



Overcoming Connectivity Challenges in ADAS/AD

Strategies for Seamless Multi-WAN networks

David Lenk

Today's Presenter



David Lenk

2013: Studies Telematics in Berlin & Graz

2013: AVL Engineer Racing

2018: AVL Engineer ADAS/AD

2020: AVL Lead Engineer Vehicle Instrumentation

2022: AVL Skill Team Leader Connectivity and Mobility Service



Overcoming Connectivity Challenges in ADAS/AD

About Us

Industry-Wide Value Creation

With future-proven tools, products and systems, augmented by our global network of experts and facilities, we support OEMs and Tier1s to shape current and future technologies for all industries.



Passenger Cars



Commercial Vehicles



Racing



Agriculture



2 and 3-Wheelers



Marine



Rail



Aviation



Industrial Energy



Automated and Connected Mobility



Technology Designed for the Human Journey

Mobility is changing. As technologies such as assisted and automated concepts gain focus, we face a paradigm shift in the way vehicles are designed, built and used. We are your professional and reliable partner for high demanding technology solutions within ADAS/AD system development.

15+

Years of
Experience

400+

Customer
Projects

90+

Automotive
Customers

19

Competence
Centers

450+

ADAS/AD Experts
Worldwide

Comprehensive and constantly evolving partner ecosystem

Motivation

Connectivity Challenges in ADAS/AD

We need a stable and fast connectivity for

Testing & Validation

- Data collection
- Testing campaigns
- Vehicle Validation runs
- Measurement Data Upload
- Remote Access to check and fix things or change configurations

Services

- Driver
 - Infotainment & Communication
 - Telemetry
 - eCall, bCall
- Operator Services
 - Passenger / Vehicle Support
 - Teleoperated Driving

Coverage

Connectivity Challenges in ADAS/AD

[...]

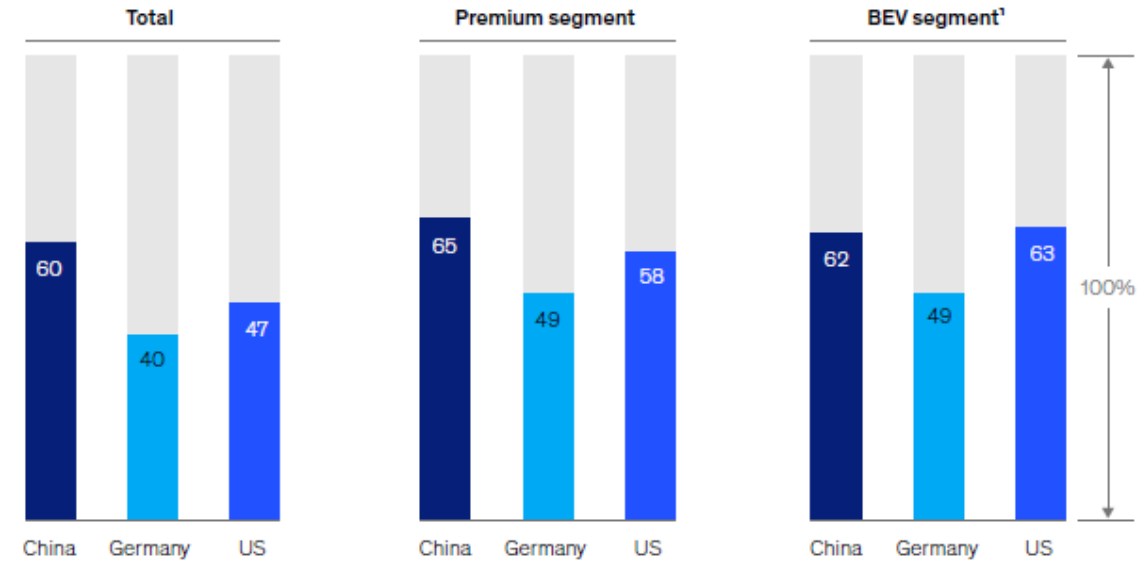
For example, it is estimated that on main European roads **~12.4 % of the time drivers have no connectivity**, especially in sparsely populated, often rural, areas. Broadband (4G+) coverage in Europe is not fully available within cellular coverage i.e., close to 7% of the time, drivers had no broadband (2G and 3G) service when travelling through rural areas.

[...]

