escrypt GmbH – Embedded Security
Systemhaus für eingebettete Sicherheit

Vehicular Security Hardware
The Security for Vehicular Security Mechanisms

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SEVENTH FRAMEWORK PROGRAMME

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Possible attacks in a vehicular environment

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- **Steal** the vehicle or a valuable component
- **Circumvent** restrictions in hardware or software functionality (e.g., speed locks, feature activation, software updates)
- **Manipulate** financially, legally, or warranty relevant vehicular components (e.g., toll devices, digital tachograph, chip tuning)
- **Spy on** manufacturer's expertise and intellectual property (e.g., counterfeits, industrial espionage)
- **Violate** privacy issues (e.g., contacts, last trips)
- **Impersonate** (e.g., electronic license plate)
- **Misuse** external communication (e.g., disturb, misuse, harm)
- **Harm** passengers, destroy OEM’s reputation (e.g., safety attacks)

➲ Strong need for reliable security mechanisms!

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The security of security mechanisms
Why applying standard solutions won't work

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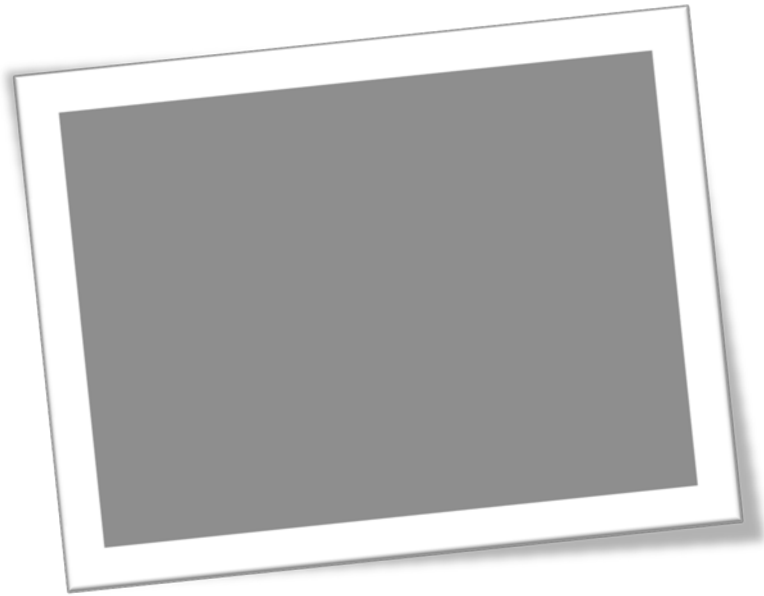
- **Beyond "standard attacks" ..**
  - **Insider attacks**
  - **Offline attacks**
  - **Physical attacks**
- **Many different attackers and attacking incentives**
- **Many different attack points**
- **Vehicular IT is client/server, embedded and mobile world**



➲ Standard security solutions won't work!

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The security of security mechanisms

Trust in security mechanisms

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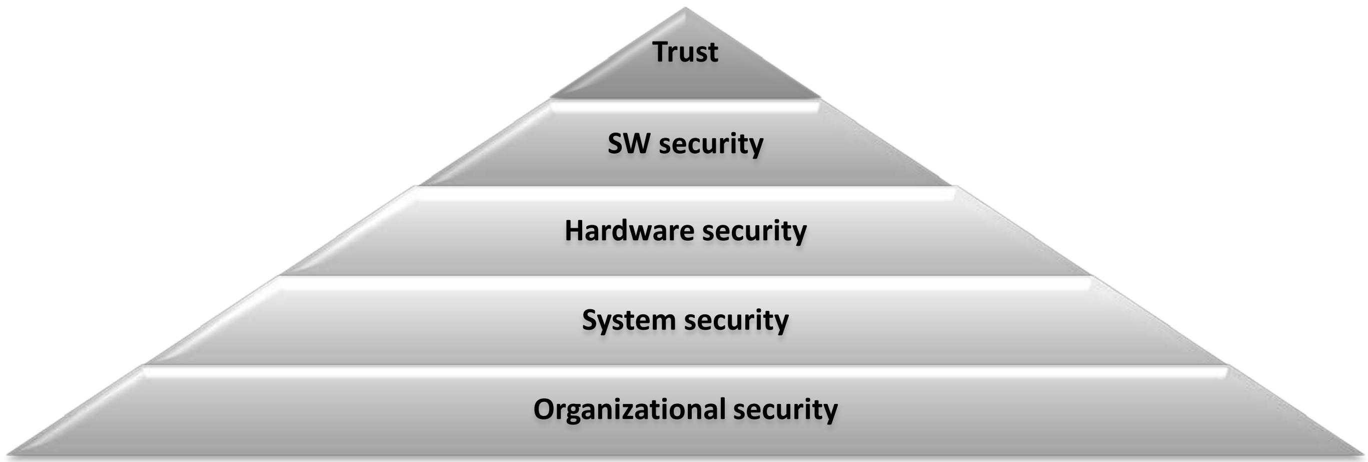

