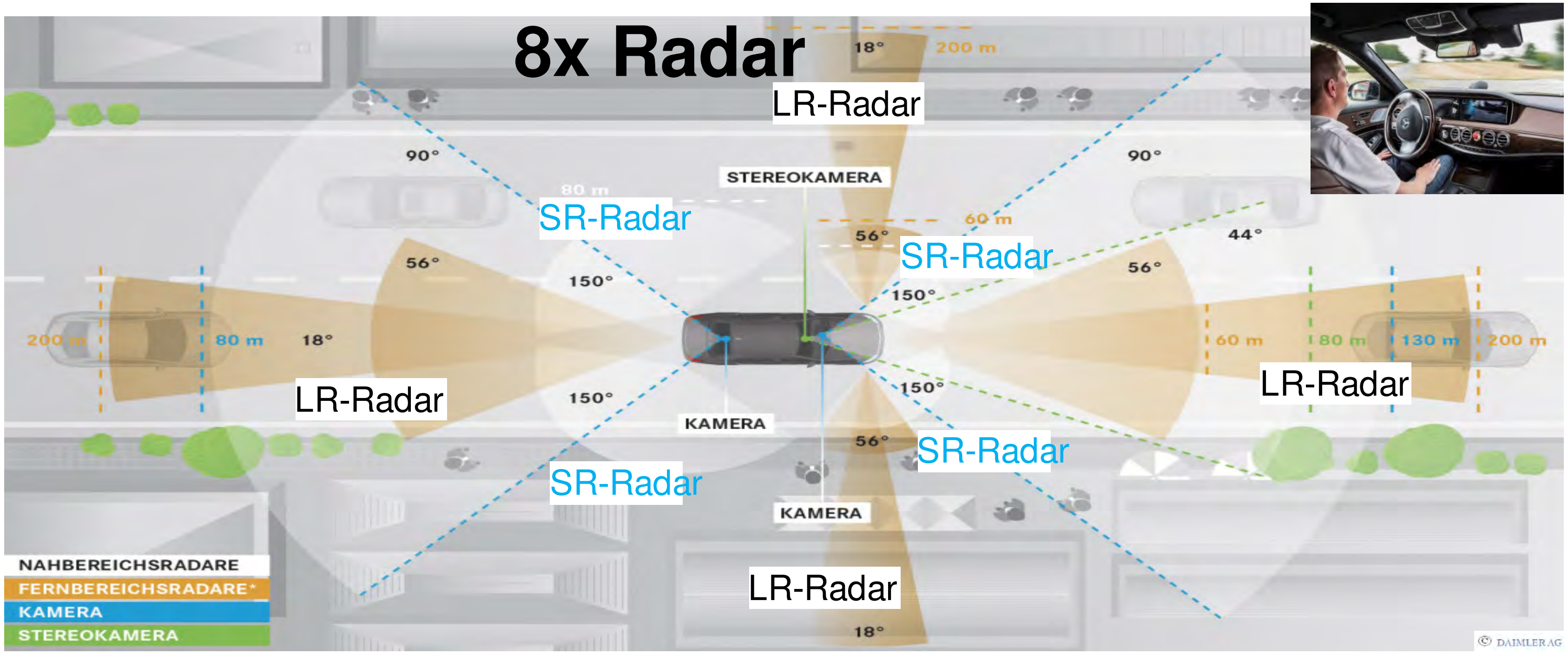
How do we see the drvless future,



... that´s how our future began in 2013

Bertha-Tour 2013:
Bertha-vehicle appears like a normal S-Class

Bertha-Tour-2013:
… and Radar had been intensively used as backbone and innovation enabler



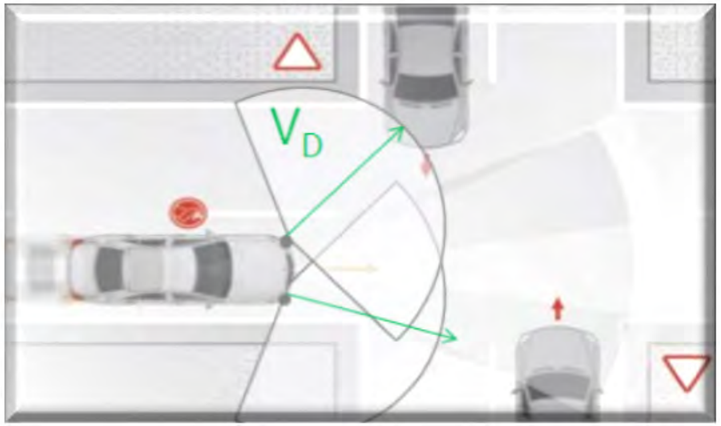
Performance Status

Truck Active Brake Assist – Radar-Based Function

COLLISION PREVENTION ASSIST PLUS

COLLISION PREVENTION ASSIST uses radar to constantly monitor closing speeds between your Mercedes-Benz and the moving vehicles around it. If the system determines that a collision is likely, it can help you apply the ideal level of braking.

The new E-Class 2016



Active Brake Assist with cross-traffic function: The system can detect crossing traffic at junctions and, if the driver fails to respond, applies the brakes autonomously. It is possible to completely avoid accidents at speeds up to 100 km/h or substantially reduce the severity of accidents at speeds above this level.

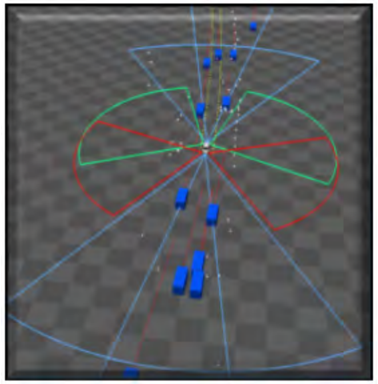
The new E-Class 2016

Foto: Daimler

Radarsensorik hilft, Fahrzeuginsassen bereits vor unvermeidlichen Frontal- und Heckunfällen in die bestmögliche Position zu bringen. Im kommenden Jahr bietet Mercedes nun auch ein System für den Seitenaufprall an.

PRE-SAFE® impulse side: The system inflates an air chamber in the side bolster of the front seat backrest nearest the side of the imminent impact in a fraction of a second, thus increasing the distance between occupant and door and, at the same time, reducing the forces acting on the occupants.