* ESA Automotive White Paper 2024



Extremely likely to purchase connectivity features, % of respondents (n = 1,649)



¹Battery-electric-vehicle (BEV) segment includes respondents who would consider buying a BEV for their next vehicle.
Source: McKinsey Automotive Digital Services Customer Survey, Oct 2023

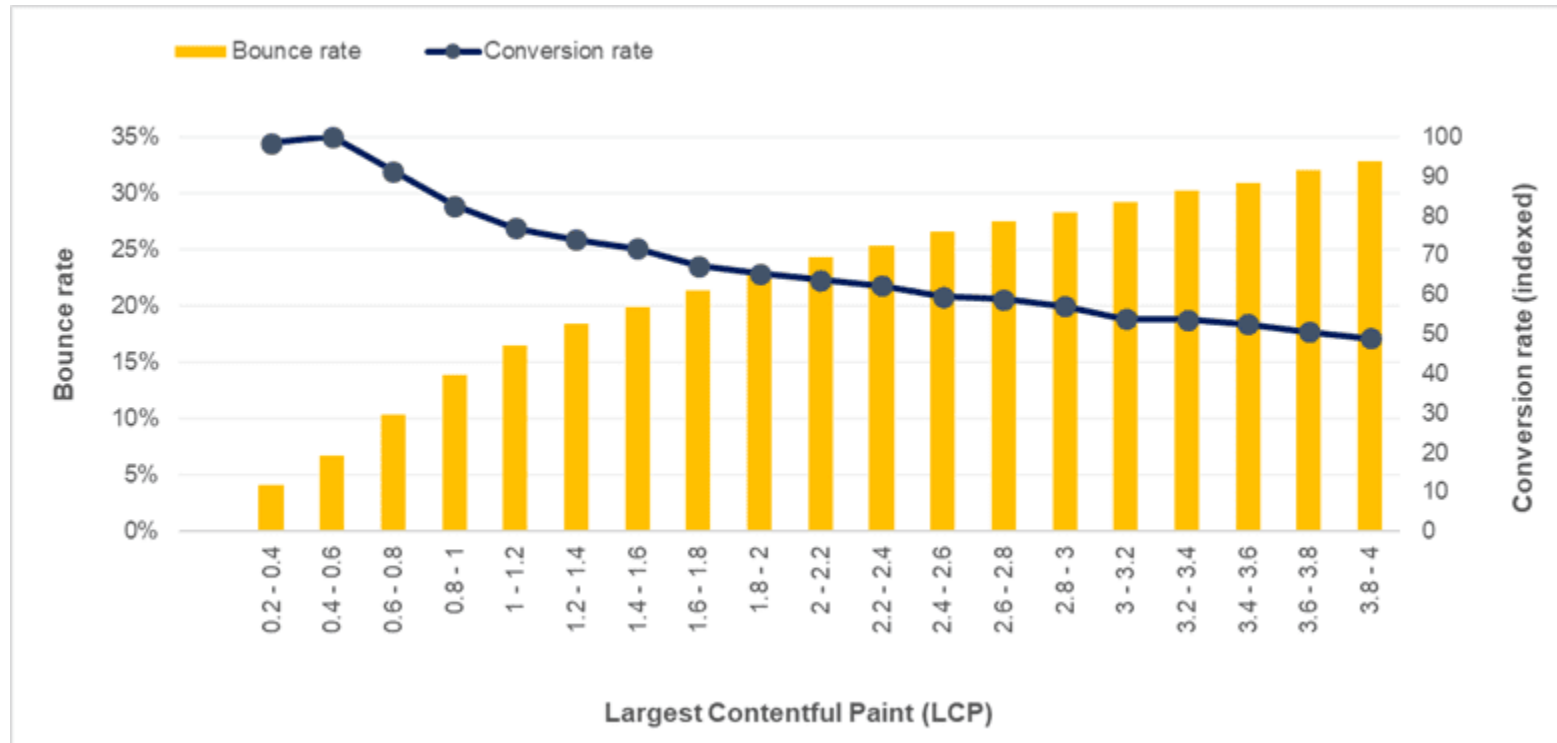
McKinsey & Company

* McKinsey & Company: Car connectivity: What consumer want and willing to pay

Latency

Connectivity Challenges in ADAS/AD

Content delivery: Low long is to long



Example: Website loading (LCP) in Second against Bouncing Rate

* <https://web.dev/case-studies/renault>

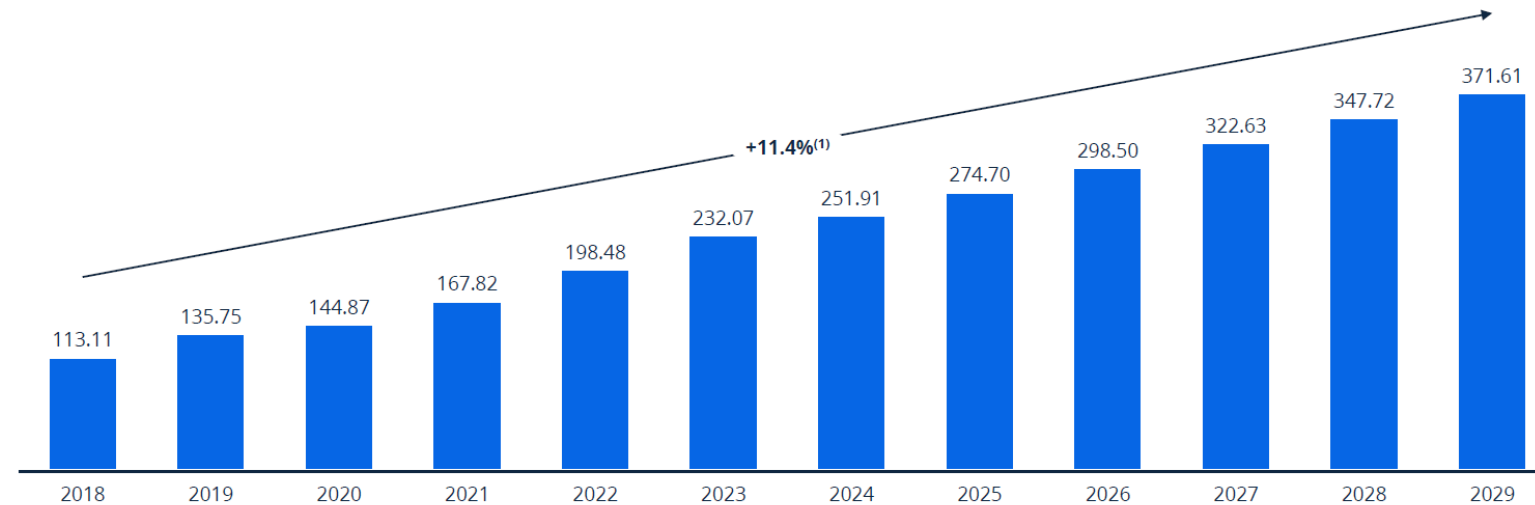
Market Trend

Connectivity Challenges in ADAS/AD

Automotive IoT revenues are estimated to increase at a CAGR⁽¹⁾ of 11.4% from 2018 to 2029

Market Size: Global

Revenue forecast in billion US\$



Notes: (1) CAGR: Compound Annual Growth Rate
Sources: Statista Market Insights 2024

Market Insights
by statista

Today's Agenda

- 1 Connectivity Use Cases**
- 2 Requirements for automated driving**
- 3 Seamless connectivity with multi-WAN**
- 4 Satellite networks for vehicles**



Overcoming Connectivity Challenges in ADAS/AD

Connectivity Use Cases

Connectivity Use Cases

Passenger Cars

Infotainment Services

Navigation Services
(ADAS/AD)

Telemetry / Remote Services

OTA / SDV Updates

V2X functions

Teleoperated Driving

Commercial

Fleet Management

Vehicle Maintenance and
Diagnostic

Traffic Management

Cargo and assets monitoring
and tracking

Full supply chain monitoring