- **Organizational attacks** (e.g., social engineering) can be prevented by well-thought *security processes, secure infrastructures and organizational security policies*
- **Logical attacks** (e.g., cryptographic weaknesses or weak APIs) can be prevented by a *secure well-thought security system design and adequate security protocols*
- **Software attacks** (e.g., weak OS mechanisms or malware) can be prevented by reliable *software security mechanisms* (e.g., secure init, secure RTEs) and the application of *hardware security mechanisms that protect & enforce security of software mechanisms*
- **Hardware attacks** (e.g., security artifacts manipulations/read-out, physical locks, side-channels etc.) can be prevented by *hardware tamper-protection measures*

Vehicular Security Hardware
What security hardware can help

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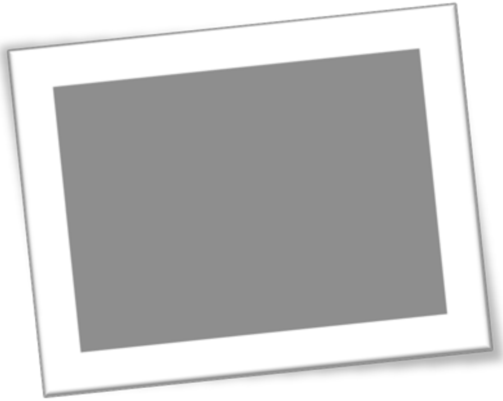
- **Protects** software security mechanisms by
  - ➲ Providing a trustworthy *security anchor* for upper SW layers
  - ➲ *Secure generation, secure storage, and secure processing* of security-critical material shielded from all pot. malicious SW
- **Prevents** hardware tampering attacks by
  - ➲ Applying *tamper-protection* measures
- **Accelerates** security mechanisms by
  - ➲ Applying *cryptographic accelerators*
- **Reduces** security costs on high volumes by
  - ➲ Applying highly optimized special circuitry instead of general purpose hardware



Engineering a **Vehicular Security Hardware**
Quick Requirements analysis

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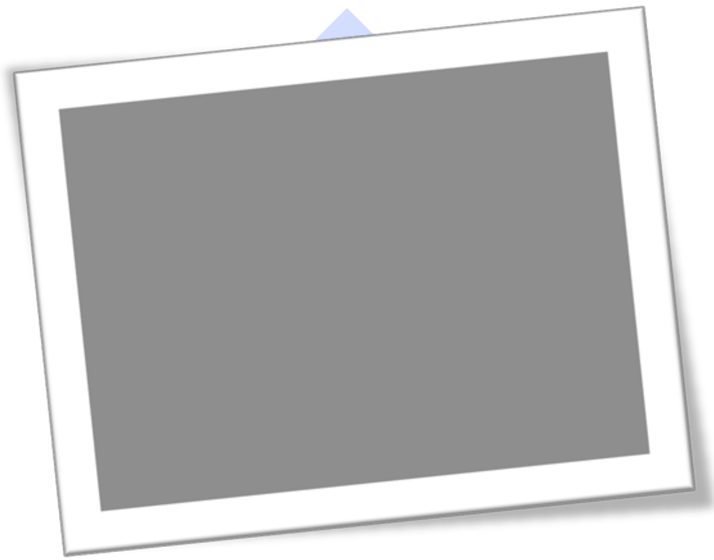
- **Security Requirements**
  - High level: creation, storage, management & processing of security artifacts (e.g., keys, certificates, random numbers), authentications schemes, secure "timer" (e.g., clock, counter)…
  - Low level: symmetric engine, asymmetric engine, hash function, TRNG, secure storage…
  - Physical level: Physical coupling, tamper-evidence, tamper-resistance, tamper-response, and side-channel resistance
- **Functional Requirements**
  - Latency and band width
  - Memory, space, and performance
  - Interface compatibility, security updates
  - Physical stress…
- **Other requirements**
  - Costs
  - Patents and export restrictions
  - Certification reg. safety (IEC 61508, SIL etc.) and security (e.g., FIPS 140, Common Criteria)



