Automotive Privacy

MOB2 Guest Lecture at Goethe University Frankfurt

Sarah Syed-Winkler | 24 June 2025

About me

Sarah Syed-Winkler

Manager Security & Privacy
Research & Innovation

July 2013

Education

- PhD-Candidate at Darmstadt University of Applied Science (2025)
- Masters in Applied IT-Security at Ruhr-University Bochum (2022)
- Bachelor of Engineering at Baden-Württemberg Cooperative State University (2016)

Roles

- S&P R&I Manager, Senior Expert in Product Privacy Engineering and Technologies

Personal Highlights

- **Over 9 years** of experience in cyber security and privacy
- Pro-actively driving **automotive privacy** topics at Continental to identify, fulfill and be compliant with current and future market requirements
- Known speaker and presenter at various industrial and scientific conferences (VDI, Automotive IQ, and more)
- Several publications on security and privacy topics (ACM-CSCS, ARES, and more)
- Guest lecturer at THM and Goethe University Frankfurt

Agenda

1	Introduction to Continental
2	Automotive Privacy
3	Use Cases and Case Studies
4	Solutions and Technologies
5	Q&A

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1	**Introduction to Continental**
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Continental Group
Our Structure

As of November 2024

Group Sectors	Automotive	Tires	ContiTech
			
Business Areas	› Safety and Motion › Autonomous Mobility › User Experience › Architecture and Network Solutions	› Original Equipment › Replacement APAC › Replacement EMEA › Replacement The Americas › Specialty Tires	› Industrial Solutions Americas › Industrial Solutions APAC › Industrial Solutions EMEA › Original Equipment Solutions › Surface Solutions

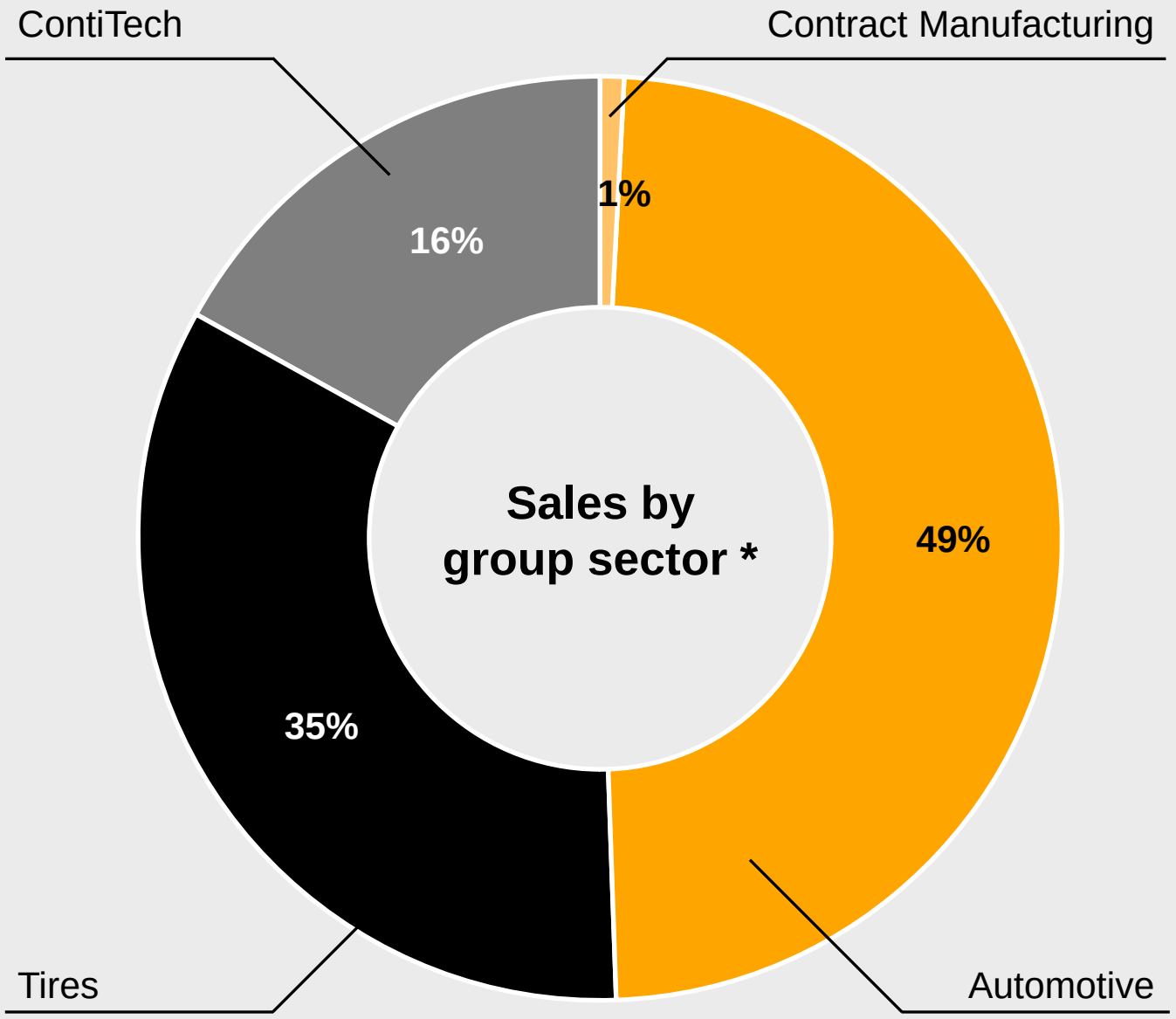
Continental Group
Overview 2024

€ 39.7 billion
sales

~190,000
employees

518 locations
in **55 countries and markets**

As of Dec. 31, 2024
*Values in the diagram may slightly differ from the original data due to rounding




CONTINENTAL AUTOMOTIVE
WE MAKE MOBILITY…
…safe, exciting, connected
and autonomous.

