Semiconductor enabling a connected and automated car

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4 megatrends are shaping Automotive market significantly increase of semiconductor content of vehicles

ADAS/Autonomous driving

- From ADAS to semi-automated and finally autonomous driving
- Every world region is striving for "0-accident"

xEV/eMobility

- Mandated CO_2 reductions make electrification of powertrain inevitable

Advanced security

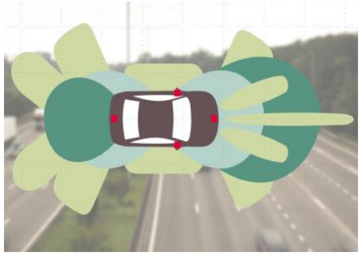
- Increased connectivity and software content increase risk exposure to hackers
- Internal/external connectivity must be secured

Connectivity

- Advanced connectivity is driven by making the car part of the Internet
- The car will be fully connected (V2I, V2V, in-vehicle)

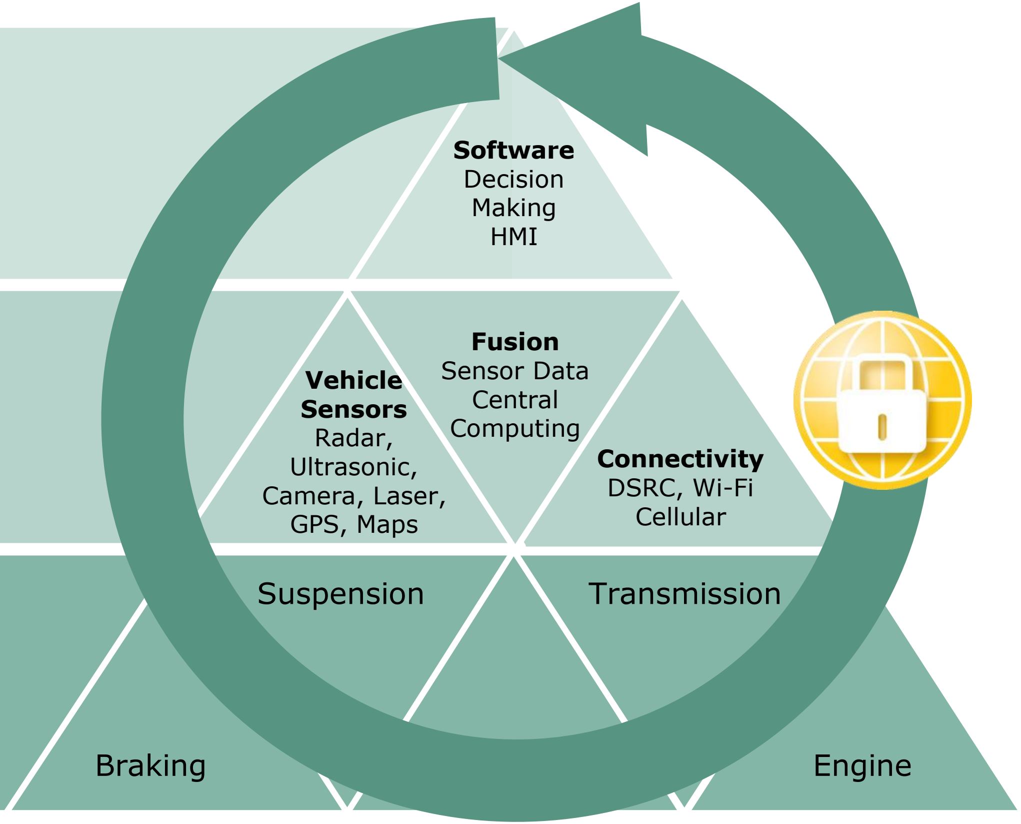
Building blocks of automated driving: Cooperation of multiple system and disciplines is key