Present E-Class: Drive Pilot

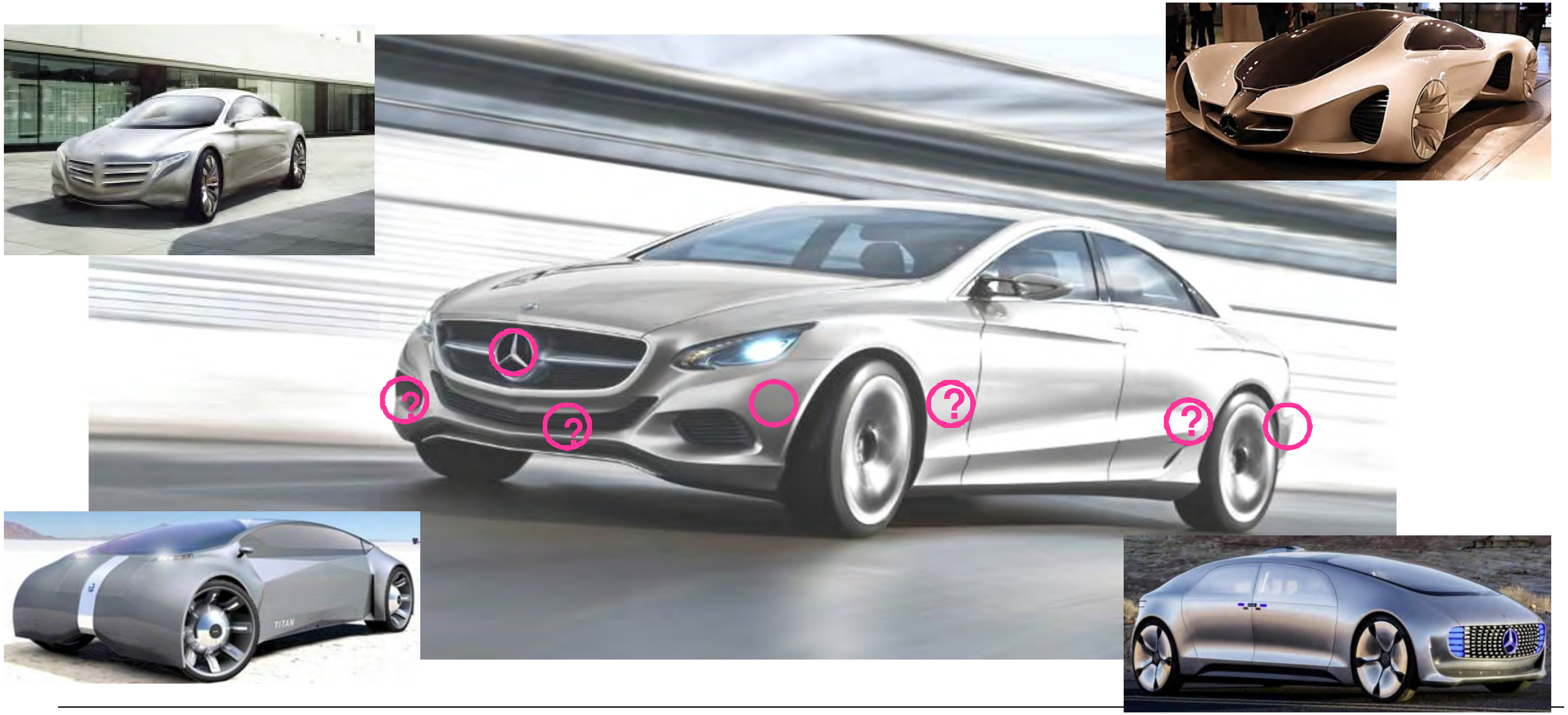


Following a lane with only occasional driver input
Changing lanes at the push of the indicator lever

Industrialization Challenges

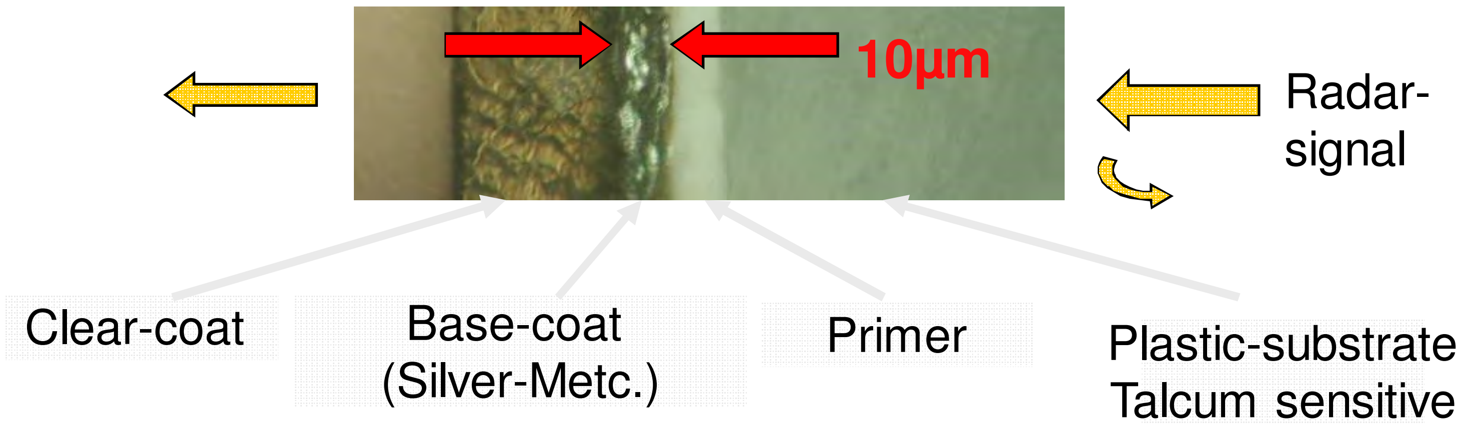
Radar enables Style Icon like designs

Hence, Radar vehicle-integration is science for sake of artworks



Typical construction of a bumper

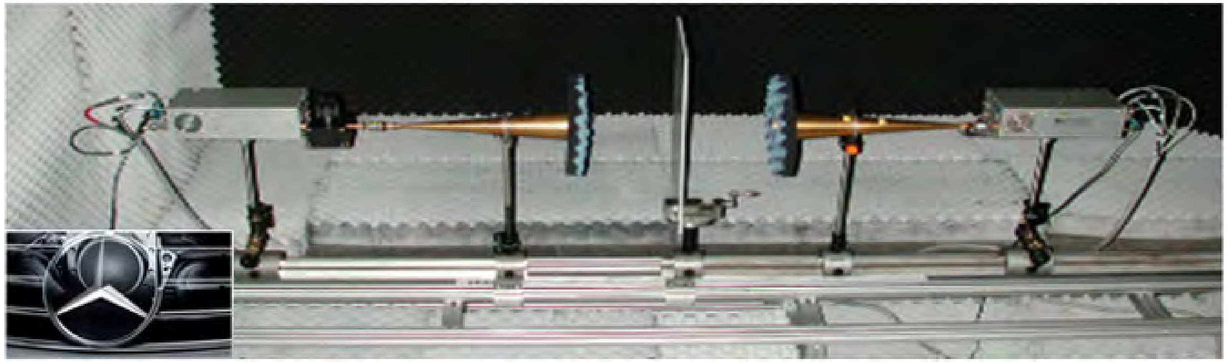
Cross-section of a standard multi-layer painting structure

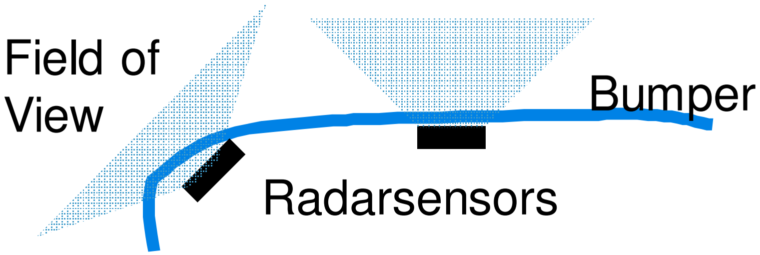


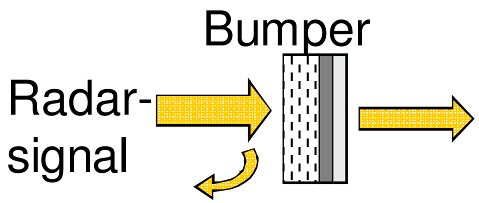
For each layer we need the characteristic RF-parameters:

- Thickness
- Permittivity ε_R
- Dielectric loss angle $\tan(\delta)$

Radar- und Microwave-Measurement set-up







Drvless Challenges to Perception

Urban City - Next Radar Challenge

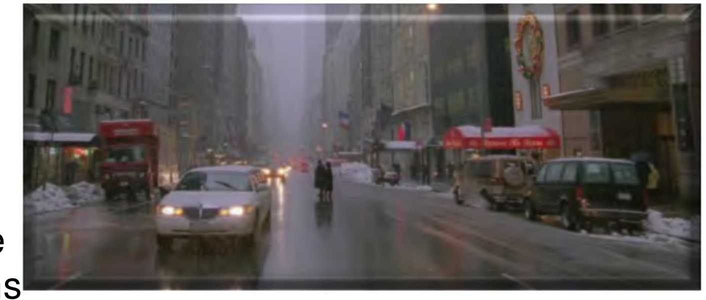
See also: https://www.researchgate.net/profile/Juergen_Dickmann