Vehicular Security Hardware
What is the current situation?

- **Proprietary** and **single-purpose** hardware security solutions in vehicular environments, for example:
  - Immobilizer
  - Digital tachograph
  - Toll Collect OBU
- General-purpose hardware security modules for **non-automotive** environments , for example:
  - IBM cryptographic coprocessor
  - Cryptographic smartcards
  - Trusted Platform Module
  - Mobile Trusted Module

➲ **Are where any solutions for vehicular security HW?**

E-safety Vehicle Intrusion proTected Application

EVITA project objectives

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- **Powerful ECU security hardware extension** that: *".. aims at designing, verifying, and prototyping an architecture for automotive on-board networks where security-relevant components are protected against tampering and sensitive data are protected against compromise."*
- **Prevent** or at least detect **malicious malfunction** of in-vehicle e-safety applications
- **Detect** manipulated information from **external entities**
- **Design** and **verify** a **ECU security architecture**, including
  - ECU hardware security extension
  - ECU software security components
  - corresponding (e-safety) security protocols
- **Implement** , **demonstrate** and **validate** ECU security architecture for practicability

E-safety Vehicle Intrusion proTected Application

EVITA background information

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- **Objective:** Automotive capable security hardware (“automotive TPM”) for enabling a vehicular security architecture protecting e-safety V2X communications (e.g., emergency break, eCall)
- **Program**: FP7-ICT-2007 of the European Community (EC)
- **Partners**: BMW, Bosch, Continental, escrypt, EURECOM, Fraunhofer, Fujitsu, Infineon, Institut TELECOM, KU Leuven, MIRA, TRIALOG from Belgium, France, Germany, Sweden, UK
- **Duration**: 36 months (July 2008 – June 2011)
- **Total cost**: 6 million €
- **Further information**: *www.evita-project.org*