Agriculture

ADAS/AD with teleoperated
driving functions

Data-driven precision
agriculture

Farm management of
autonomous machines

Connectivity Use Cases

Remote Services	Cellular, BLE	Online Services	Cellular, WiFi	Off-Board Functions	Cellular, WiFi
– Remote locking and unlocking – Vehicle search – Temperature control and preconditioning – Remote 3D View – Transmission of destinations to the vehicle via Local Search – Vehicle status / doors & light – Honking & flashing		– News, social media and UX services – POI, Charging, and other user-oriented services – Location services, Real time traffic and navigation – Integration of emails, notification, calendar, notes and other productivity tools – Over-the-air map update – Over-the-air software update – Feature on demand – Internet Hotspot		– Predictive vehicle health (Diagnosis) – Cyber Security Cooperative Anomaly detection – Fleet management (tracking, logbook, driving efficiency, position tracking and route history, consumption analysis, maintenance management) – Voice Recognition – Teleoperation	
Support Services	Cellular, WiFi, BLE	V2X Services	CV2X/11p, GNSS	Access – BYOD*	WiFi, BLE, UWB, ISM, LF
– Stolen-vehicle tracking – x-Call (S-Call, B-Call, E-Call) – (Precise positioning) – Assisted parking		– Awareness Driving (Warnings) – Sensing Driving (Warnings+Control) – Cooperative Driving (Warnings+Ext. Control) – Platooning		– Access - RKE / PEPS / Classical – Access - NFC / Phone-As-a-Key – Access – Passive Entry-Start / Phone-As-a-Key – Android Auto, Apple Carplay, Mirrorlink *Bring-Your-Own-Device	