Traffic Challenges

Complecxity, sudden appearance and diversity of Urban Scenarios

Large area crossings
Crossing traffic

Non cooperative
weather conditions



Unpredictable, surprising
obstacle positions and
object movement

Manifold object types
Hooded or partly
covered objects

The Automation Dilemma

Wish for dissipation, relaxing and opportunity of parallel activities

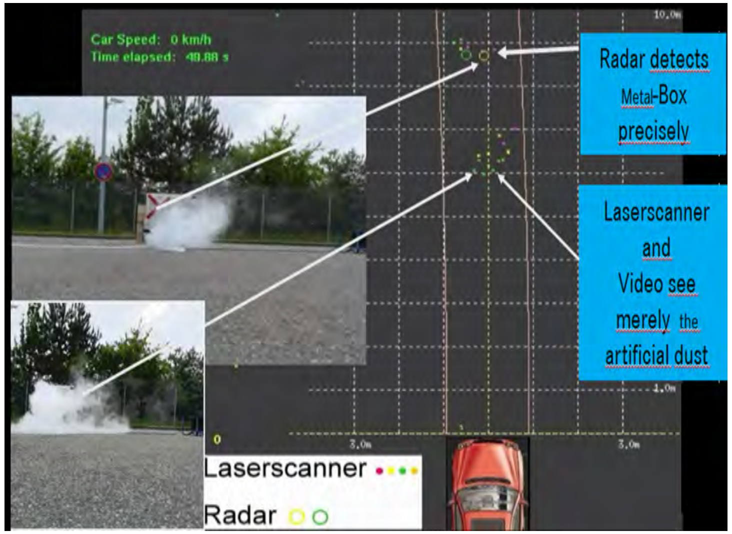
Expected extremely high safety level to autonomous systems

Present automatisation practice	Future autmatization expectation
Accidents cased by limitations of human driver	Humans perform more right than wrong if driving
Reduce some accidents caused by human drivers	Additional task: Automating tasks that humans do right
Know your neighbour	Know your neighbourhood
Know the relevant object	Know what is what Motion Prediction as future estimate

Radar Perception Paradigm

Radar perception paradigm

Transvision-Use the physical nature of mmWaves



You can only react on

what

You can see

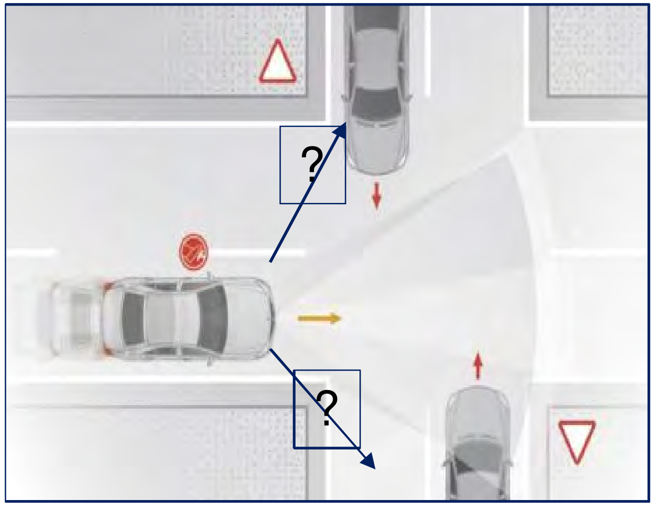
and what

You can properly

assess

Radar perception paradigm

Full 360° FoV coverage and global representation



You can only react on

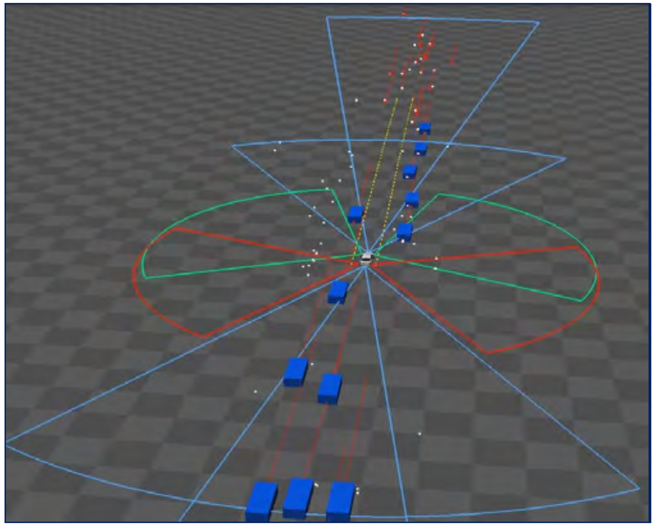
what

You can see

and what

You can properly

assess



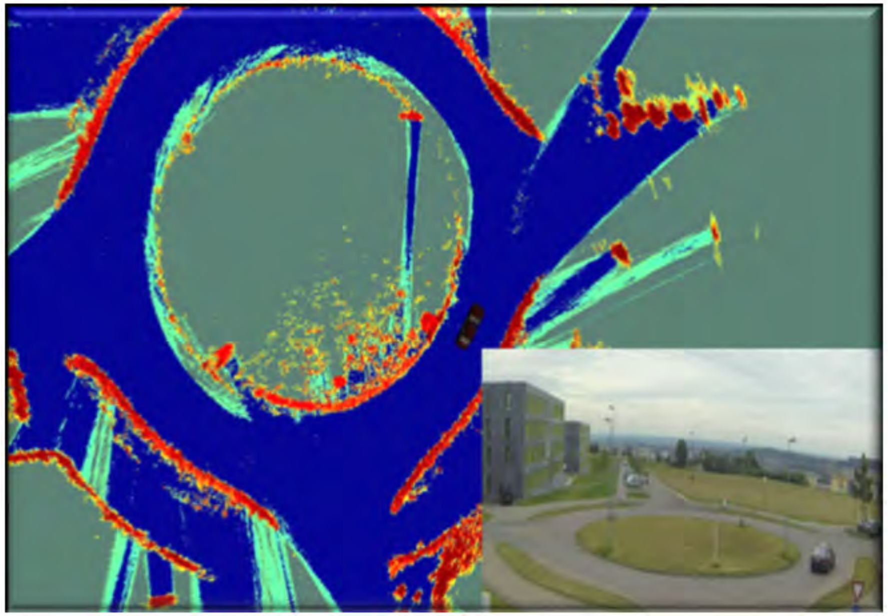
Radar development directions

Radar paradigm

Use ultra high resolution in space and time

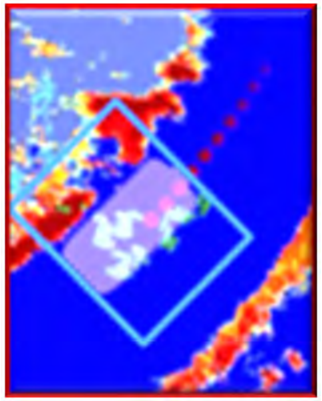
Represent and classify dynamic objects comprehensively

