A Case Study: Securing Communication using J1939-91C Certificate-Based Authentication in Autonomous Commercial Vehicles

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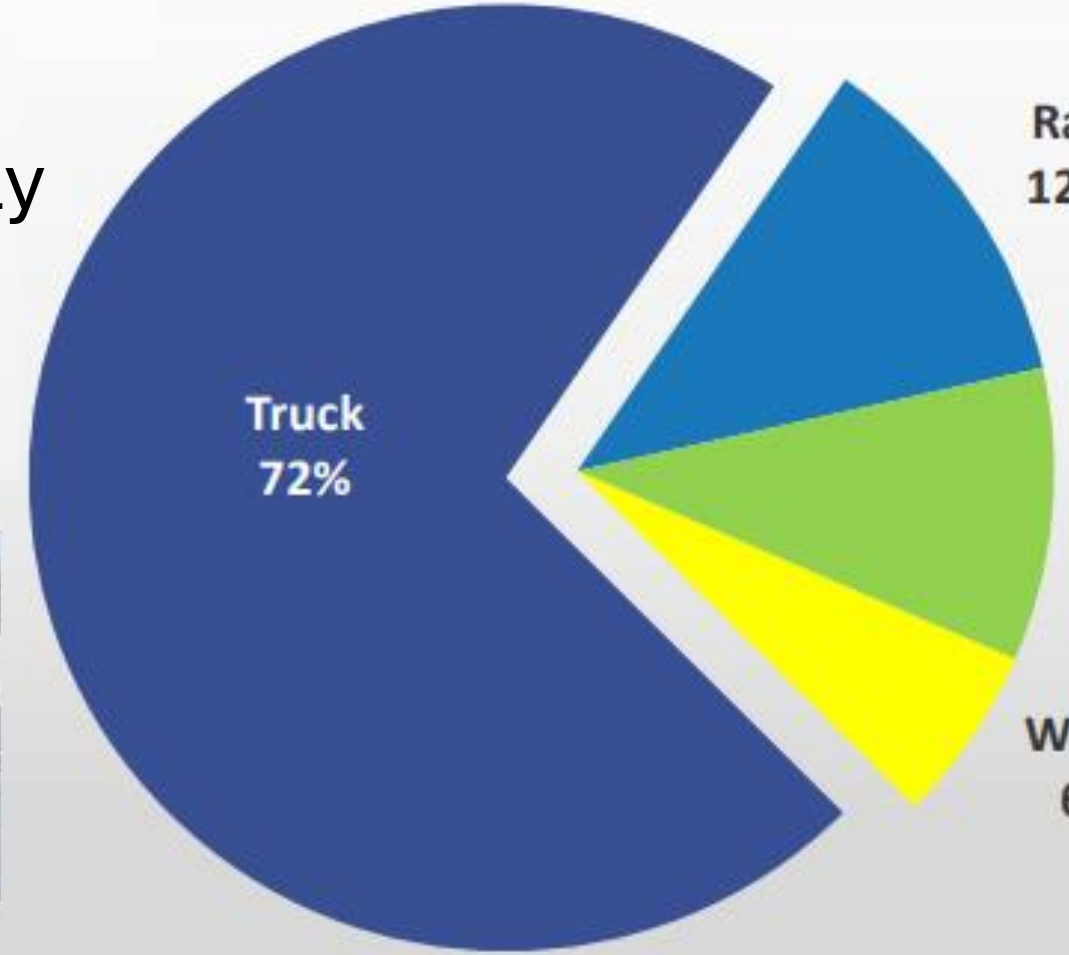
Topics

1. Commercial vehicle challenges
2. Introduce the project
3. Authentication options considered
4. Overview of J1939-91C
5. Lessons-learned