Data processing
and decision making

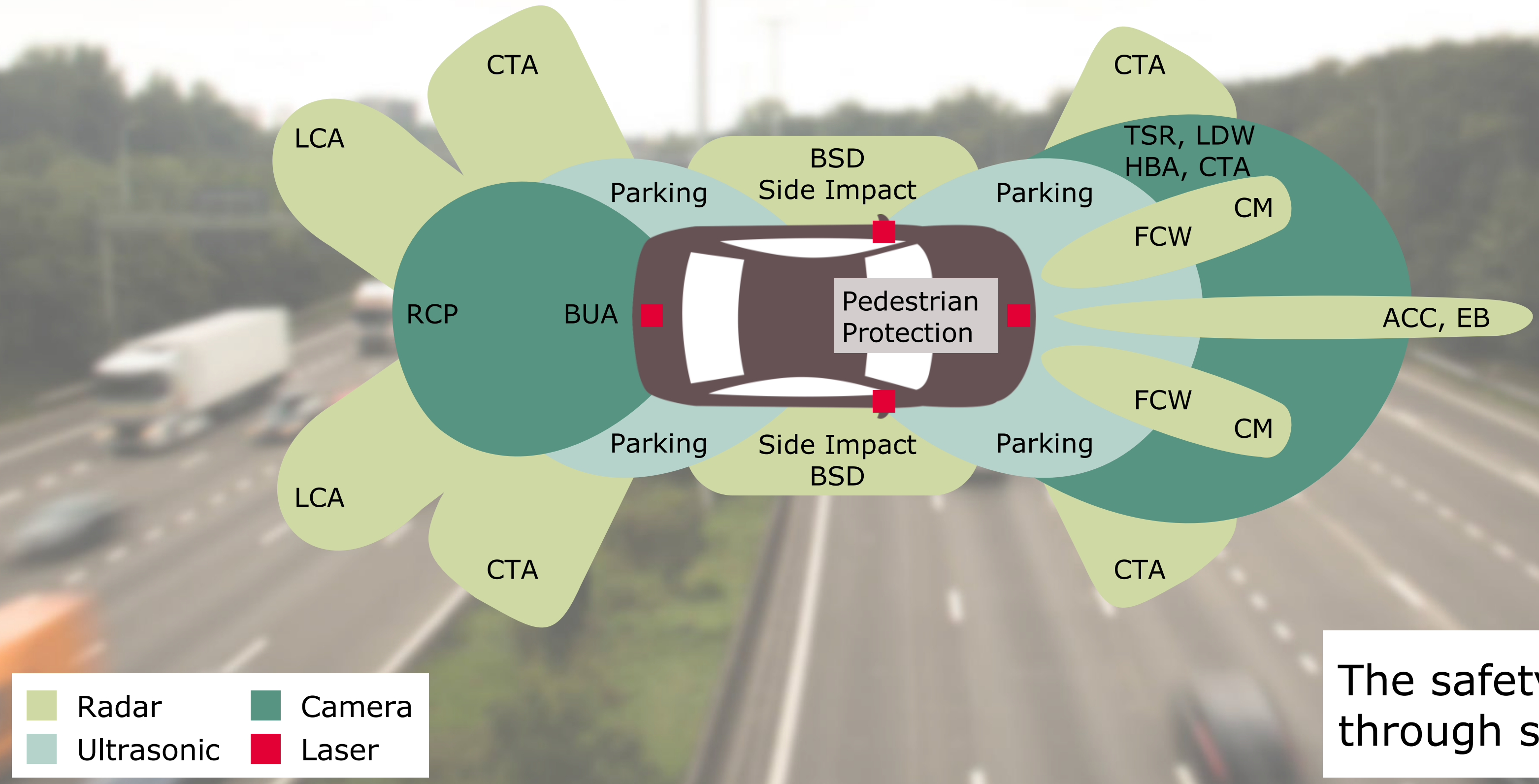


Sensing

Vehicle dynamics
and control

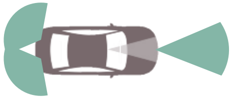
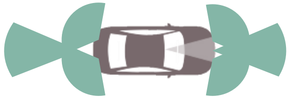
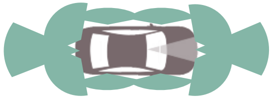
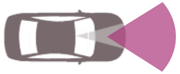
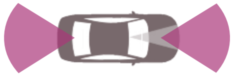
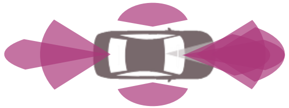