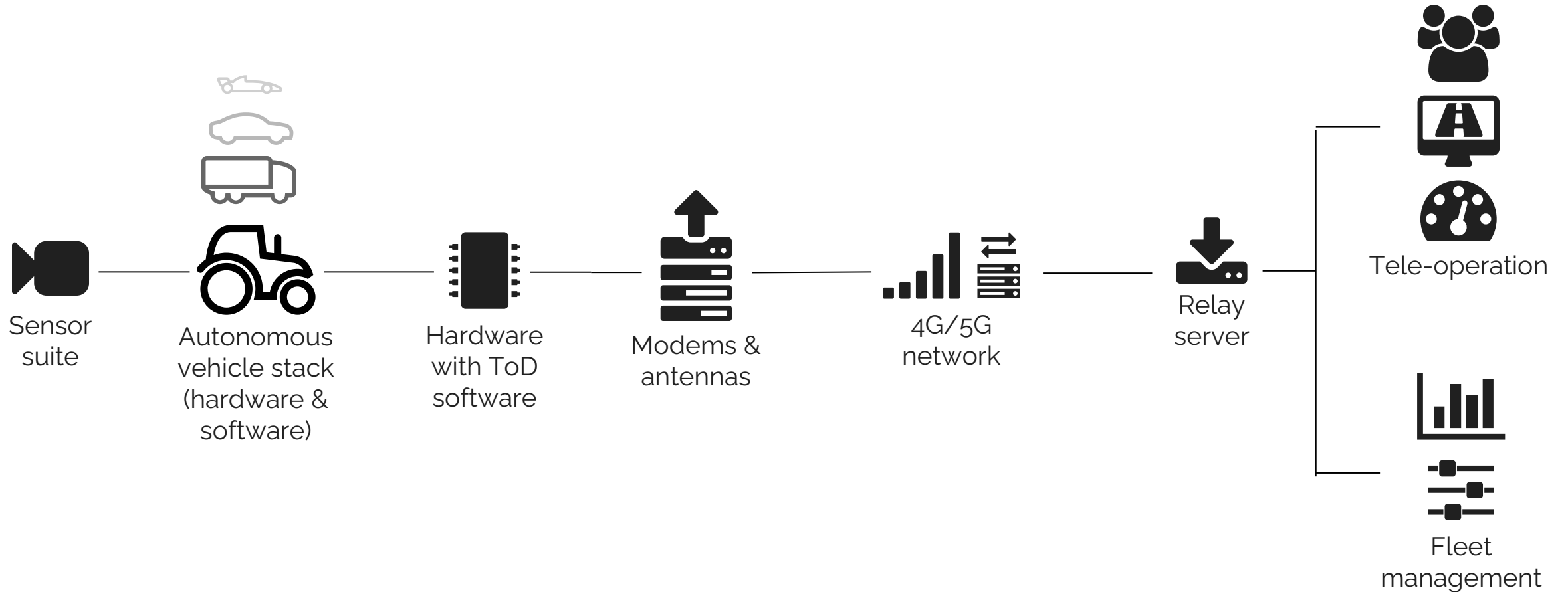


Overcoming Connectivity Challenges in ADAS/AD

Teleoperated Driving

Teleoperated Driving

Requirements for automated driving



Requirements for Teleoperated Driving



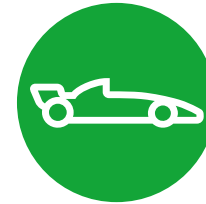
Stability

99.99%



Bandwidth

Up to 36Mb/s



Latency

Max 300ms roundtrip time

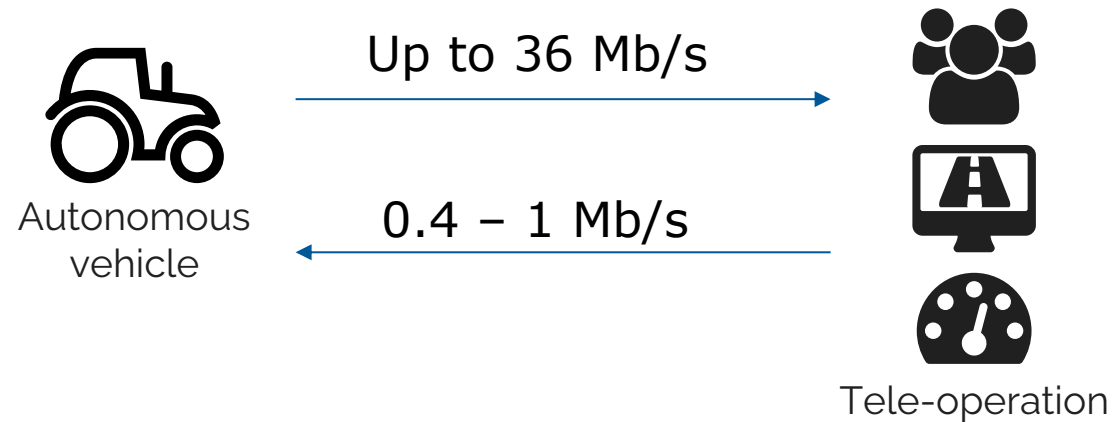
Stability

Requirements for automated driving

- **Coverage**