Trucking Moves the U.S. Economy

72% of freight

11B tons annually



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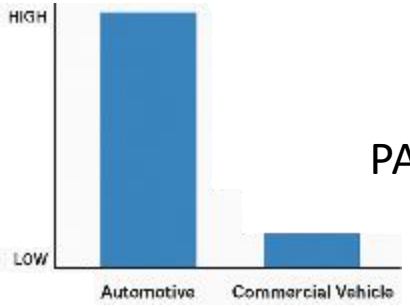
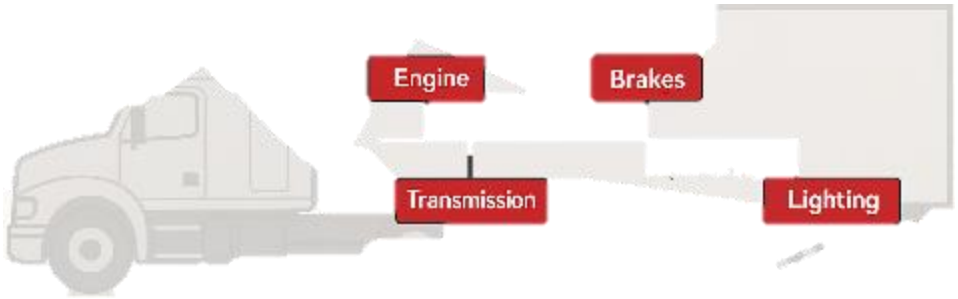
Commercial Vehicle Market

Lower Volumes



PACCAR: ~200K units annual

Legacy E/E Architecture



High Variability

Cost Sensitivities

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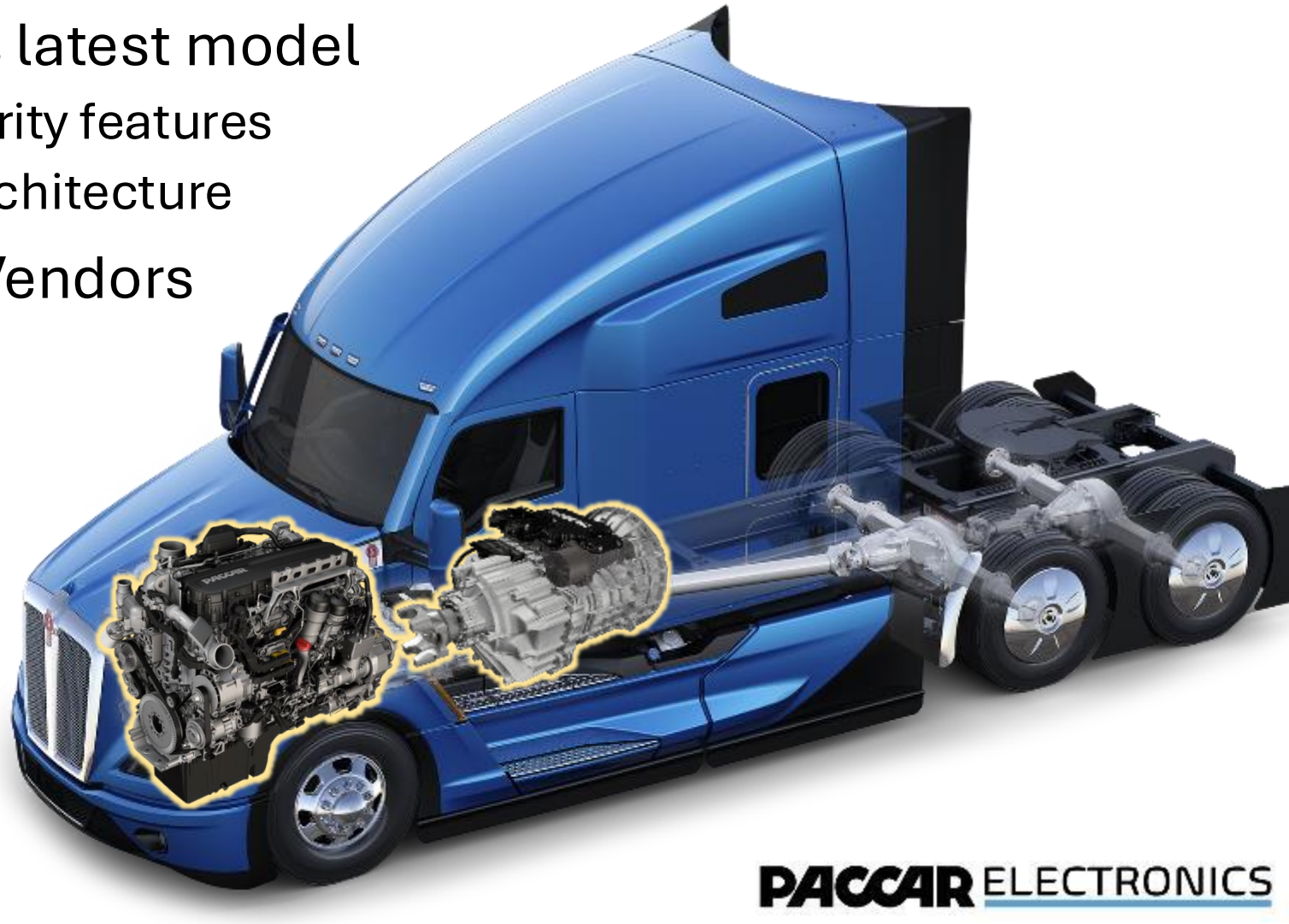
Autonomous Enabled Truck (AET) Platform