Driver's senses will be replaced by a cocoon of sensors in various technologies



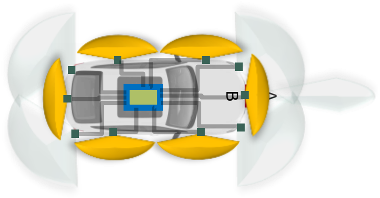
The safety cocoon through sensors

Any next automation level requires more sensors and thus higher level integration → Higher level of simulation/training

	Level of automation		
	Level 2	Level 3	Level 4/5
Application*	Parking assist		Valet Parking
	Highway & Traffic Jam Assist	Highway pilot	Urban pilot / Robot Taxi
Radar # of modules**	 ≥ 3	 ≥ 6	 ≥ 10
Camera # of modules**	 ≥ 1	 ≥ 2	 ≥ 8
Lidar # of modules**	 0	 ≤ 1	 ≥ 1
Others	Ultrasonic	Ultrasonic Interior camera	Ultrasonic Interior camera V2X***

* Source: VDA (German Association of the Automotive Industry), Society of Automotive Engineers
** Market assumption; *** See glossary

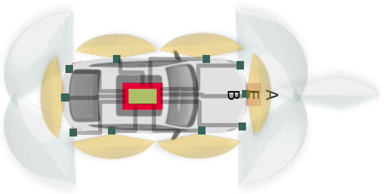
360° Radar requires a new type of sensor, bus- and processing-architecture



More radars in the car in area with less space and worse thermal condition

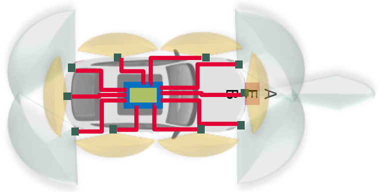
→ **Small sensors**

→ **Low power consumption**



Sensor fusion needed to get best performance in dense urban situation

→ More (raw) data from sensors required in central fusion box → **higher data rates**