 - RSSI, RSRP, RSRQ
- **Packet loss**
 - percentage of data packets that fail to reach their destination
- **Jitter**
 - variation in the arrival time of data packets
- **Redundancy and Failover**
 - Multi WAN
 - Capacity Management

Bandwidth

Requirements for automated driving



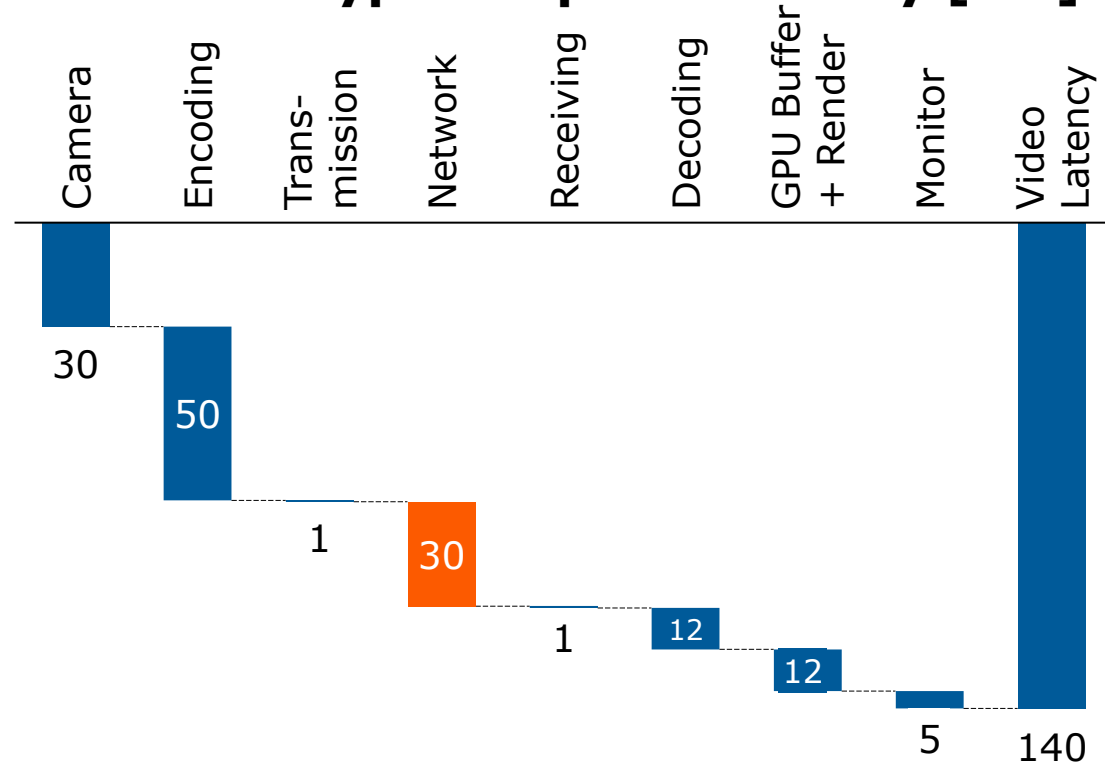
* nominal 8 Mb/s per stream, four streams in total = 32 Mb/s, with 3* front, 1* rear) + 4 Mb/s for object Data and sound