CONTINENTAL AUTOMOTIVE

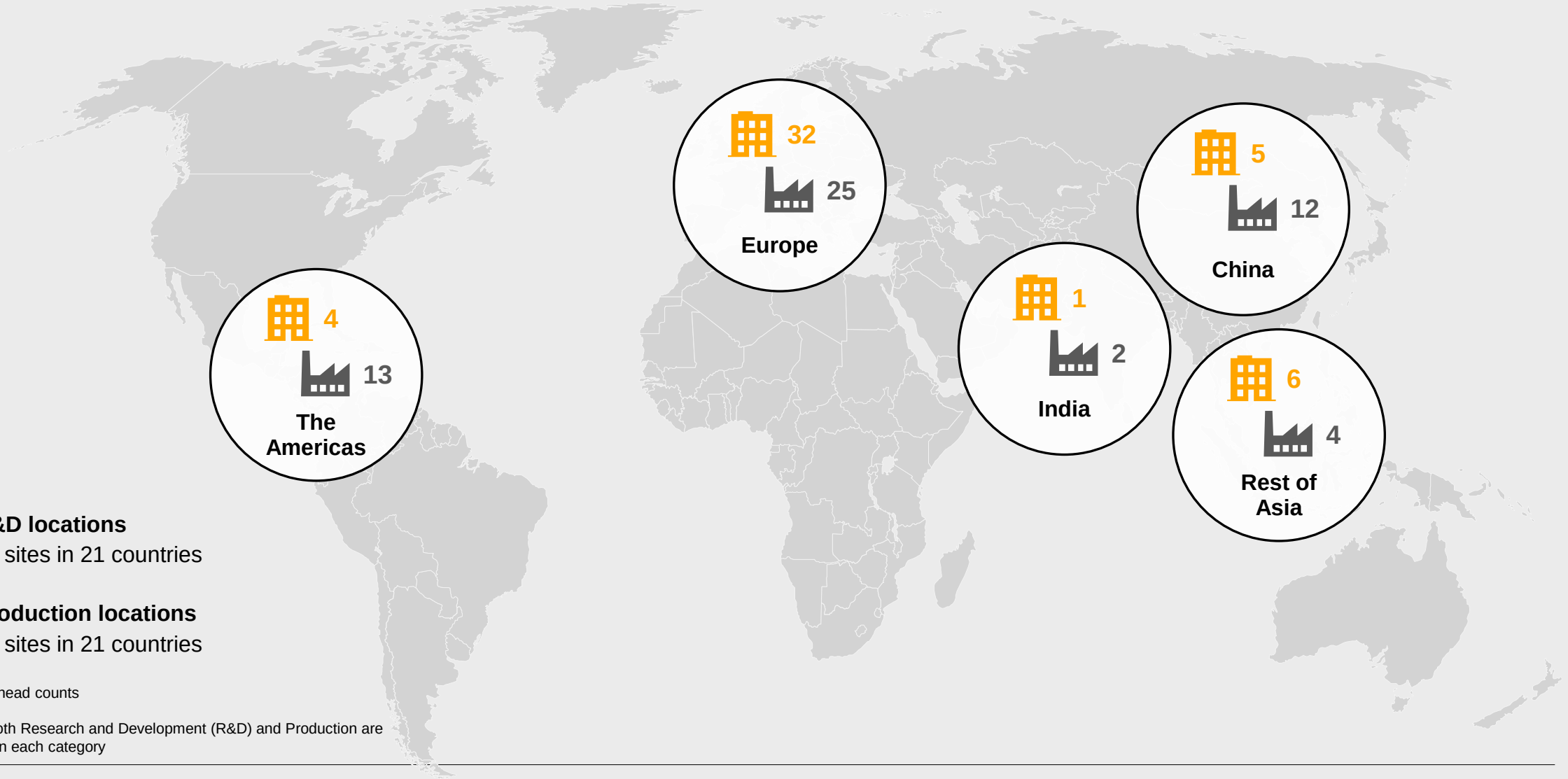
WE *MAKE* MOBILITY…

…safe, exciting, connected and ***autonomous.***

We offer components, functions and solutions that make mobility safer, more exciting, connected and autonomous, by combining highest product performance with sustainability and finally connect all the dots – from the road to the cloud and from virtual to real.

In our business areas and central functions, we work together to develop products for the mobility of today, tomorrow and beyond.

Our R&D and Production Locations



R&D locations
48 sites in 21 countries

Production locations
56 sites in 21 countries

Locations with > 50 head counts

Locations offering both Research and Development (R&D) and Production are counted separately in each category

As of February 2025

Continental Automotive Group Sector

Our Structure

Safety and Motion

Architecture and Network Solutions

Autonomous Mobility

User Experience

Operations and Technology

Continental Automotive Group Sector

Our Product Portfolio

Safety and Motion

- Brake Systems
- Integrated Safety Systems
- Sensor Systems
- Suspension Systems
- Holistic Motion Control
- Aftermarket [3]

Architecture and Network Solutions

- High-Performance Computers & Services & Tools
- Zone Control Units
- Connectivity Solutions incl. Advanced Antenna
- Smart Device Integration
- Access Solutions
- Body & Actuator Controls Electronics
- Pneumatic Seat Systems
- Front & Rear Light Control [2]
- Near Field Projection [2]
- Function as a Product
- Automotive Re-usable Modules [4]
- Build-to-Print
- UX Assets
- Electrical/Electronic (EE) Architecture [4]
- Software & System [4]
- HPC Reference Integration [4]
- Real-time (RT) Operating Systems (OS) [4]
- High-performance Computer (HPC) OS [4]
- Engineering Services

Autonomous Mobility

- Radar
- Camera
- LiDAR
- Ultrasonic Sensor
- Automated Driving (AD) Control Units
- Software as a Product
- ADAS Sensors & Instrumentation [1]
- Control Units & Telematics [1]
- Tachograph & Fleet Management [1]
- Key as a Service [1]

User Experience

- Display Solutions
- Digital Clusters
- Head-up Displays

Operations and Technology

- Research and Advanced Engineering [4]
- Sustainability [4]
- Processes, Methods and Tools (PMT) [4]
- Locations Management [4]
- Continental Engineering Services [4]
- Product Cybersecurity and Privacy Office [4]

[1] former Smart Mobility (SMY) Business Area Commercial and Special Vehicles portfolio [2] former SMY Business Area Light and Actuator solutions portfolio [3] former SMY Business Area Automotive Aftermarket portfolio [4] former Software and Central Technologies portfolio

Next-Gen Mobility

Motivation and Challenges

- Digitalization
- Differentiation
- Sustainability
- Lifestyle
- Reliable & Safe

The vehicle is no longer a closed system but a part of a much bigger ecosystem – the Internet of Things

- Short time to market
- Increasing Complexity
- Lifetime Updates
- Software-defined (Hardware independent)
- Artificial Intelligence

Software-defined Vehicle (SDV)

The Software-defined Vehicle
Redefines the Value of a car

SDV is driven by consumers:

- ✓ **Up to date,** new features, improved performance
- ✓ Ease of use, **exciting experience**, seamless integration to smartphones and cloud services
- ✓ Act in a **secure and sustainable** environment
- ✓ Integrated in the world of information, **IoT** and exchange
- ✓ **Personalization,** seat positions, driving modes, infotainment

And by OEMs:

- ✓ Capture value in **new revenue opportunities**
- ✓ **Faster time to market** to introduce new platforms and architectures
- ✓ Keep **costs under control,** minimizing physical recalls
- ✓ **Manage complexity** and number of variants
- ✓ Improve **diagnosis and repair**
- ✓ **Compliance updates** due to new legislations

The vehicle is no longer a closed system but a part of a much bigger ecosystem – the Internet of Things

Software-defined Vehicle

Characteristics

Characteristics of a Software-defined Vehicle:

Decoupling software from hardware development

Software and hardware evolve independently from each other. Updating software doesn't necessarily mean upgrading hardware – the hardware can remain the same throughout the entire product life cycle.

Deliver new or additional software features

Software-defined Vehicles are providing new functions and services to existing devices as well as easing maintenance.

Software can be reused across devices and vehicles.

Capture value with software solutions

When software updates provide new value cross-domain independent of hardware sales, Software-defined Vehicles can enable the monetization of the software value.