EVITA ECU security architecture

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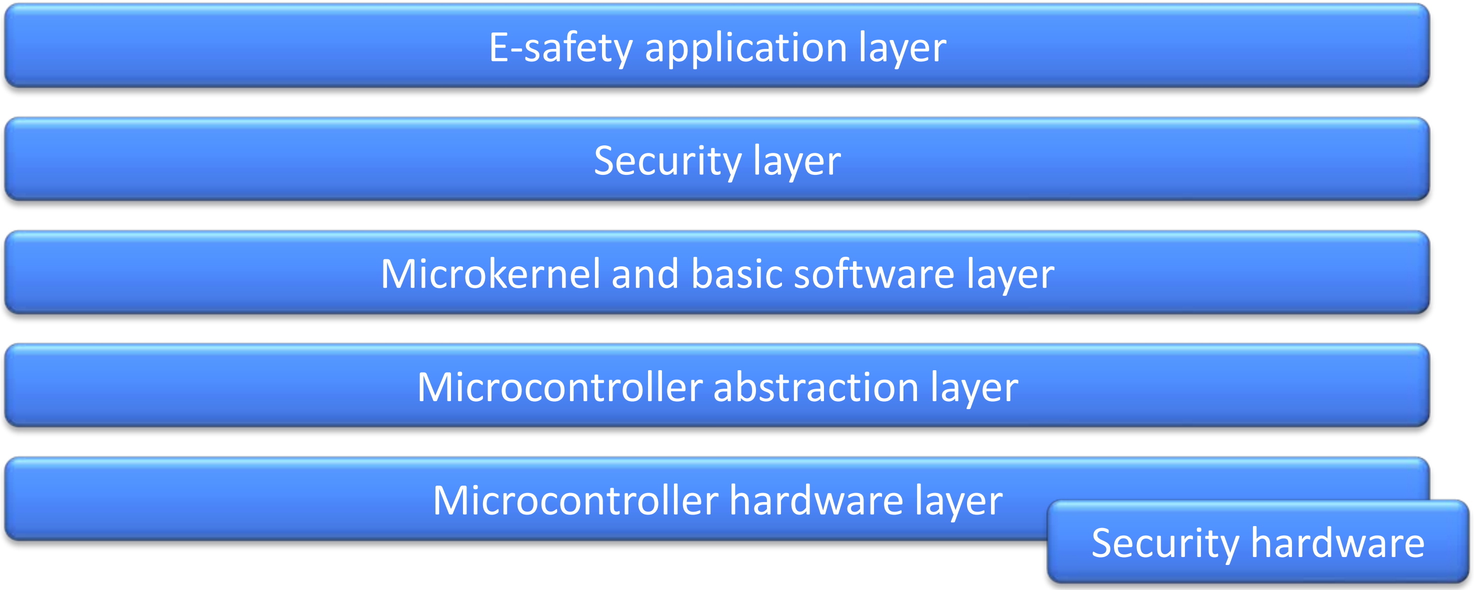
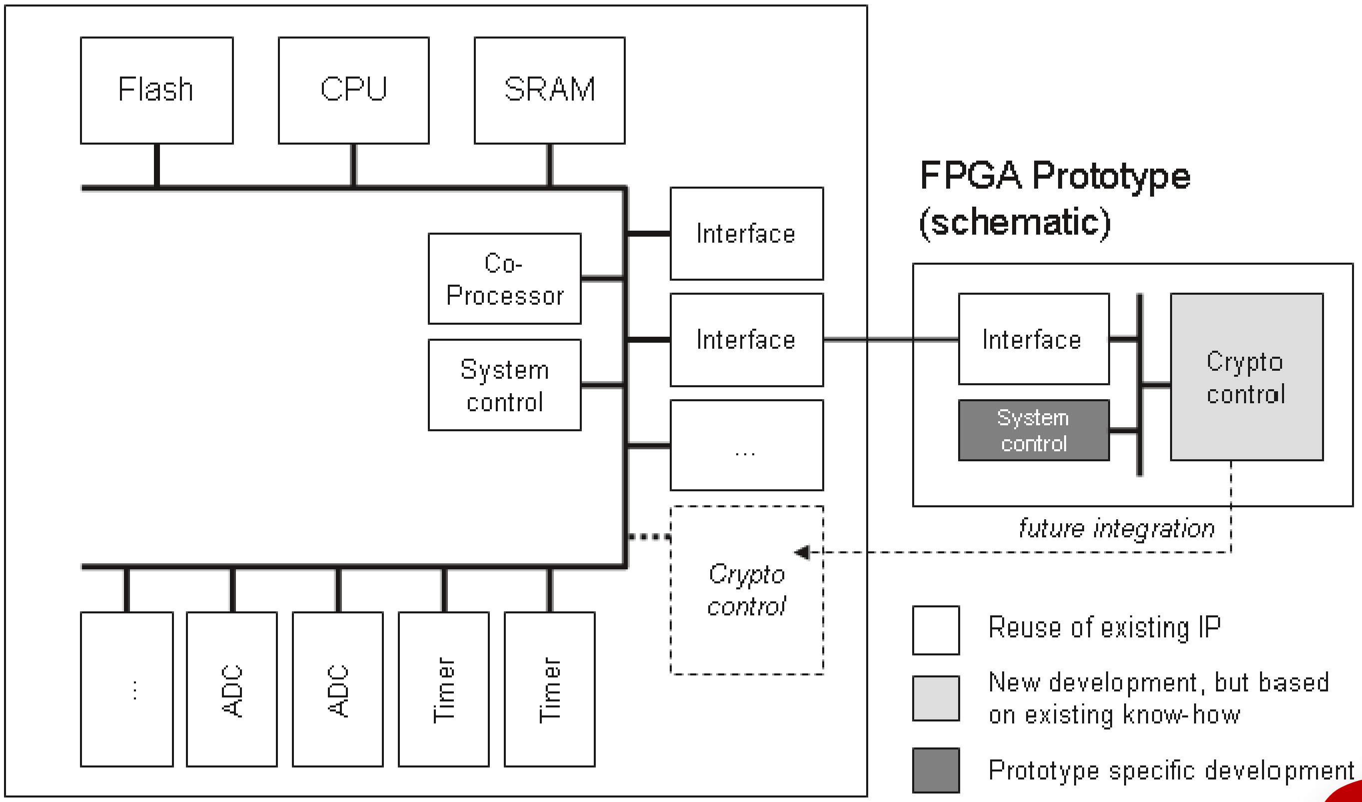