Platform Constraints

- Not “Green Field” – extends latest model
  - ↑ Able to utilize existing security features
  - ↓ Some legacy controllers/architecture
- Commercial Vehicle Tier1 Vendors
- Business Requirements
  - Protocol Constraints



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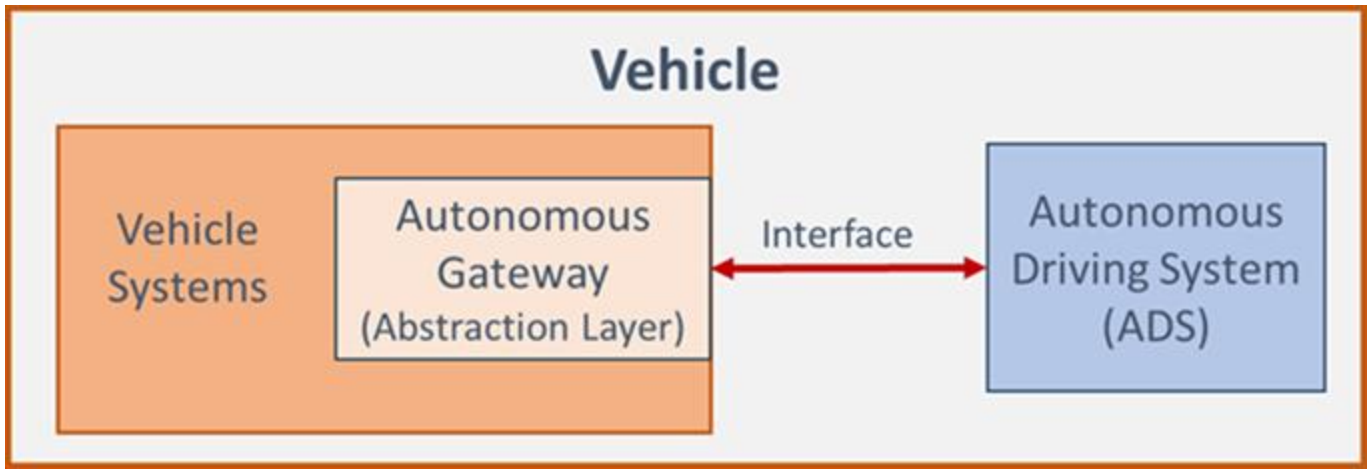
Security Strategy (high-level)



- A federated control architecture employing a service-oriented interface between the Vehicle and ADS.
  - Isolated trust domains
  - Secure and auditable interactions
  - Unified control requests enabling system flexibility and supplier diversity

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Automotive Ethernet Network

- Why not IEEE 802.3?
- For “business reasons”… program was constrained to CAN

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Some CAN Authentication Options

AutoSAR SecOC	Transport-layer agnostic. Message authentication with symmetric keys.
CANcrypt	Encryption and authenticated communication based on a secure heartbeat.
CANAuth	Pre-shared symmetric keys for message authentication.
CANSec	Security layer for CAN XL. Message encryption, authentication, integrity.