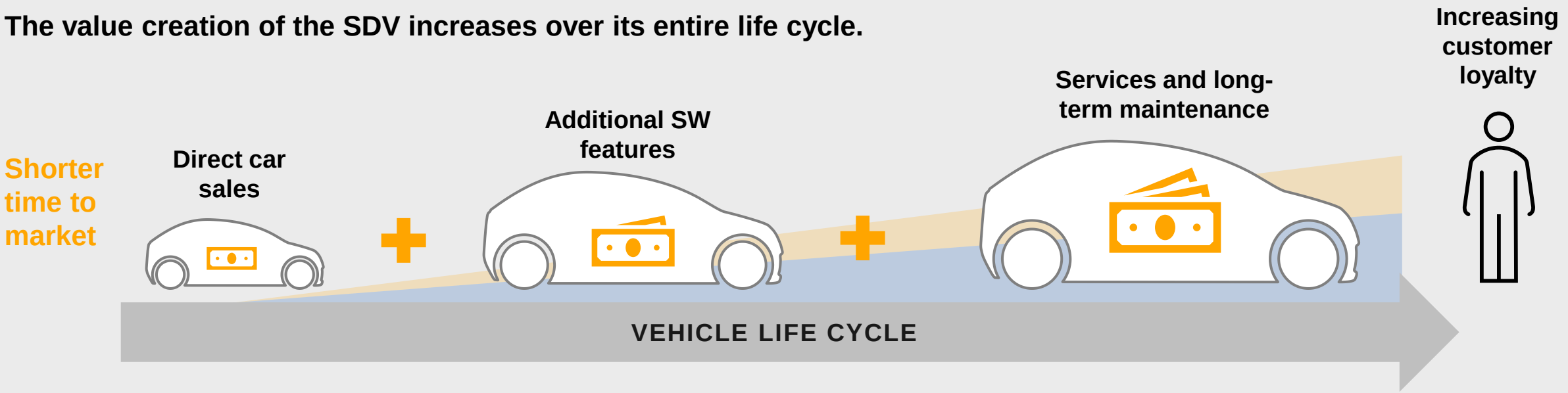
Hardware and System knowledge as well as our Software know-how are key success factors for our customers.

The Software-defined Vehicle

What Is the Value of a SDV for the OEM?

The Software-defined Vehicle (SDV) enables OEMs to create additional value by facilitating over-the-air updates, allowing continuous improvement and feature enhancements without requiring physical recalls.

The value creation of the SDV increases over its entire life cycle.



Increasing direct and indirect revenue and customer loyalty

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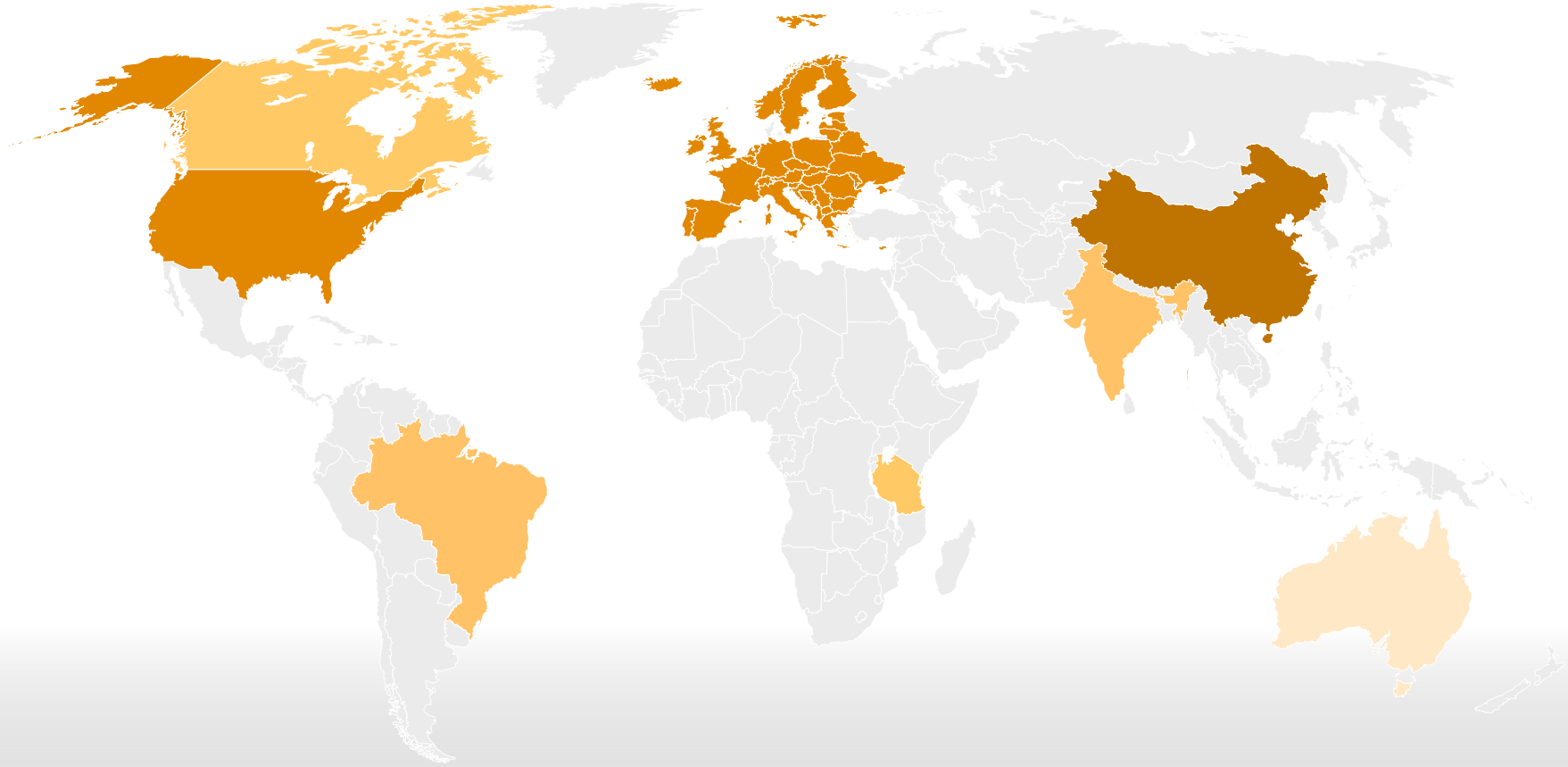
Data Protection Regulations
Worldwide