EVITA microcontroller security extension

Microcontroller (schematic)



EVITA project work plan / milestones

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- Work plan
  - **2008: Security requirements analysis**
  - 2009: Secure on-board architecture design
  - 2010: Reference implementation in SW & HW
  - 2010: Prototyped-based demonstration (lab car)
  - 2011: Publication as open specification

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ECU Trusted Module (ETM)
Enabling a holistic vehicular sec. architecture

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➲ EVITA security extension in every ECU? **Surely not!**

- Standardized , minimized ECU hardware security module
  - Protect simpler less security-critical ECUs such as sensor & actuators
  - Prevent software attacks and some hardware attacks (e.g., root artifacts)
  - Capable to interact securely w/ higher level security HW (e.g., EVITA)
- Vehicular equivalent to TCG's "Mobile Trusted Module (MTM)"
  - Hardware/software co-design for maximum on compatibility & flexibility (e.g., pure chip, hardware anchor + support software, pure software)
  - Secure boot for integrity protection
  - Protected (root) security artifacts processing and storage
  - Secure (in-vehicle) communication (Int. + opt. Auth./Conf.)
  - Unique ECU identification

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ECU Trusted Module (ETM)
Enabling a holistic vehicular sec. architecture

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- **Security requirements**
  - Non-detachable connected with ECU hardware
  - Minimal immutable core root of trust code
  - Minimal internal non-volatile memory for storing root security artifact(s)
  - Isolated security processing environment, e.g.,
    - Additional parallel environment (e.g., dedicated RAM and µC)
    - Physical isolation mechanism (e.g., ARM TrustZone)
    - Strictly logical isolated environment (e.g., microkernel)
  - Security enabled ECU processor and software stack
  - Only standardized, established security algorithms (e.g., NIST, FIPS, BSI)
  - …

ETM

ECU Trusted Module (ETM)
Enabling a holistic vehicular sec. architecture

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- **Other requirements**
  - Physical stress resistance and other functional demands (latency etc.)
  - Compatibility with other (higher-level) security modules and security mechanisms and with existing ECU microprocessor architectures
  - Standardized security classification according to the individual requirements to enable comprehensive flexible architectures, e.g.,
    - *Security level I*: Pure software application
    - *Security level II*: Key security artifacts shielded
    - *Security level III*: All security functionality shielded
    - *Security level IV*: Tamper-protection
  - Open and patent free specifications for cost-effective OEM-wide application

ETM

Strong Vehicular Security Architectures

Coupling ETM and EVITA enabled ECUs

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- Powerful EVITA extension in 2 - 4 central multi-purpose ECUs
  - Central gateway
  - Immobilizer
  - Engine control
  - Front/rear module
- Small ETM in less, but security-critical client ECUs
  - Critical sensors: e.g., wheel, acceleration, pedal sensors
  - Critical actuator: e.g., breaks, door locks, turn signal indicator
  - Critical small ECU: e.g., GPS module, lighting, clock