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SAE J1939 Introduction

- Suite of Open Standards
- High-layer CAN Protocol
- Used Extensively in Commercial Vehicles
- Strengths Include:
  - Deterministic
  - Fault-tolerant
  - Scalable
  - Extendable

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Early SAE J1939 Weakness = Cybersecurity

First Published in 1994

Lacks built-in security:

- ☹ Confidentiality
- ☹ Integrity
- ☹ Authentication

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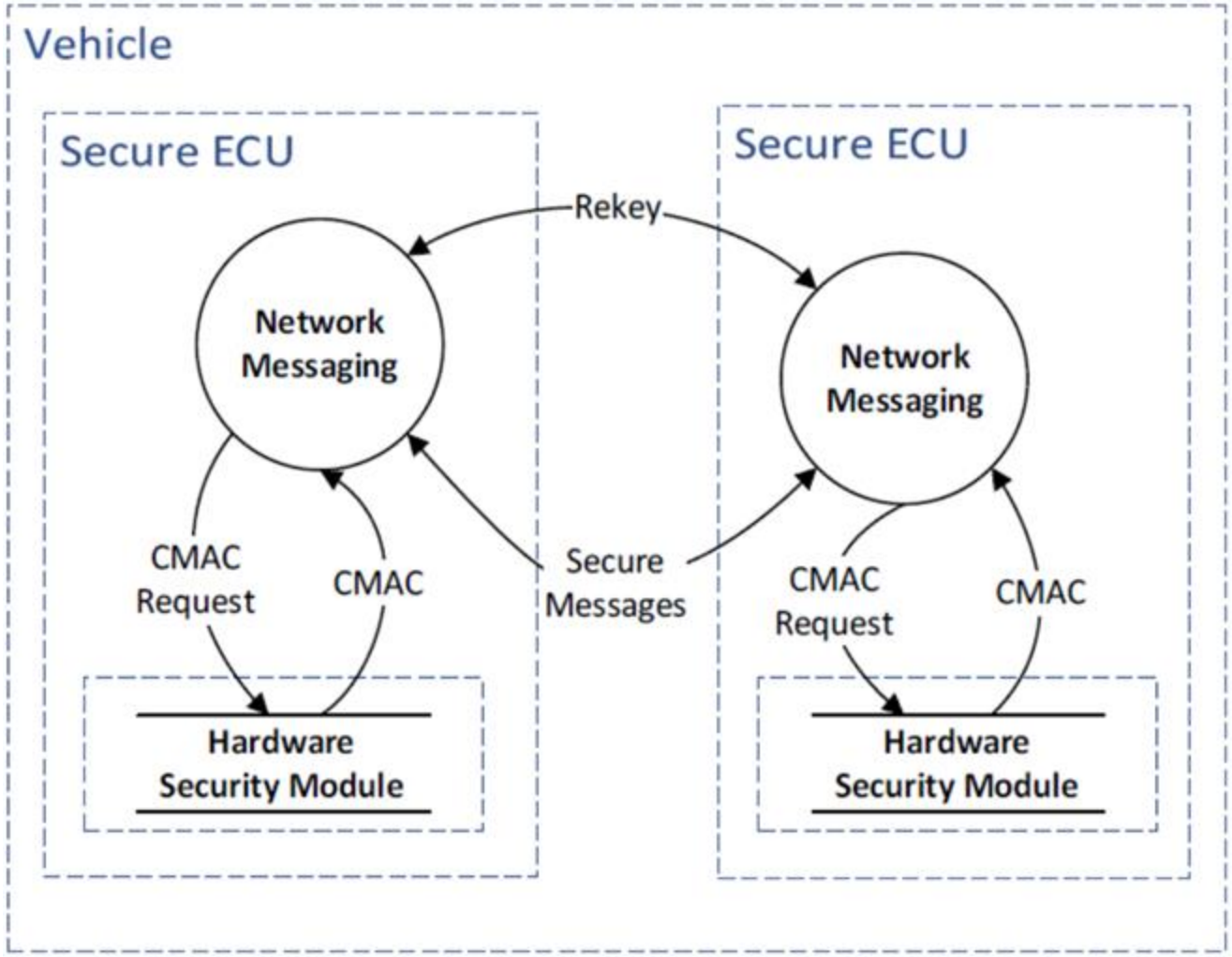
SAE J1939-91C: The Cybersecurity Extension

"J1939-91C describes Secure Onboard Communications with optional Encryption (SecOC/E) for an internal CAN FD network and the processes and infrastructure required to make [J1939] secure."
– SAE Abstract