137

countries have enacted data protection and privacy legislation

40+

countries are in the process of drafting or considering such laws

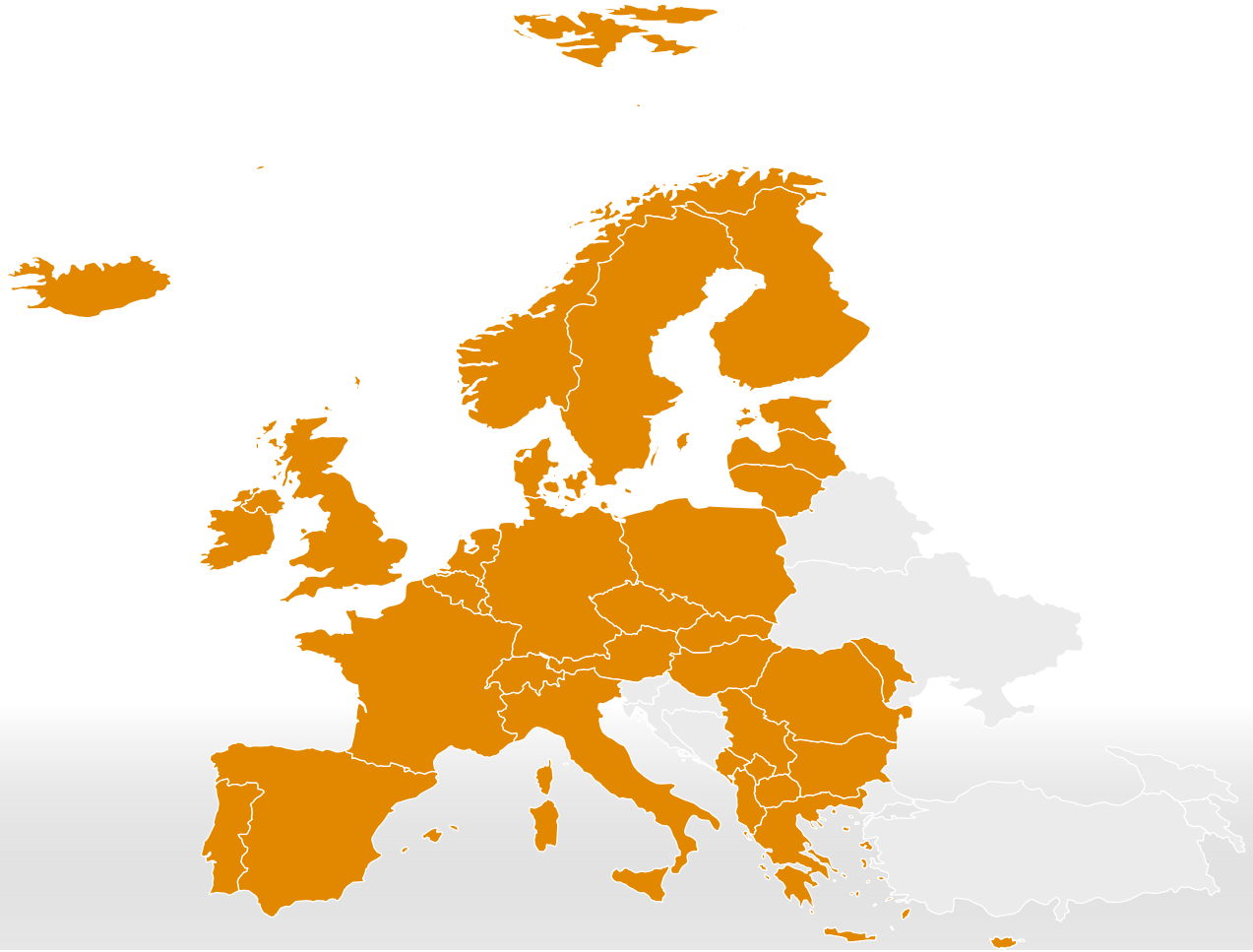


Source: UNCTAD's Data Protection and Privacy Legislation Worldwide Tracker, June 2025

General Data Protection Regulation

Europe

The GDPR is the most comprehensive data protection regulation in the world, setting the standard for how personal data must be handled.



700k+

Data protection officers (DPOs) appointed across the EU since GDPR enforcement.

261M+

Estimated number of EU citizens whose personal data is protected under GDPR.

Source: European Data Protection Supervisor – General Data Protection Regulation (EU) 2016/679, June 2025

Data Protection Regulations

Milestones

2012

› **General Data Protection Regulation**
Draft passed the EU Parliament

The Privacy Principles ISO/IEC 29100 (2011)

2013

Edward Snowden

2016

› **European General Data Protection Regulation**
Published

2018

› **EU GDPR**
Enforced

2020

› **Tesla Data Protection Study**

2021

› **Expert Study**
"GDPR application in the context of car connectivity "

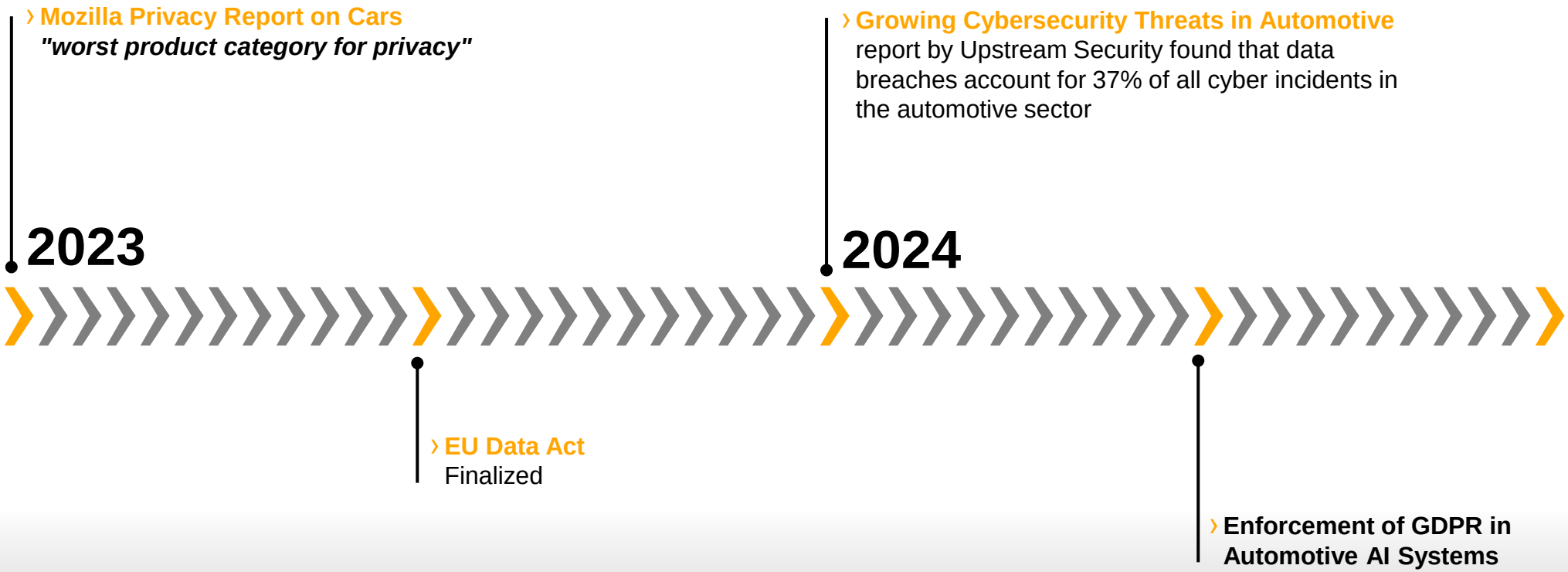
2022

› **VW GDPR Violation Penalty**
€ 1,1M

Guidelines 1/2020 on processing personal data in the context of connected vehicles and mobility related applications(2020)