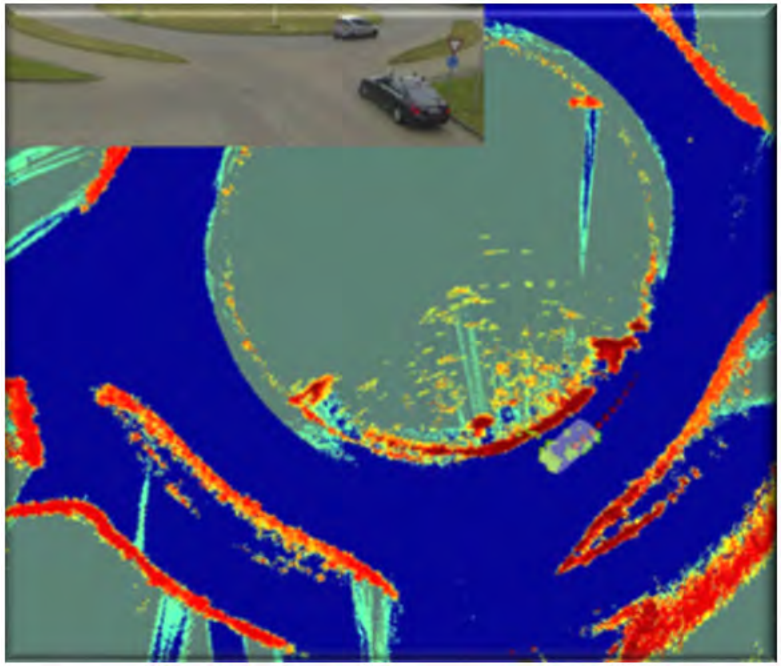
Radar perception plan



Represent the static world comprehensively

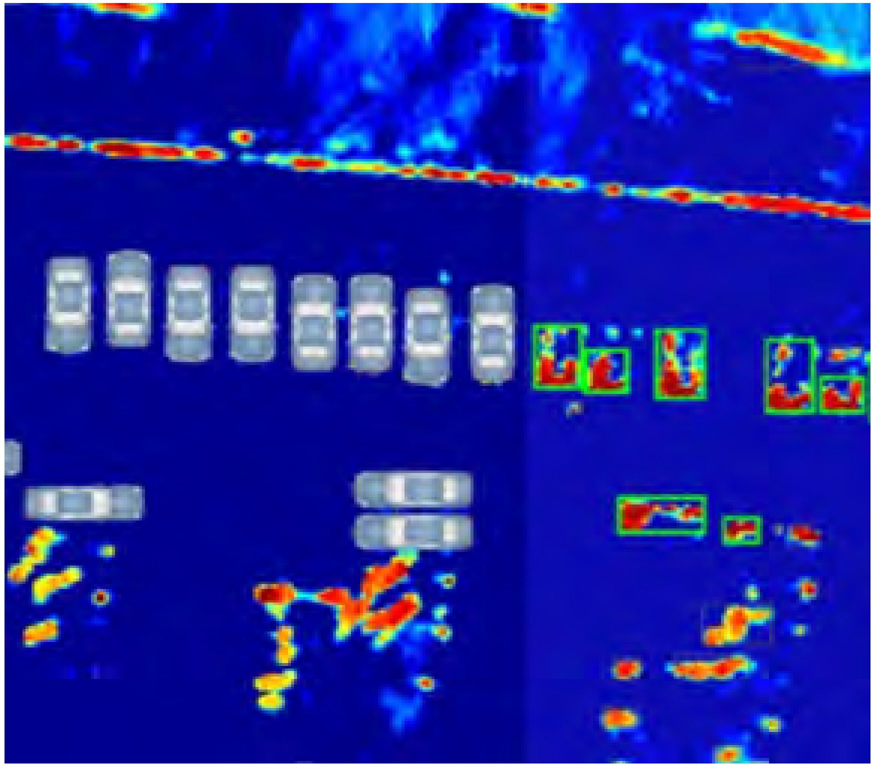
Radar-perception plan





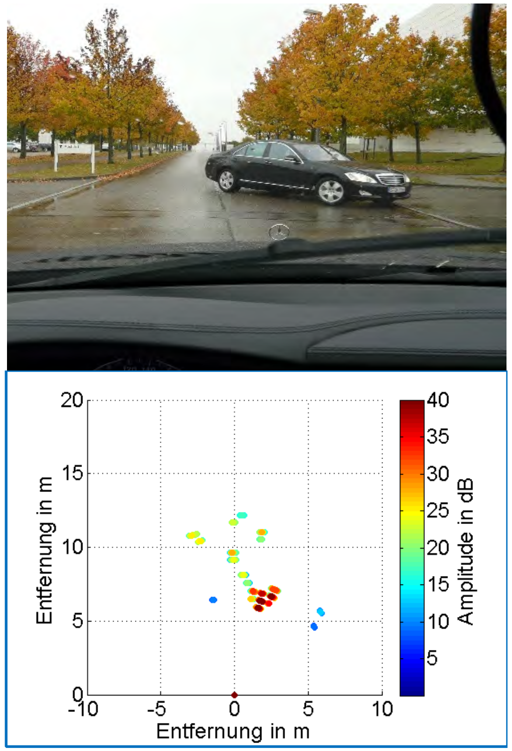
Bring both worlds into context to each other

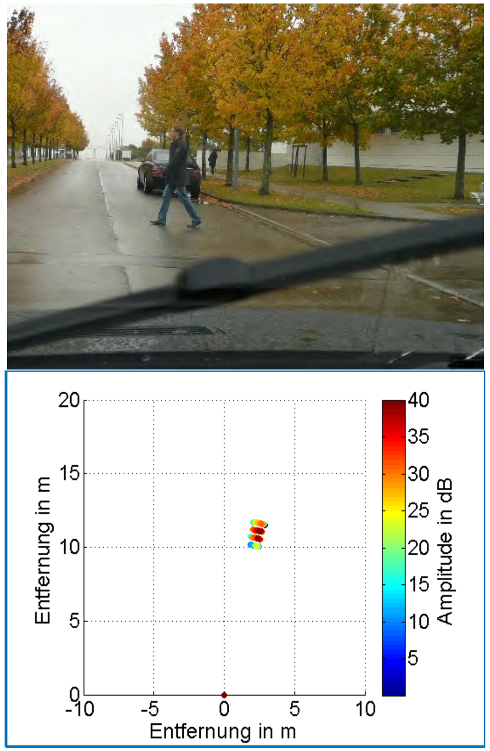
Radar paradigm
Adopt machine learning and AI to radar