➲ **Secure cooperation of small ETM and powerful EVITA security extensions allows to create a cost-effective, flexible, and holistic vehicular security architecture**

Strong Vehicular Security Architectures
Coupling ETM and EVITA enabled ECUs

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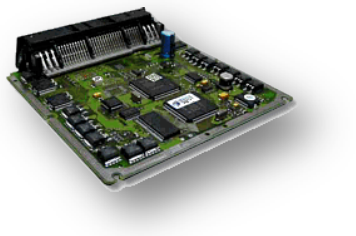
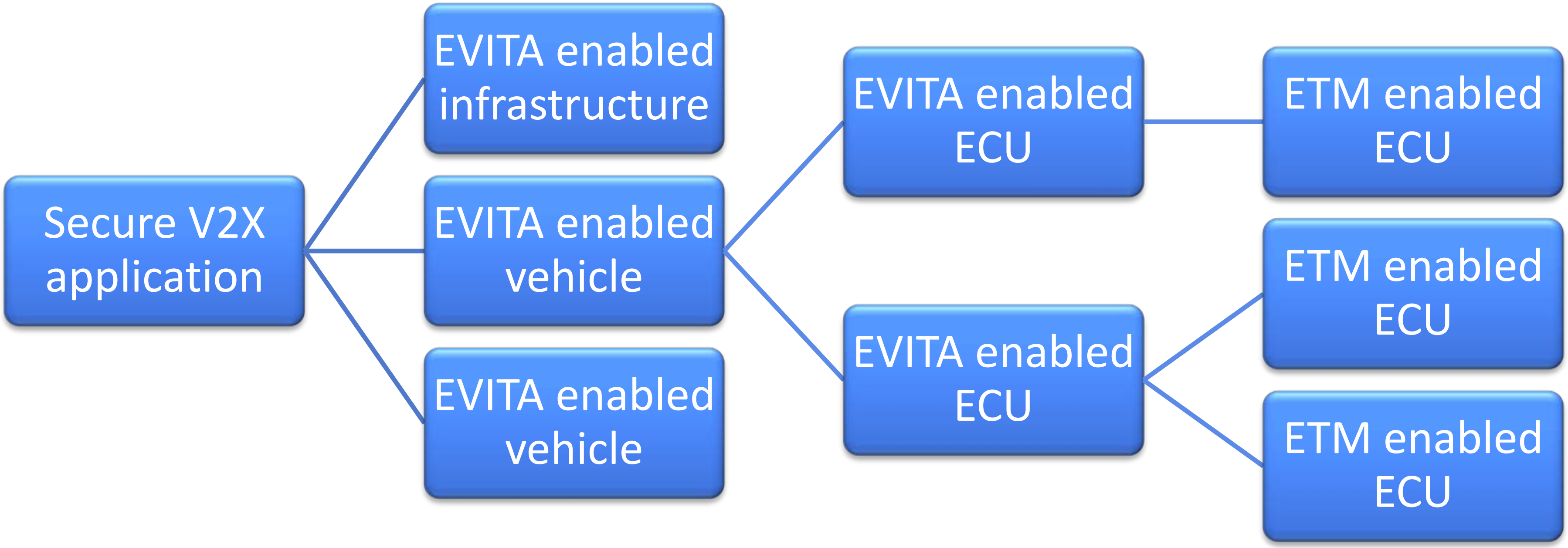


Vehicular applications | Cars & infrastructures | ECU masters | ECU clients



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Conclusions and Outlook

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- Standardized security hardware is **essential** for the security of **vehicular security mechanisms**
- Vehicular security hardware helps **preventing** almost **all software attacks** and **many physical attacks**
- Automotive proof security hardware (or even standards) **currently not available** (neither low-level nor high-level)
- However, open **ETM** and **EVITA** prototypes could be **promising opportunities** to act as effective, trustworthy and cost-effective hardware security anchors in vehicular environments