Data Protection Regulations

Milestones



Fines and Penalties

GDPR Enforcement Tracker

- 200.000€
- OR 4% of the annual turnover

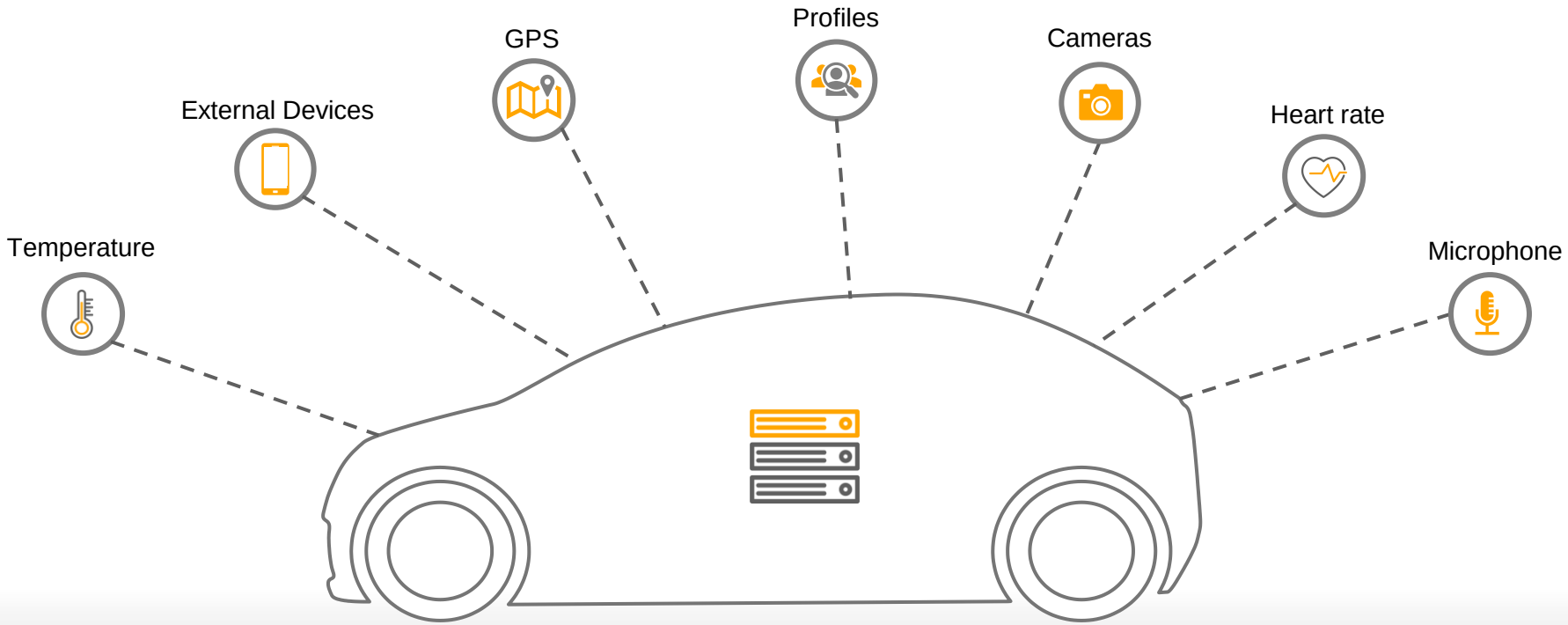
(whichever amount is higher)

ETid-1844	IRELAND	2023-05-12	1,200,000,000	Meta Platforms Ireland Limited
ETid-778	LUXEMBOURG	2021-07-16	746,000,000	Amazon Europe Core S.à.r.l.
ETid-2584	IRELAND	2025-05-02	530,000,000	TikTok Technology Limited
ETid-1373	IRELAND	2022-09-05	405,000,000	Meta Platforms, Inc.
ETid-1543	IRELAND	2023-01-04	390,000,000	Meta Platforms Ireland Limited
ETid-2032	IRELAND	2023-09-01	345,000,000	TikTok Limited
ETid-2469	IRELAND	2024-10-24	310,000,000	LinkedIn
ETid-2447	THE NETHERLANDS	2024-07-22	290,000,000	Uber Technologies Inc., Uber B.V.

Source: https://www.enforcementtracker.com, June 2025

Data Collection in Smart Vehicles

Examples

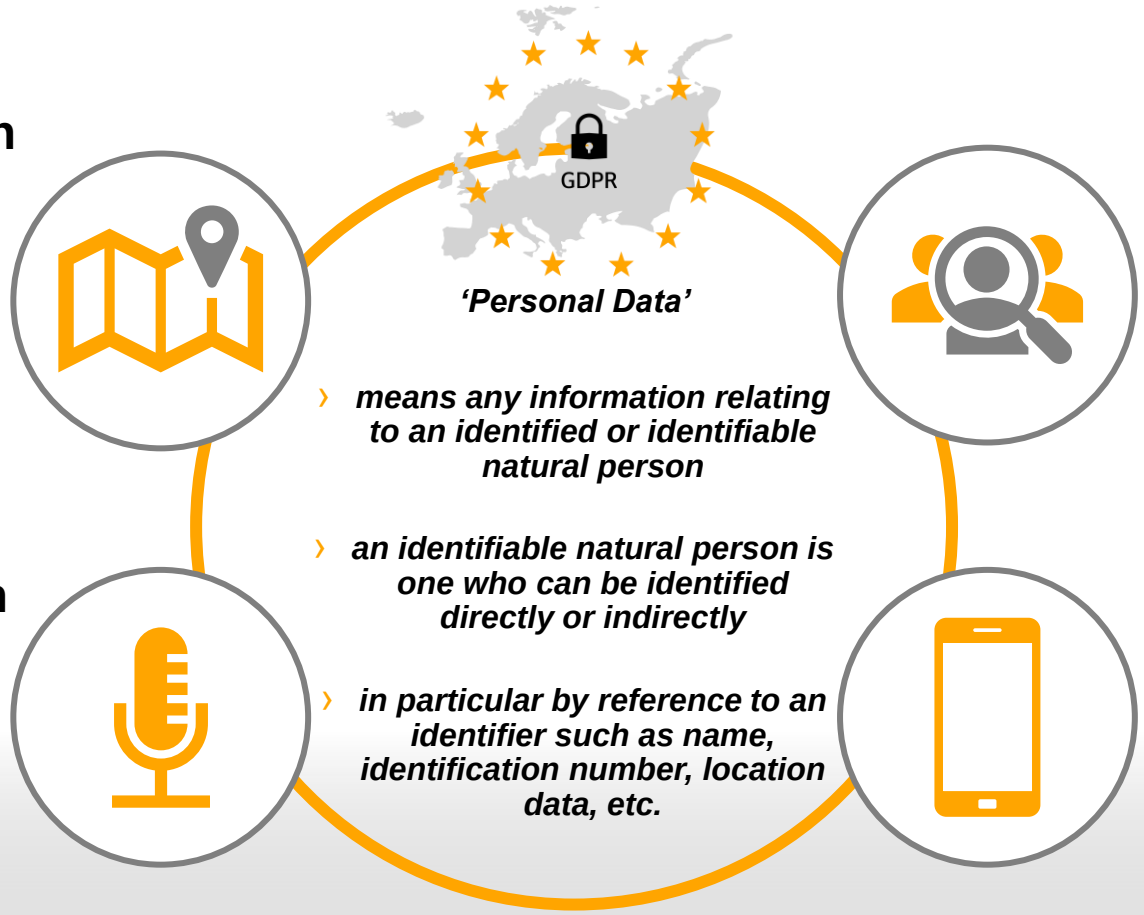


Data Collection in Smart Vehicles

Examples

- **Location Information**
  - Starting position
  - Destination
  - Route
  - Time
  - Speed

- **In-Cabin Information**
  - Microphone
  - Camera
  - Infotainment
  - Vehicle Occupants



- **User Recognition**
  - Physical/ Biometrics
  - Fingerprint
  - Face
  - Eye movement
  - Seat Configuration