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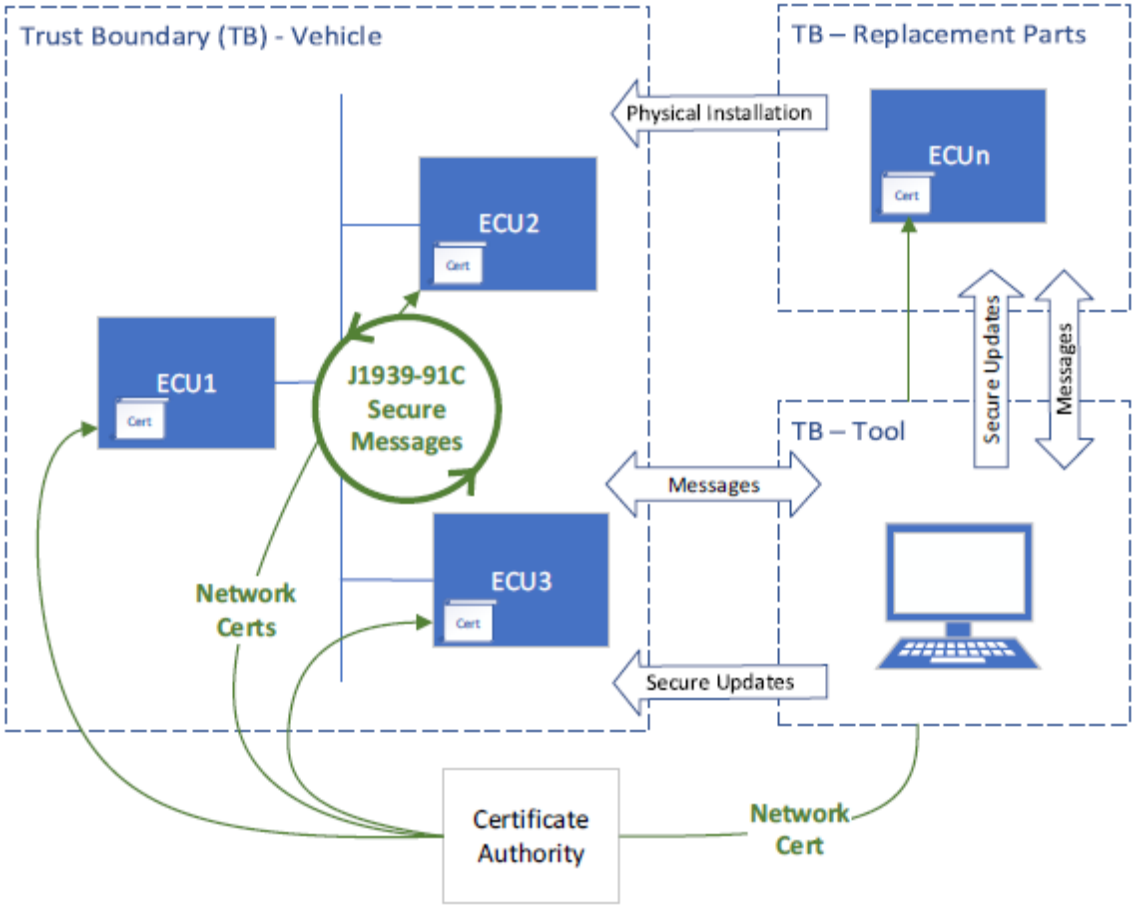
Lovingly stolen from SAE J1939-91C

J1939-91C

- Messages are authenticated via a truncated AES-128 CMAC
- Messages can be encrypted
- Messages include a Freshness Value for replay attack mitigation
- **Leverages native J1939-22 (CAN FD) data frame**

C-PG Format (Figure 19 from J1939-22)					
C-PG Header: 4 Bytes				C-PG Payload: 0-60 Bytes	
TOS	TF	CPGN	PL	PG Data	Assurance Data (CMAC&FV)
3 bits	3 bits	18 bits	8 bits	0-52 Bytes	8 Bytes

J1939-91C: ECU Authentication



- Network Formation
  - Mutual authentication of X.509 certs
  - OEM defines members
- Forward and backward secrecy
- Certificates are ECU-specific and vehicle-specific
- PACCAR mechanism for service part replacement
- PACCAR mechanism for certificate revocation and reissuance

Source: SAE J1939-91C

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Lessons Learned

- Securely crossing different network types can be tricky
- Working with a draft standard:
  - Untested protocol implementation = unknown unknowns
  - Don’t forget about service tools, engineering tools, test tools
- Zero-trust strategy
- PKI framework requires a lot of back-office support (OEM and vendors)
- Don’t be afraid to ask for help

- Many thanks to **NCC Group**!

Thank you!

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