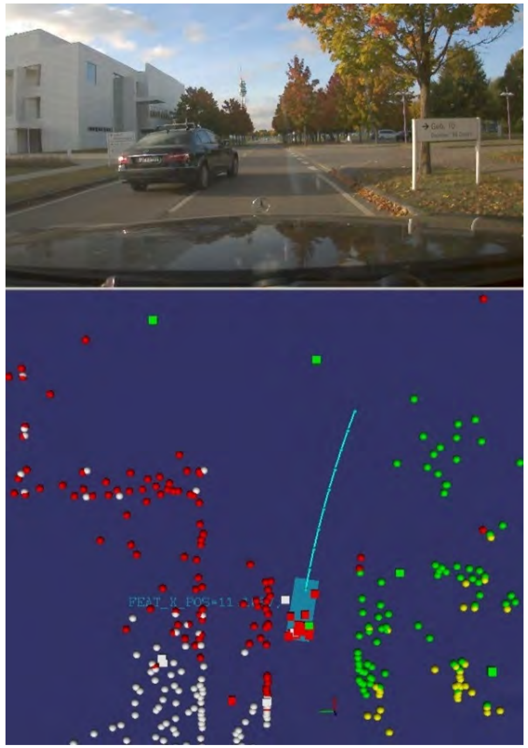


Achievements on our way

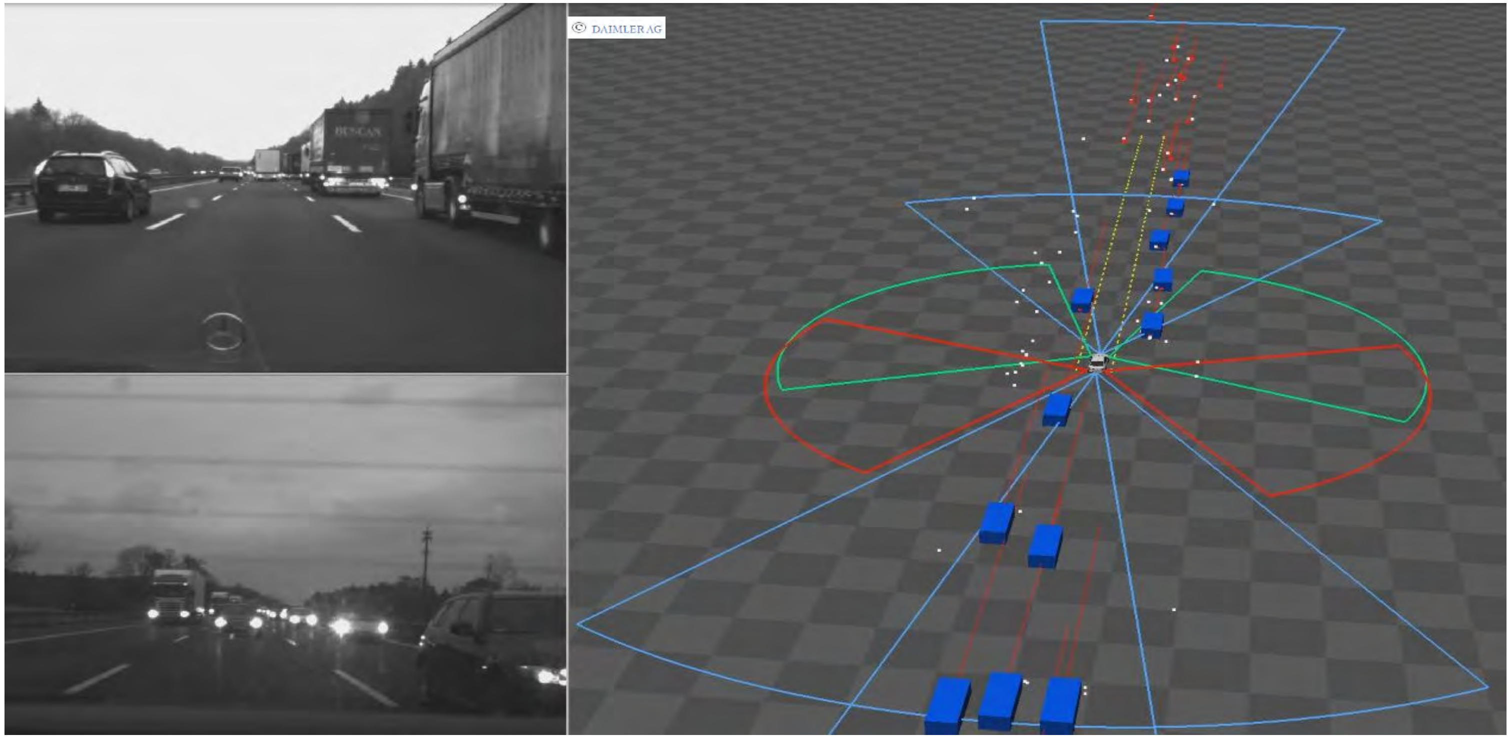
High resolution Radar



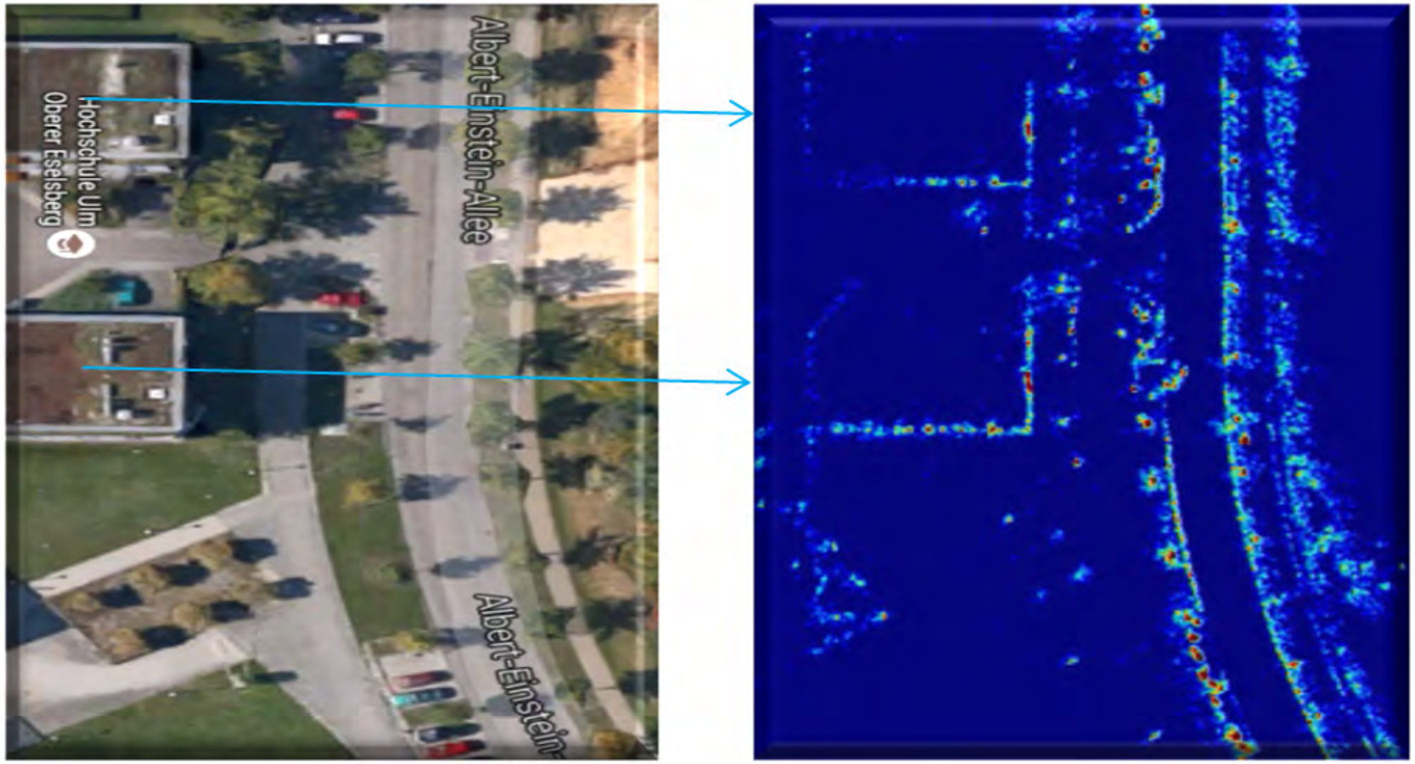




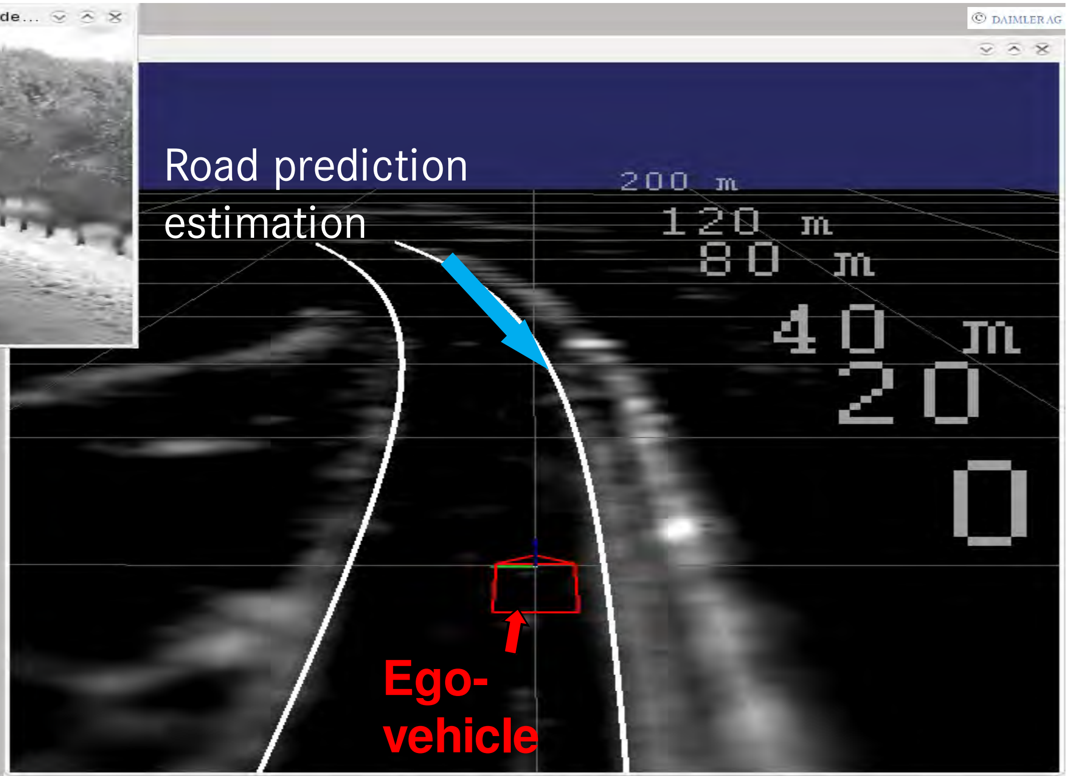
360° Global Object Map