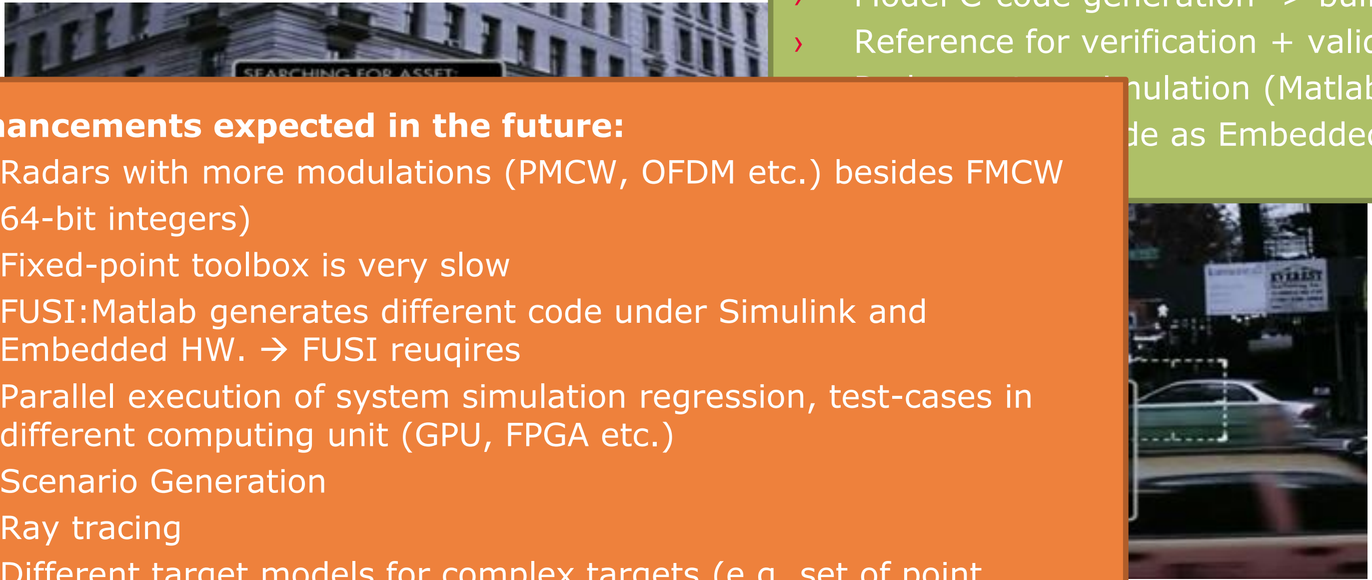


More sensors in the car lead to higher wiring effort

→ **Cost efficient architecture** and **inexpensive wiring** (un-shielded twisted pair)

Small-form-factor of multiple near-range radar-sensors are the important enablers for autonomous cars

Complextiy is increasing and new methologies are needed
Simulate and ,dirve in the computer is the only chance

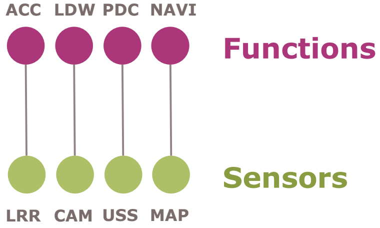


Current UtilizationSimulink/Matlab:
- Functional Modelling for HW accelerator IP development
- Model C-code generation -> built as MEX
- Reference for verification + validation
- nulation (Matlab & MEX)
- de as Embedded SW

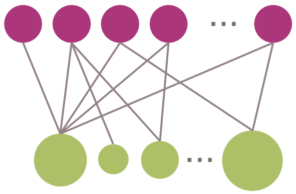
Enhancements expected in the future:
- Radars with more modulations (PMCW, OFDM etc.) besides FMCW
- 64-bit integers)
- Fixed-point toolbox is very slow
- FUSI:Matlab generates different code under Simulink and Embedded HW. → FUSI reuqires
- Parallel execution of system simulation regression, test-cases in different computing unit (GPU, FPGA etc.)
- Scenario Generation
- Ray tracing
- Different target models for complex targets (e.g. set of point targets for car/pedestrian/infrastructure objects)
- Sensor Fusion: multiple sensors on ego-vehicle as well as on multiple vehicles in the environment

Sensor network and V2X data volumes require more computing performance and new domain architecture

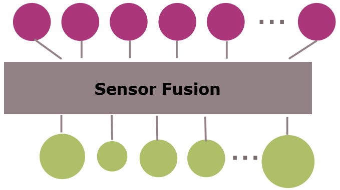
TODAY



- ECU functional integration
- Sense-compute-function per ECU



- Sharing of sensor data across car architecture
- Fusion of data in different ECUs



- Secure domain- and fusion-ECUs
- Local signal (pre-) processing

2025+

New technologies/sensors

- Lidar, sensor networks
- High-resolution maps
- Car-to-X connectivity

New computing architecture

- GPU architecture
- New SW architecture, e.g. Hypervisor
- Integrated security architecture

New business models

- SOTA updates and new applications
- Big data
- New insurance models

Introduction of central computers triggers demand for high-performance, fail operational microcontrollers (MCUs)

decision making

L0 / L1 / L2 vehicles

human acts

L3 / L4 / L5 vehicles

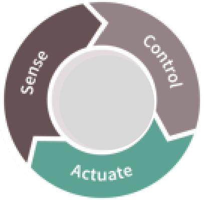
camera → radar → lidar → GPS → central computer: CPU / GPU + MCU (AURIX™)

central computer triggers car operations

basic car functions

classic ECU

- temperature
- pressure
- position
- speed



- MOSFETs
- IGBTs
- power ICs

- MCUs, e.g. AURIX™

future ECU = classic ECU

+ higher performance
+ fail operational
+ secure

fail operational systems require redundancy in

- power switches, power supply
- sensors
- MCUs

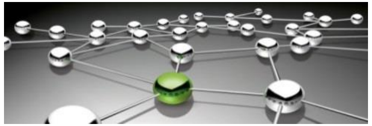
car security is achieved through

- discrete security controller (OPTIGA™)
- integrated security modules in MCUs (AURIX™)