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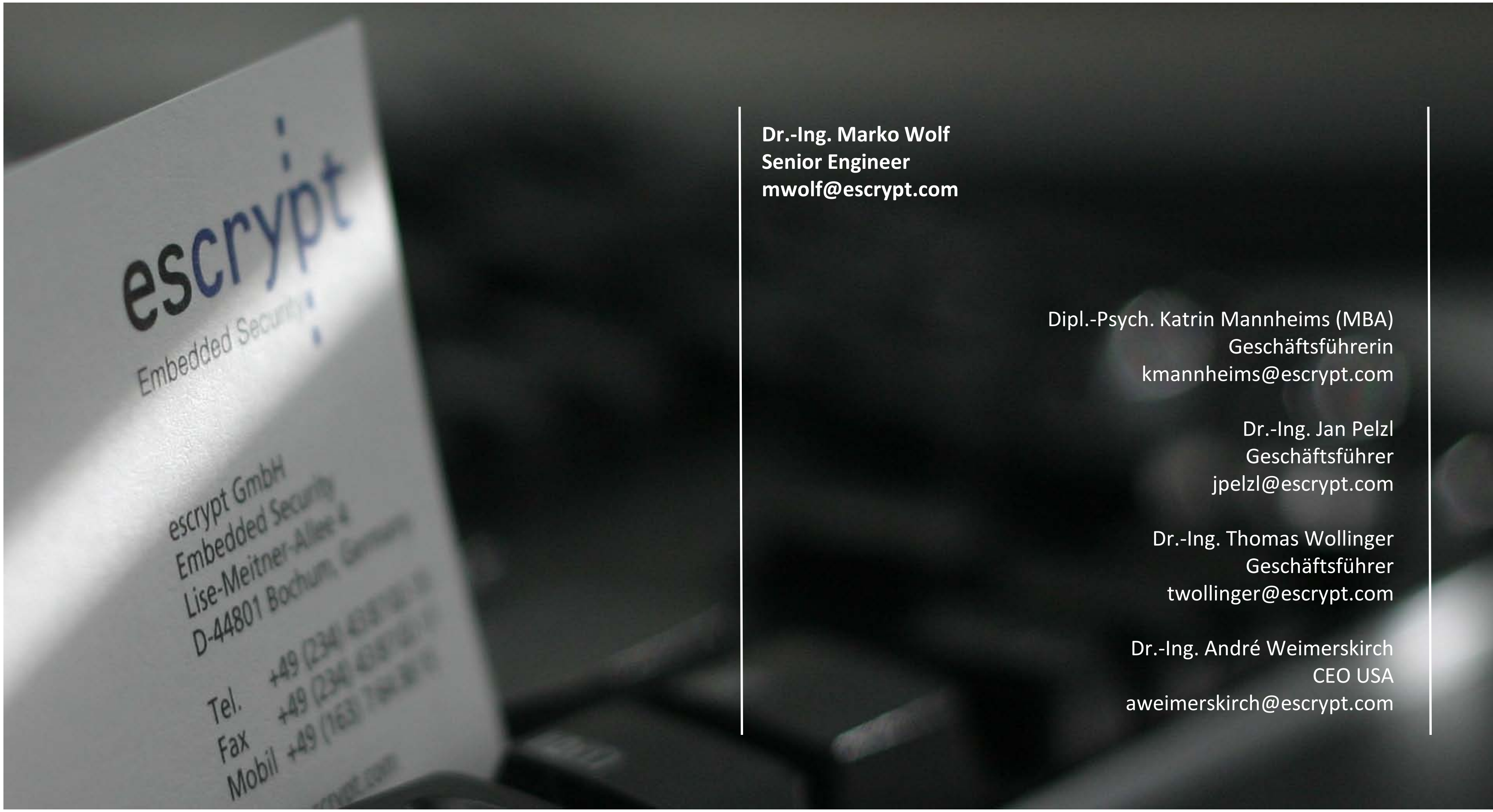

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