Occupancy and other Radar-Grid Maps



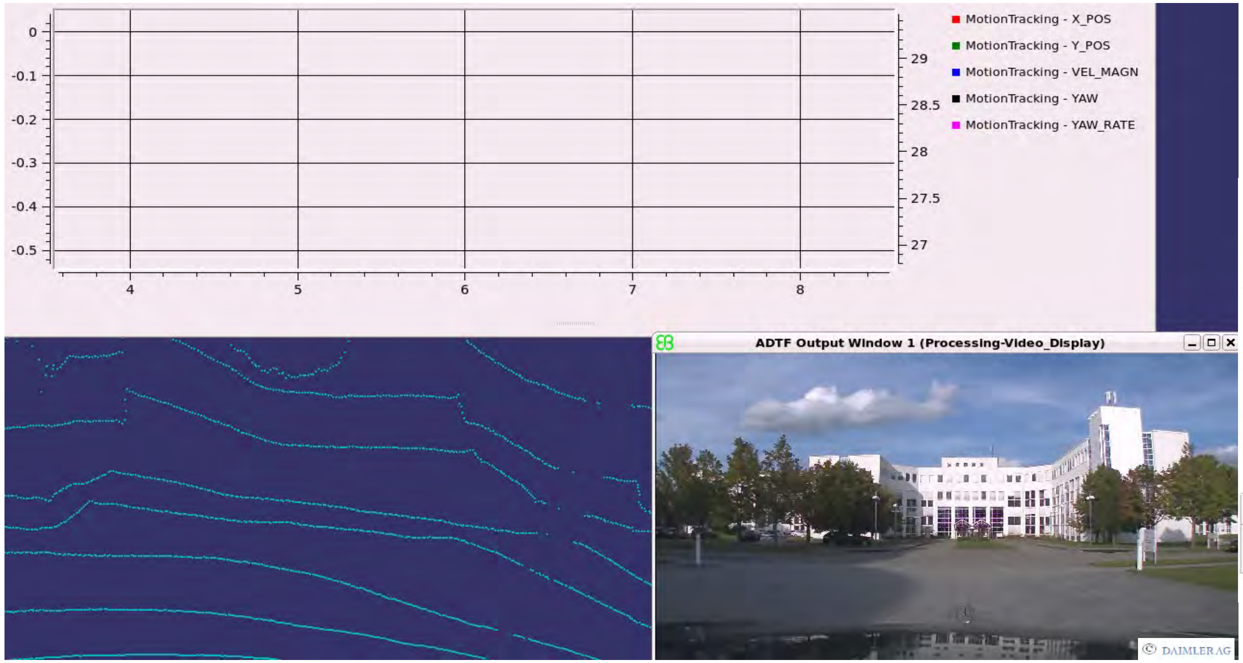
High Definition Radar enables all weather capability

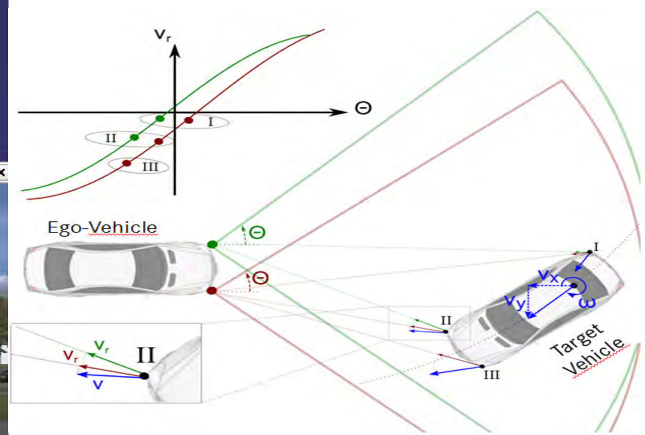


Far Range
Track prediction
also in snow
(with white
lane markings in
white snow ☺)