From ECU to domain architecture: Secure µC from Infineon offer the required safety and necessary scalability

Sensor fusion

AURIX™ as main or host controller

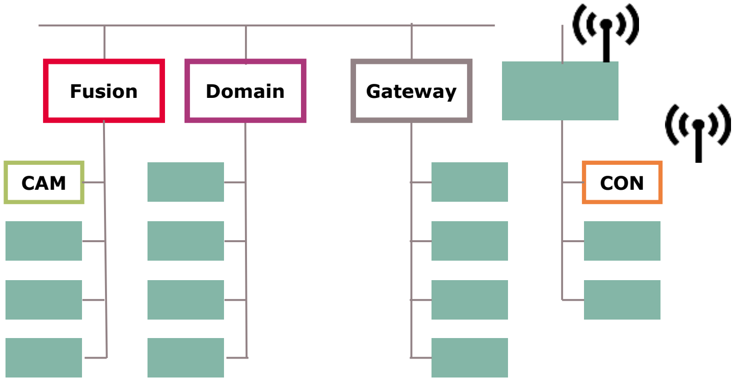


Radar & camera

AURIX™ as main* or host controller

Domain control

AURIX™ as hard-realtime main processor



Safety Security Automotive quality

Connectivity gateway

AURIX™ as hard-real time main controller

Always-on connectivity

AURIX™ as host controller

*for radar

AURIX™ microcontroller complements CPU/GPU to make the central computer robust and fail operational

Examples of central computing platforms

Functionality

- Data processing for applications (e.g. parking)
- Fusion of object data, deep learning algorithms
- Environmental model calculation (road, objects)
- Trajectory planning
- Modelling of driver behaviour

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NVIDIA

DRIVE™ PX 2

❷

INTEL® GO™
DEVELOPMENT PLATFORM FOR AUTOMATED DRIVING

AURIX™ as real-time main controller or host controller

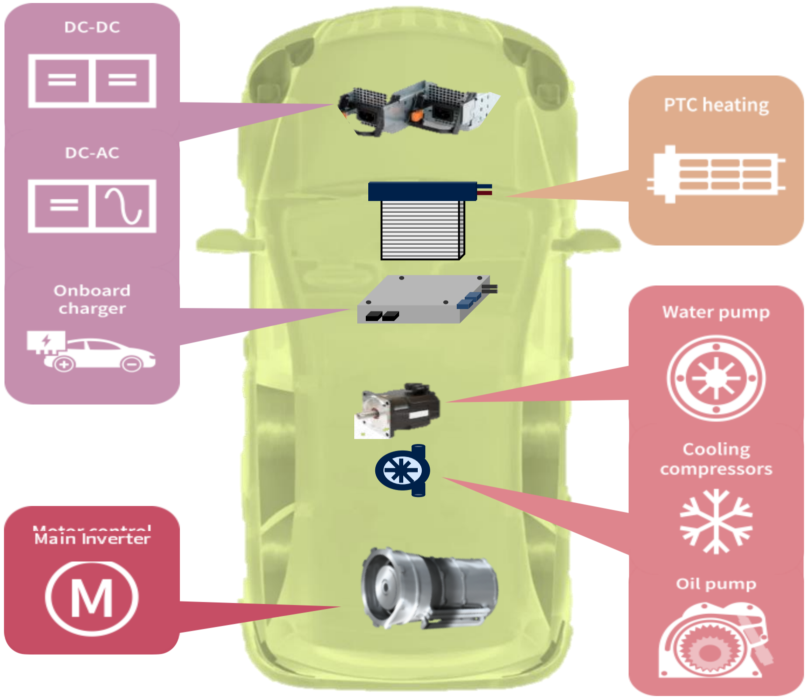
- ISO 26262 ASIL-D safety host monitoring operation of the data fusion ECU
- Safe and secure gateway to the vehicle network
- Fallback operation in case of a GPU/CPU fail
- Safe communication to actuator control units

Cooperation is needed to combine automotive world with high performance computing