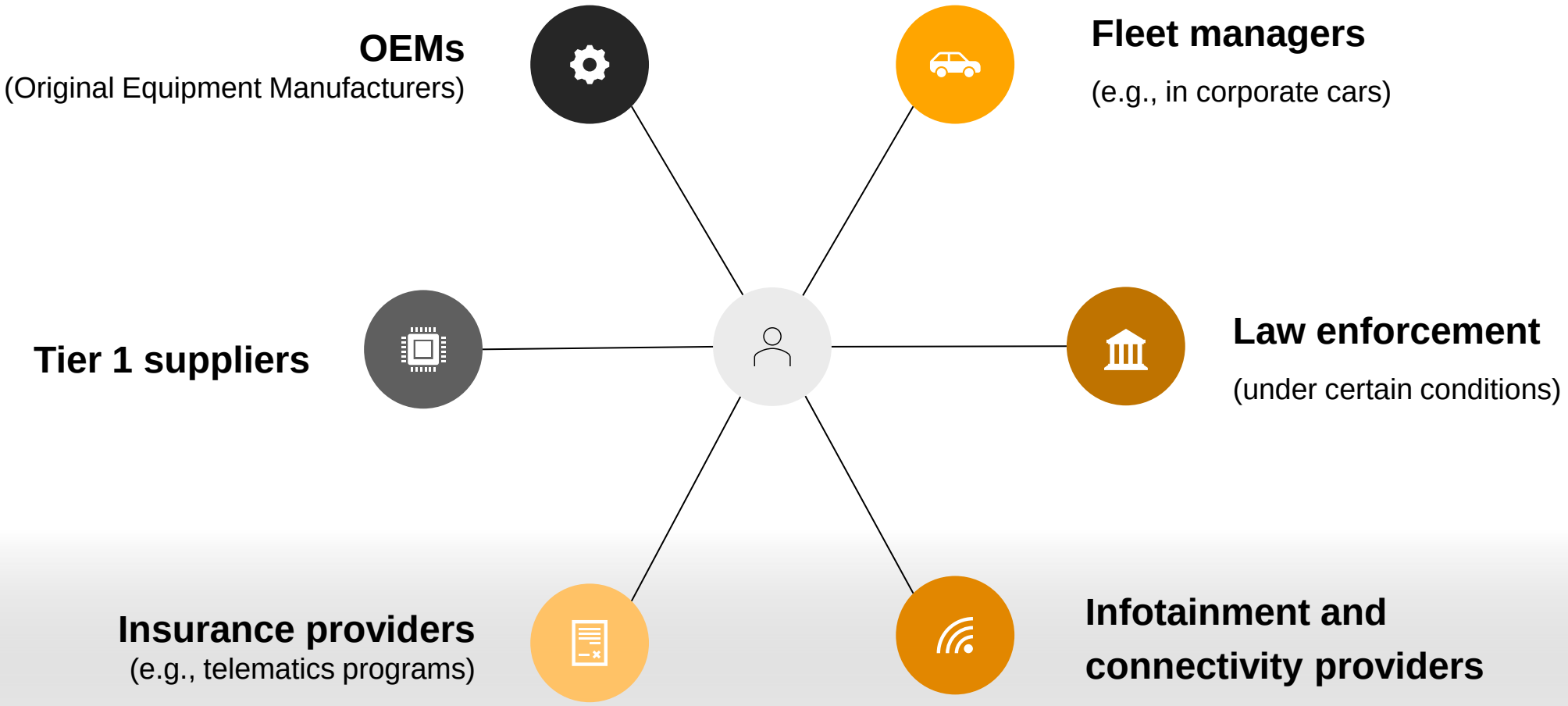
- **Applications**
  - Contacts
  - Call logs & Messages
  - Payment
  - Subscriptions

Source: PERSONAL DATA IN YOUR CAR, National Automobile Dealers Association and the Future of Privacy Forum, https://fpf.org/wp-content/uploads/2017/01/consumerguide.pdf

Categories of Sensitive Data
Examples

Data Type	Example	Sensitivity
Location	GPS tracking, route history	Can reveal habits, workplaces, private visits
Biometrics	Face recognition, driver fatigue detection	Identifies individuals
Behavioral	Driving style, braking habits	Used in insurance or employee monitoring
Communications	Voice commands, phone syncs	Contains private conversations
Multimedia	Cameras, microphones	Potentially records people without consent

Who accesses the data?



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Case Studies

MCU Hack & Data Protection Report

MCU HACK

Data Protection Report

Case Study
Volkswagen Penalty for Test Vehicles

› Art. 13: **Information to be provided where personal data are collected from the data subject**

For example, magnetic signs with camera symbols on vehicles illustrating video recording

› Art. 28: **Processor**

Missing processing agreement with the contractor for test drives

› Art. 35: **Data protection impact assessment**

Missing DPIA prior to data processing

VIOLATIONS OF GDPR

1,100,000.00 €

Source: German state data protection commission fines Volkswagen for GDPR violation (iapp.org), 26.07.2022

Use Case
Location Privacy

Scenario: Navigation Systems and connected services continuously track vehicle location

Risks: Reconstruction of daily routines, stalking, inference of sensitive locations (e.g., hospitals, religious sites)

Privacy Enhancing Technologies (PETs) & Techniques:

- **Location fuzzing** or **geo-indistinguishability**
- **Local computation** for route planning (vs. Cloud)
- **Differential privacy** in mobility analytics

Use Case
Driver Profiling

Scenario: Driving behavior is recorded for ADAS tuning or UBI (Usage-Based Insurance).

Risks: Invasive profiling, insurance discrimination, cross-service data linkage

PETs & Techniques:

- **Federated learning** for behavioral model training
- On-device analytics with **encrypted aggregation**
- Policy enforcement via **trusted execution environments (TEEs)**

Use Case
Infotainment & Personal Devices

Scenario: Smartphone paired via Bluetooth, call logs and messages accessed by infotainment

Risks: Personal data leakage, unintended data sharing with passengers or service technicians

PETs & Techniques:

- **Access-Control policies** for device data
- **Secure data wipe** upon unpairing
- **Compartmentalization** of user profiles (e.g., driver vs. passenger mode)

Use Case
Interior Monitoring

Scenario: In-Cabin cameras and microphones used for driver monitoring, voice assistants, child detection

Risks: Sensitive visual/audio data, consent issues, surveillance concerns

PETs & Techniques:

- **Real-time on-device processing**, no raw uploads
- **Voice anonymization** or **synthetic** representation
- **Privacy overlays** for cabin footage (blurring faces)

Use Case
Shared Mobiltiy & User Profiles

Scenario: Shared vehicles, fleets, rentals or car subscriptions with individual user settings and accounts (e.g., seat/mirror position, navigation history etc.)

Risks:

- Cross-user data leakage
- Profile persistence after vehicle hand-off
- Exposure of personally identifiable info (PII)

PETs & Techniques:

- Ephermal or containerized user profiles
- Automatic wipe/reset on handover
- Edge-only personalization with cloud sync opt-in