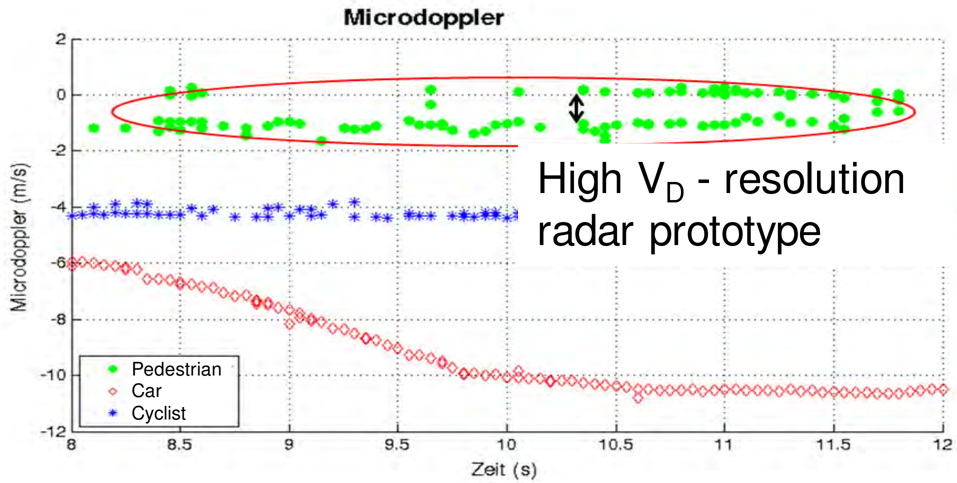
Instantenous motion prediction

azimuthal doppler distribution



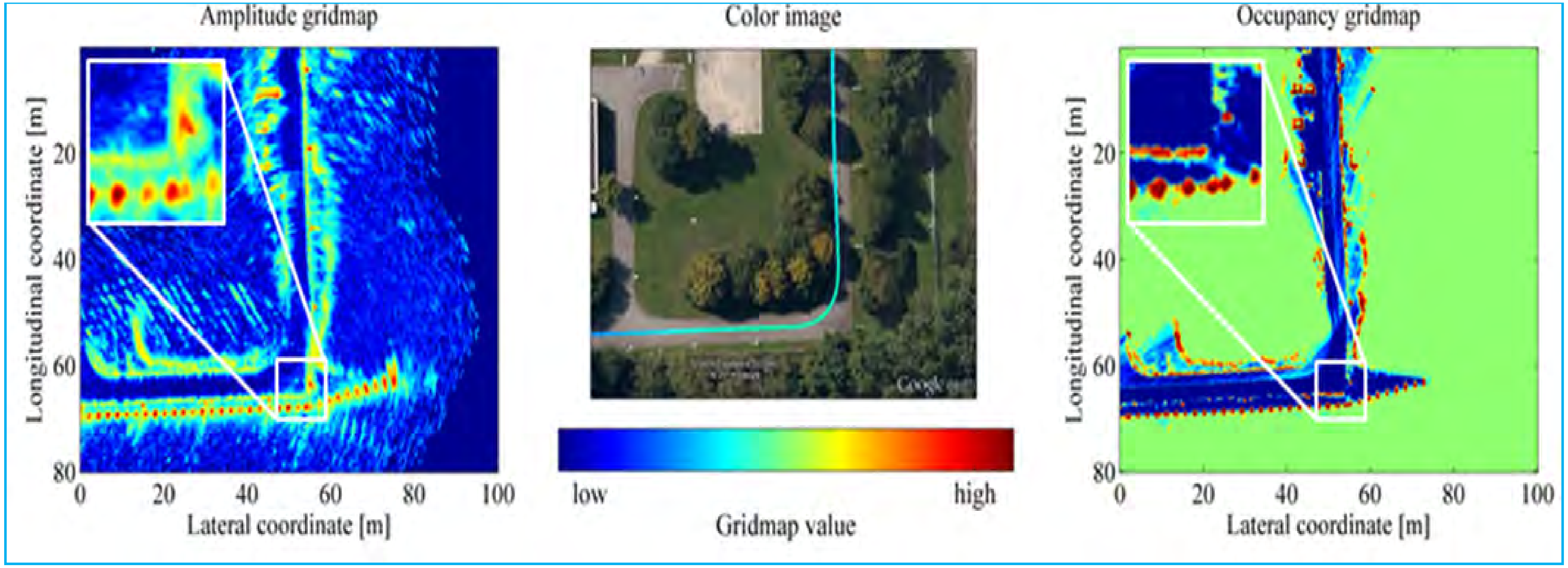


High Definition Radar perception and classification for moving objects

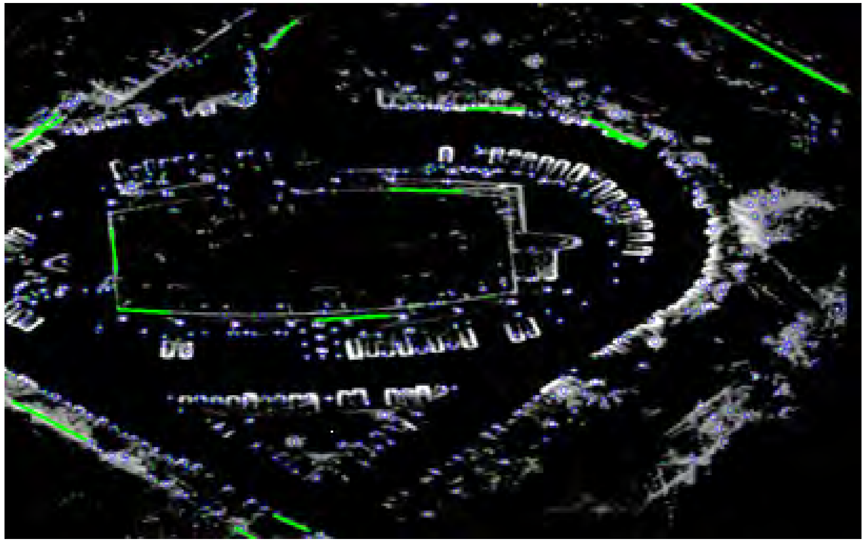


Localization support from Radar

CRR: Characteristic-Radar-Regions



Localization: Radar may help with landmarks

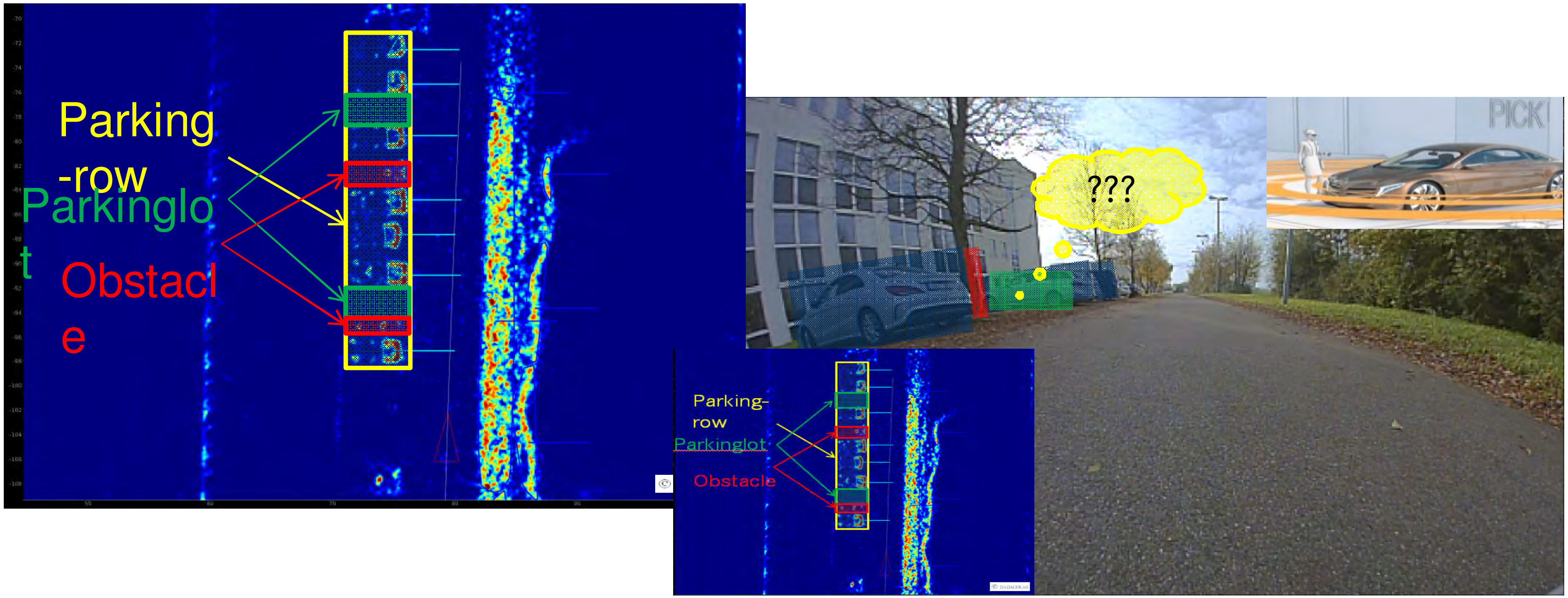


DGPS
Particle-Filter-Result
CRR-Points, CRR-Lines

Simultaniously representation of static and dynamic world

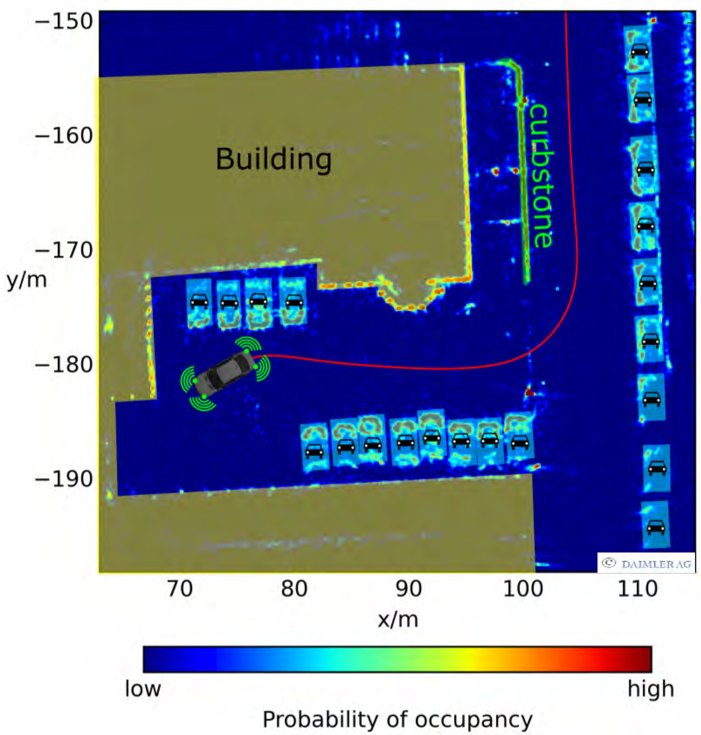
Interpretation of the environment