Pictures: Courtesy of Nvidia, Intel

Infineon addresses a wide range of xEV components – from Main Inverter to Auxiliaries

Key Components of Electric Vehicles



Categorization of Key Components

Category	Component	Power [kW]
Main Inverter	Main Inverter	30 – 400
Power Supply	OBC	1.5 – 6.6
Power Supply	DC-DC	1.5 – 2.5
Heater	PTC Heater	2 – 5
Motor Drives	Compressor	1.5 – 5
Motor Drives	Water Pump	0.2 – 1
Motor Drives	Oil Pump	0.2 – 1

OBC = On-Board-Charger

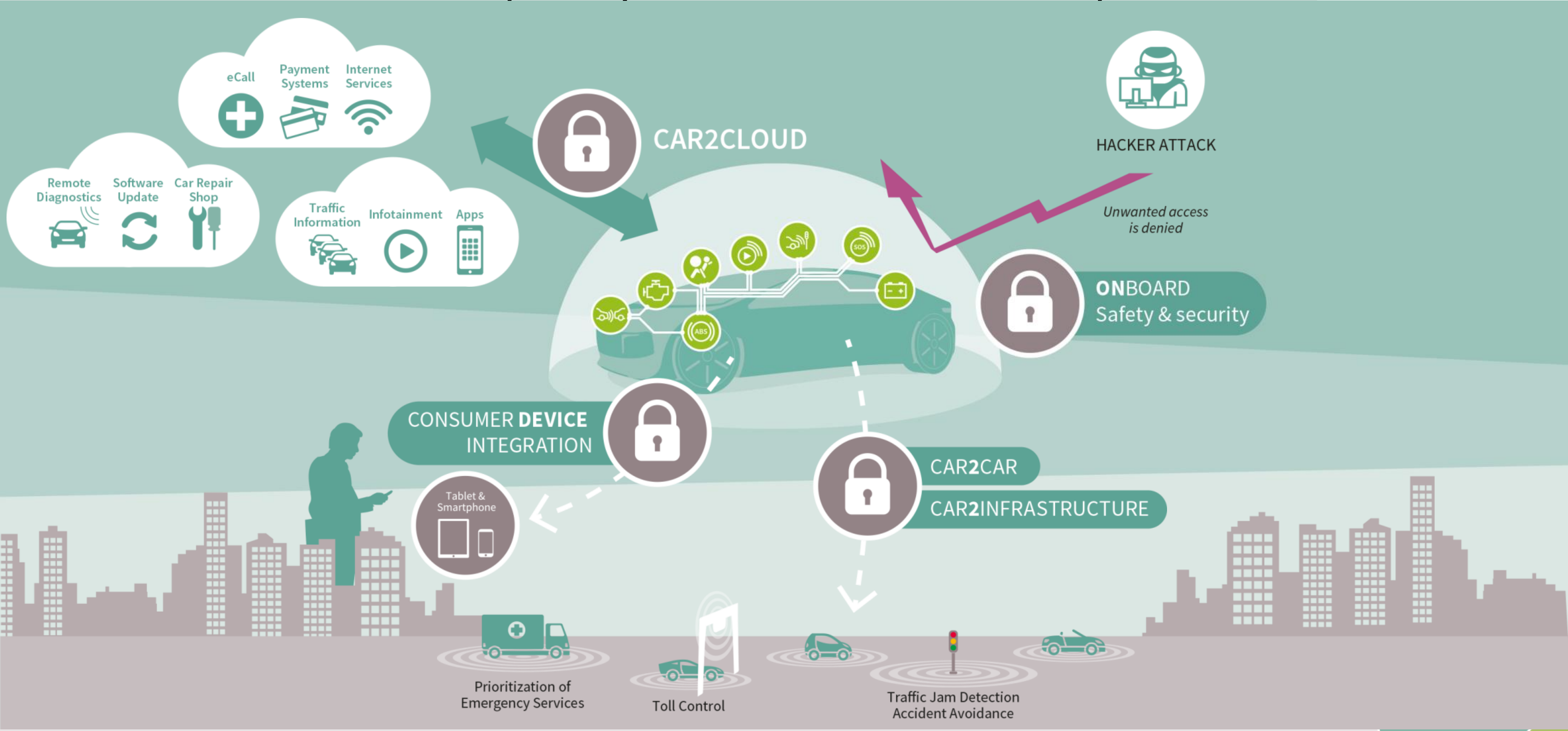
A comprehensive product portfolio requires a advanced simulations & design environment for xEV applications