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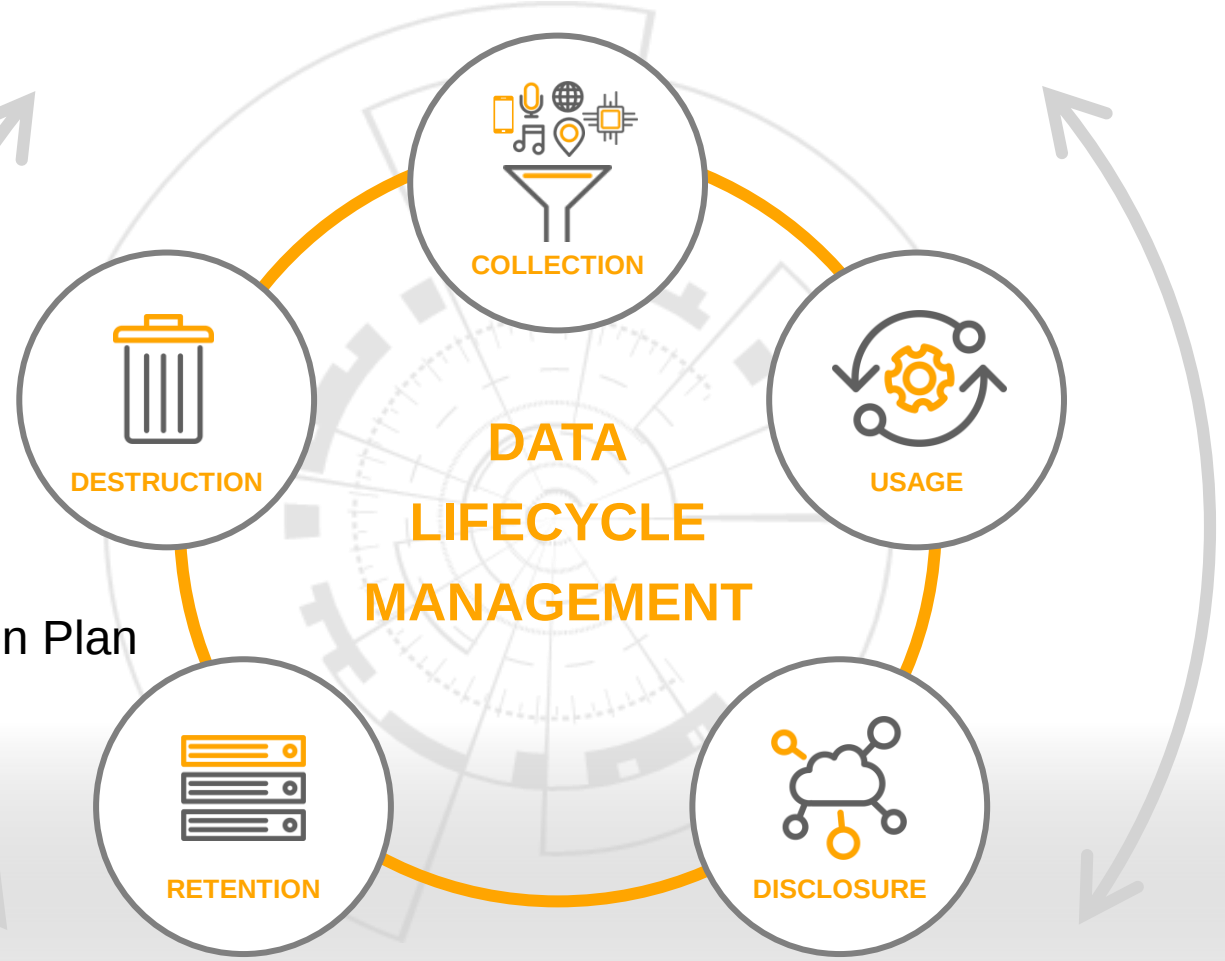
Data Lifecycle Management
Data Protection Measures



- User Consent Management
- Privacy Notice (ext)
- Privacy Policies (int)

- Data Minimization
- Purpose Limitation

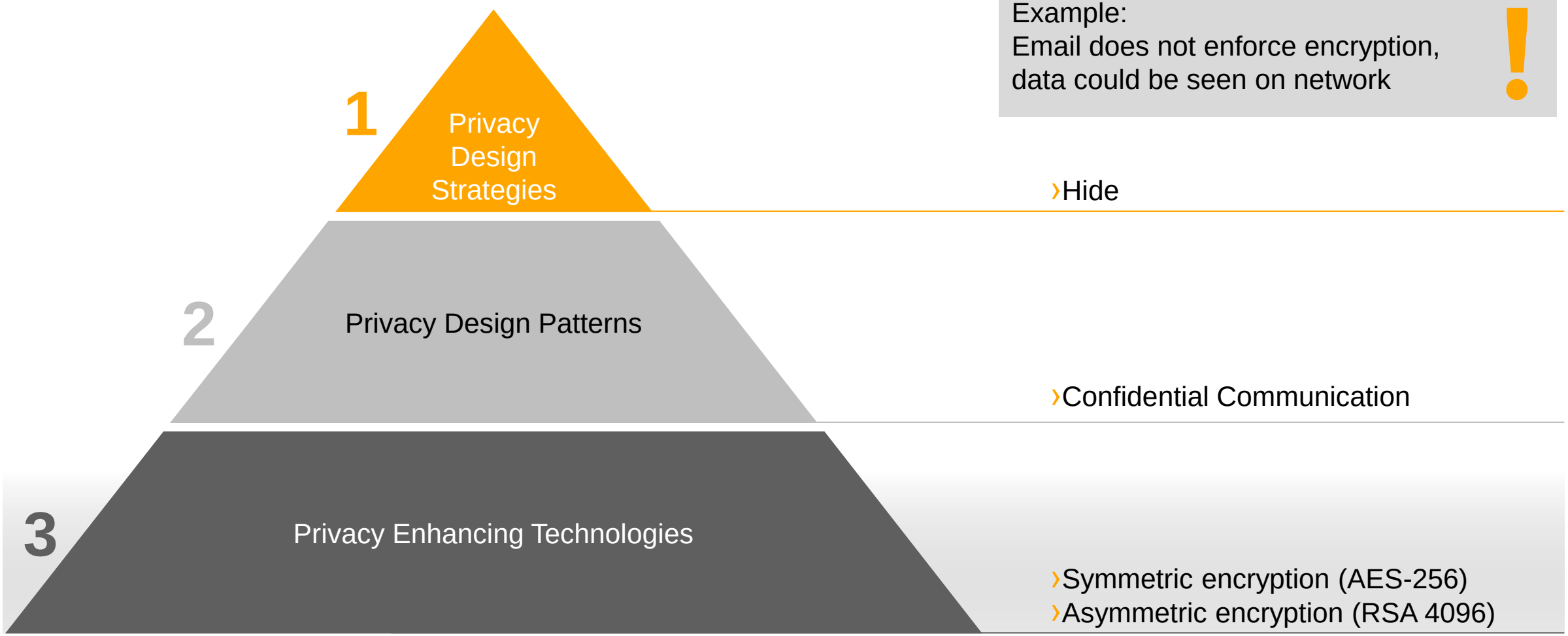
- Deidentification
- Identity and Access Management

- Retention Period
- Automatic Destruction Plan

Privacy-Preserving Framework

Privacy Desing Abstraction Levels

Example:
Email does not enforce encryption, data could be seen on network



- Hide
- Confidential Communication
- Symmetric encryption (AES-256)
- Asymmetric encryption (RSA 4096)

Privacy Enhancing Technologies

PETs

- tools and techniques designed to protect personal data while enabling its use for analysis and decision-making
- help organizations comply with data protection regulations like GDPR by ensuring data privacy and security

Main Benefits for GDPR Compliance:

Data Protection by Design and Default

supports the principle of data protection by design and by default, ensuring privacy is integrated into data processing activities from the outset

GDPR Principles

supports several GDPR principles with cryptographic measures, reducing the risk of data breaches and limiting access

Enhanced Security

provides robust security measures to protect sensitive data, preventing unauthorized access and ensuring data integrity and confidentiality

Possibilities to Modify Data Without Compromising Privacy:

Homomorphic Encryption

enables computations on encrypted data

Differential Privacy

adds noise to data sets for privacy protection while still allowing accurate analysis