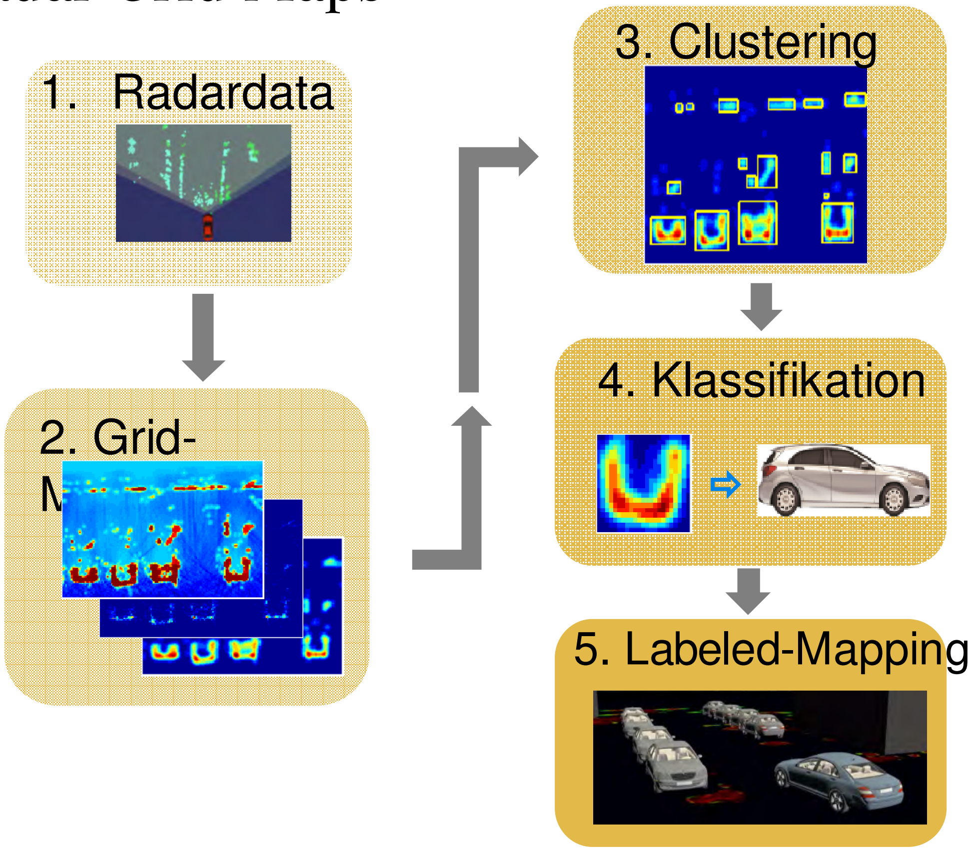
Machine learning helps



Automotive Radar Future

Deep Learning for Cognitive Radar Grid-Maps

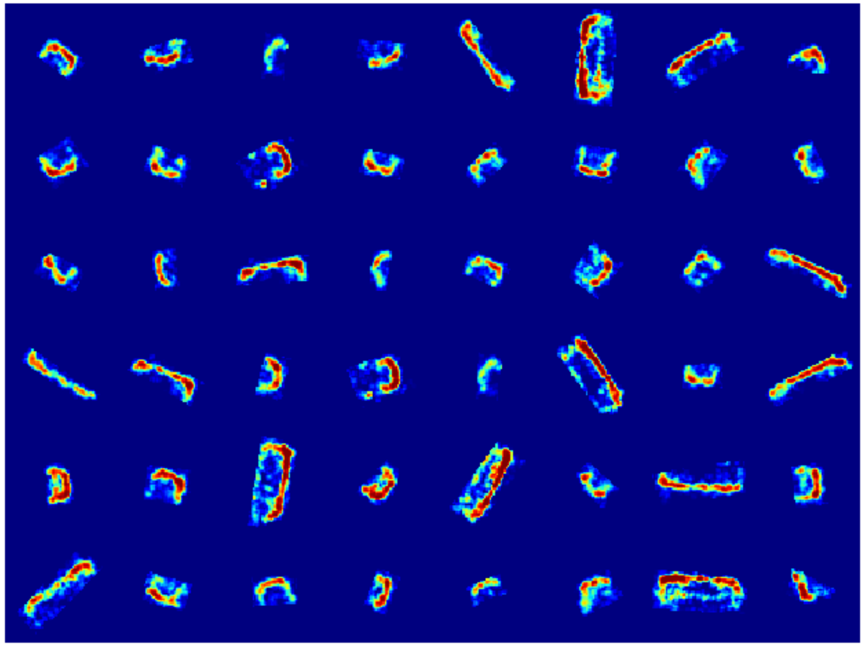




Classification (connected components) in Radargrids as input in CNN

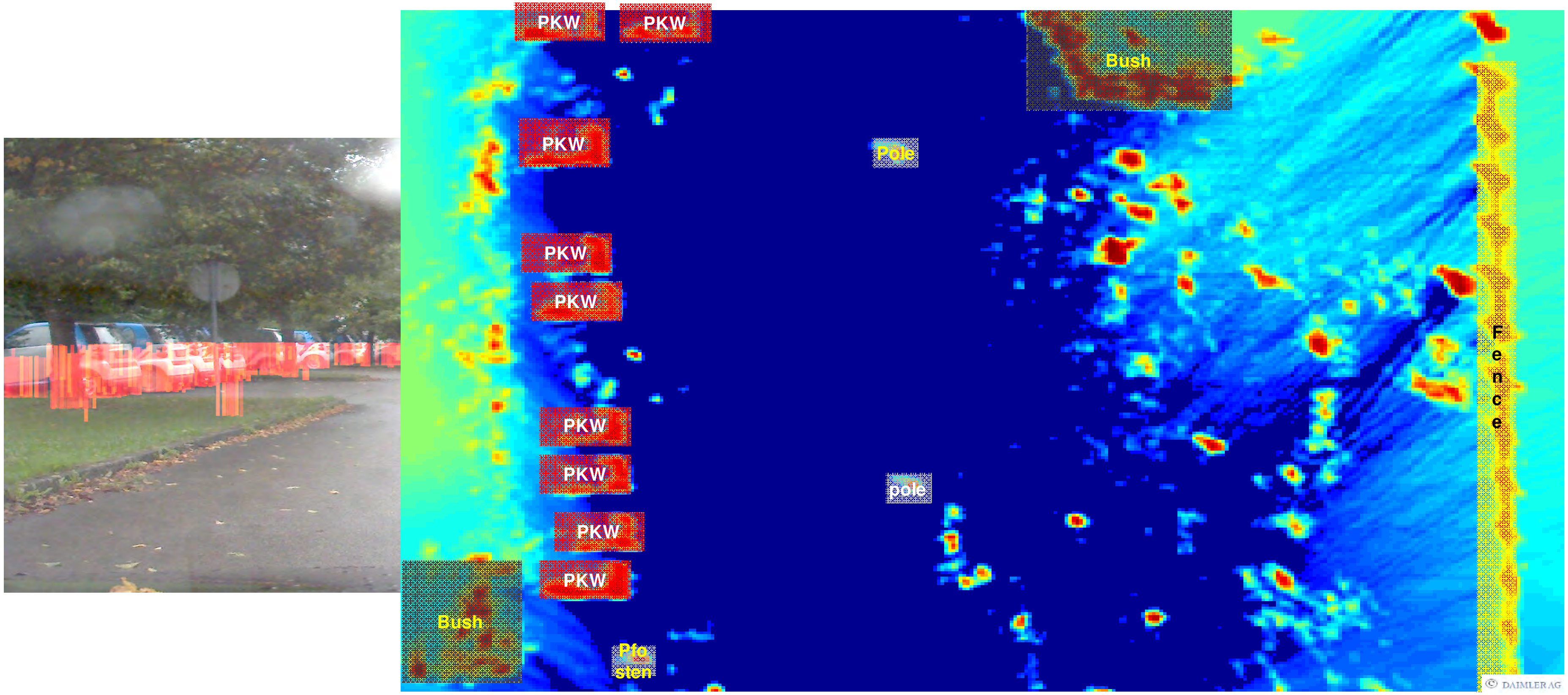
	Classified as vehicle	Classified as non-vehicle
True vehicle	94.2% ±0.3%	5.1% ±0.2%
True non-vehicle	1.4% ±0.5%	98.6% ±0.7%

A lot of staff to do…

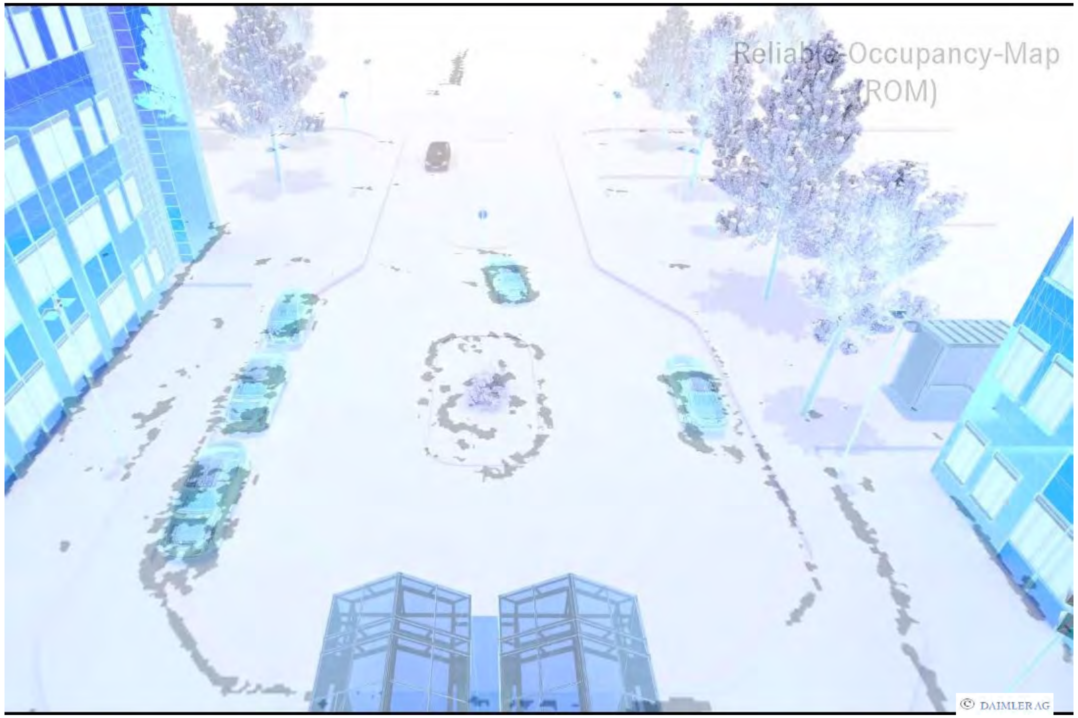


car

Deep Learning for Cognitive Radar Grid-Maps



Localisation with Radars (SLAM) and understand your detections




THx, Questions?