Current UtilizationSimulink/Matlab:
- Functional Modelling for HW accelerator IP development
- as MEX
- tion
- & MEX)
- SW

Use Case today and in the future:
- Optimization of power converters (specially SMPS) simulation
- Simulation deployment on FPGA based platforms (including Speedgoat and dSpace)
- First proof of concept done with MathWorks‵ AE support (improvement of factor x3)
- Closed loop simulation for verification control algorithm and power electronics
- First proof on concept with translation of Spice models to MathWorks
- Multi-domain simulation and Analog-Mixed signal simulations
- Hydraulic/Mechanical/Electrical block modeling (e.g. transmissions)
- IDE with workflow that supports FS (ISO26262)
- Automated code generation for uC and Control algorithm analysis

Expectation and Improvements which helps in NEW designs:
- Real-time (or near to real-time) simulation speed
- HDL coder support for physical modeling tools
- Interface between IFXspice (Titan) and MathWorks toolboxes
- Tool for FS analysis (like Medini form ANSYS)
- Multi-core support

The connected car offers many use cases for our customer. Move from closed to open system introduces multiple risks



Security is not just one more feature in the modern car
Safety and Security are intrinsically linked

Danger of unintentional errors disrupting the safe operation of the vehicle

Safety

“It must not happen”

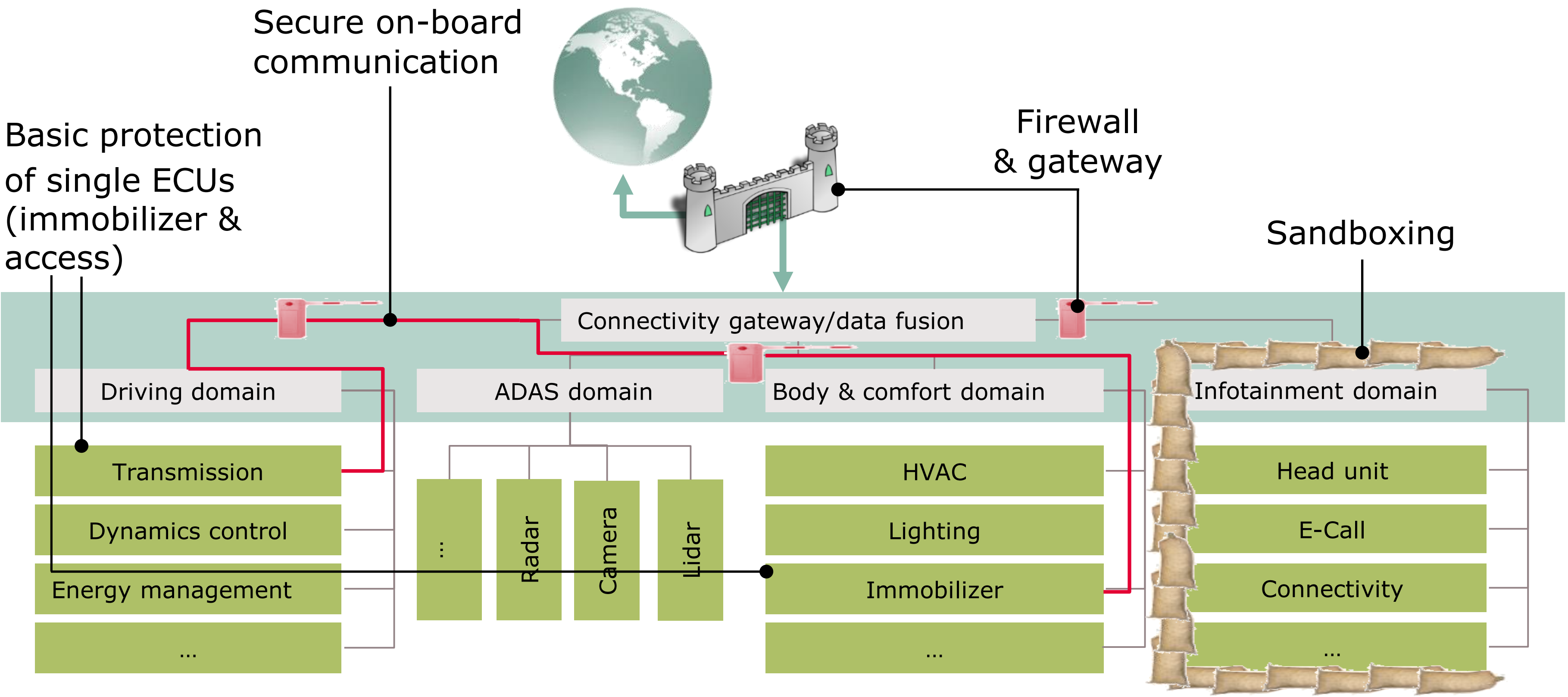
Intentional attacks on systems and software