Secure Multiparty Computation

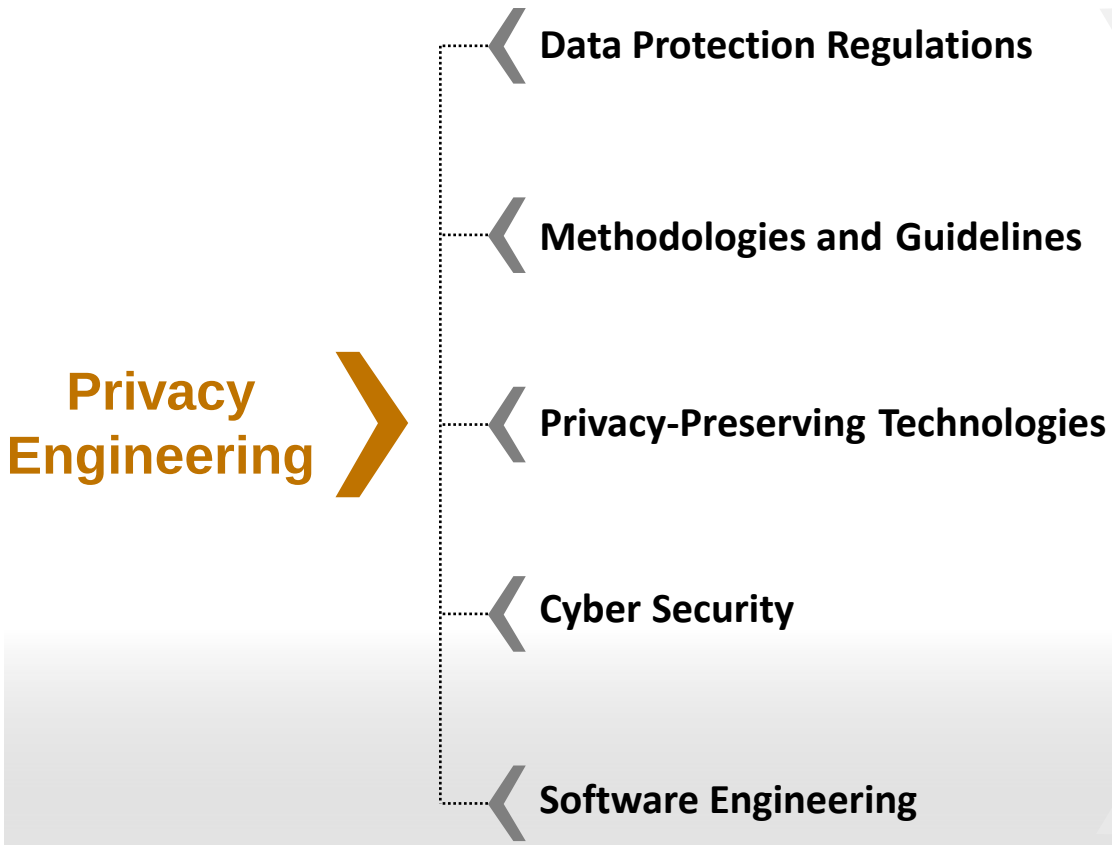
allows joint computation while keeping inputs private

Synthetic Data

generates artificial data mimicking real data, allowing analysis without exposing sensitive information

Product Privacy Engineering and Technologies

What we Offer



Privacy Engineering topics at Continental:

- Privacy (Impact) Analysis
- Data Protection Requirements
- Privacy-Enhancing Technologies
- Data Lifecycle Management
- Automotive Privacy and Data Protection Guidelines & Methodologies
- Automotive Privacy Trainings

Cross-Cutting Solutions

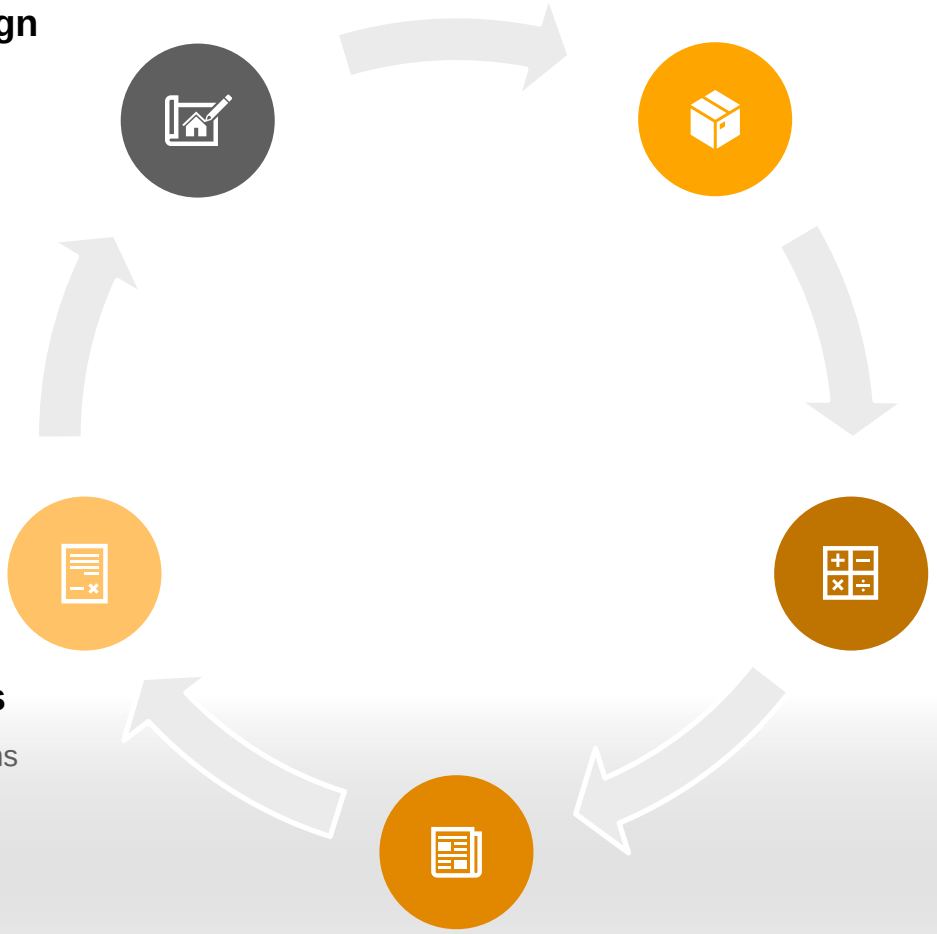
Techniques across domains

Data minimization by design

- Collect only data strictly needed for specific vehicle functions.
- Process data locally to avoid unnecessary external transmission.

Data sandboxing

- Isolate data from different vehicle functions to prevent unauthorized access.
- Limit cross-system data sharing through strict boundaries.



Strong user consent frameworks

- Clearly inform users & obtain explicit consent before data collection.
- Allow users to manage and revoke consent anytime.

Cryptographic PETs

- Use encryption and secure computation to protect data during processing.
- Apply techniques like differential privacy or homomorphic encryption where applicable.

Transparent privacy policies

- Provide clear, accessible explanations of data usage.
- Regularly update policies to reflect current practices and technologies.

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Key Take-aways

(Almost) **all data in vehicles** is likely to be **personal** data, even if it does not seem that way at first glance

All Automotive Products and Mobility Services need to meet Data Protection Regulations (since 2018)

Privacy Enhancing Technologies **are enablers** for future personalized Mobility Services and Automotive Products

Privacy Enhancing Technologies open **new business opportunities**

Further investigation and collaboration with stakeholders is sought

Thanks for Listening

Any Questions?

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