Security

“It must not pay off”

A safety or security breach could result in the same consequence:
Threat to life and limb

A single firewall will not be enough! Various security tools have to be added on the way to a secure architecture



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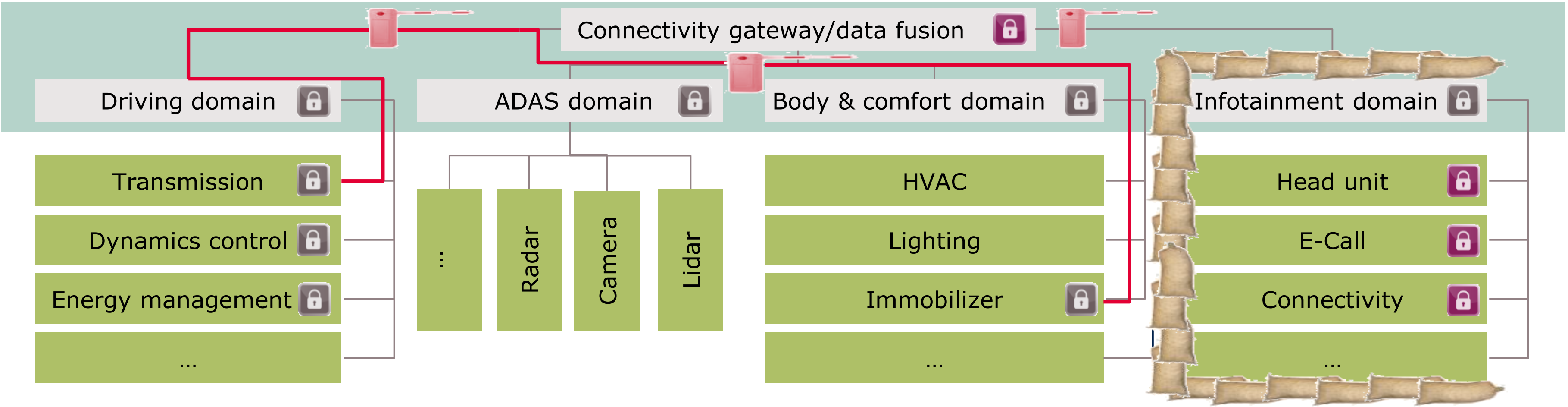

Trust anchors

Protected execution environments hosting

- Key storage and related cryptographic operation
- Security applications

Integrated on MCU

- High speed
- Secure onboard communication
- Logical security

Discrete security controller

- External communication
- Protecting high value
- By certified hardware security

Enabling the root of trust for internal and external communication

Semiconductors enable the future of driving: More safety, more comfort, less pollution

- Semiconductors enable ~80% of innovation in automotive
- Autonomous driving will increase safety and comfort, but also support CO_2 reduction
- A secure system architecture combined with hardware security will provide the appropriate level of protection
- SIMULATION is key to shorten time to market and reliable system

Part of your life. Part of tomorrow.