* Up to 1000 bytes per message (up to 400 Kb/s) as commands + voice

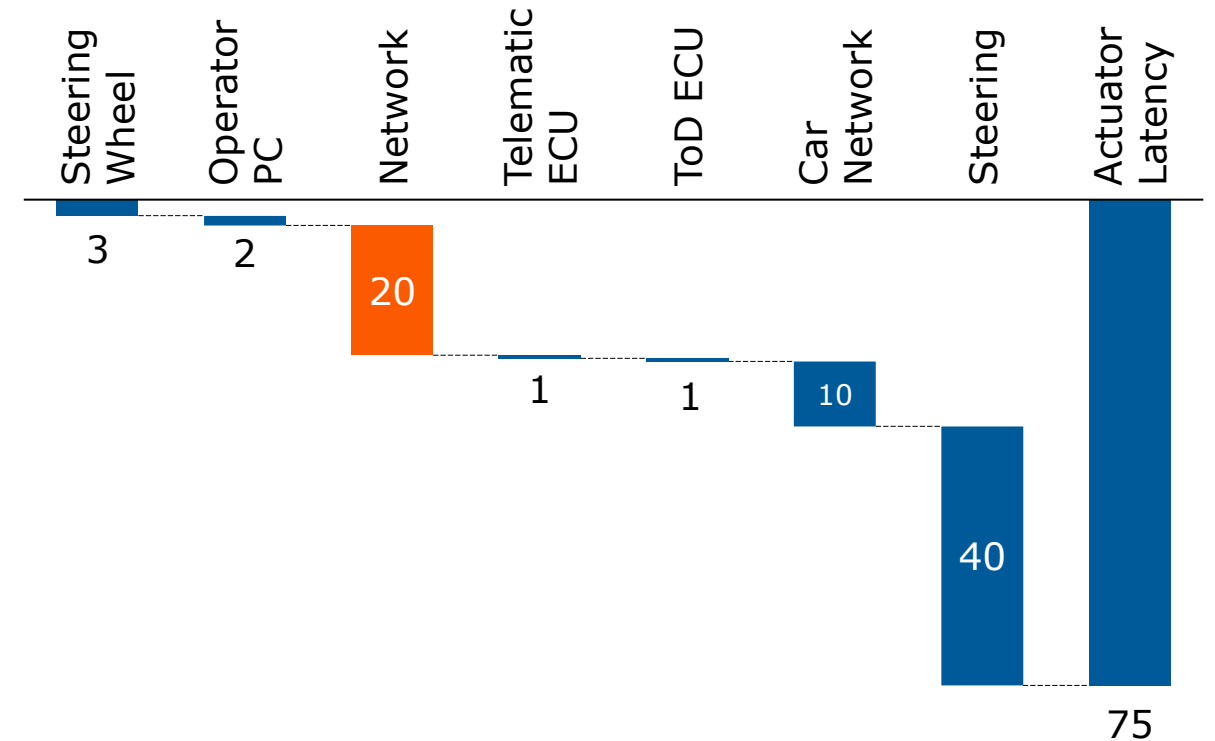
Latency

Requirements for automated driving

Typical Uplink Latency [ms]

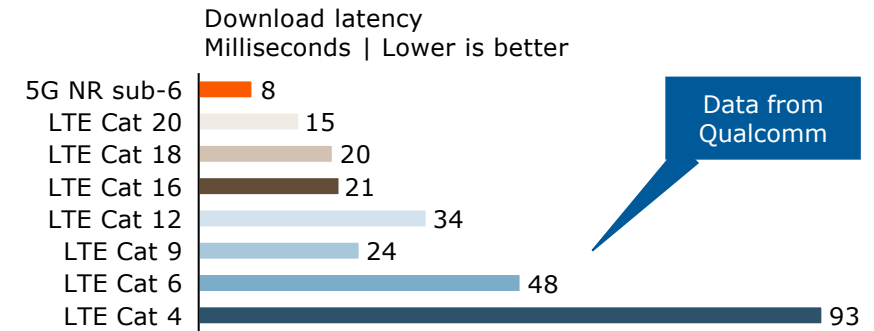
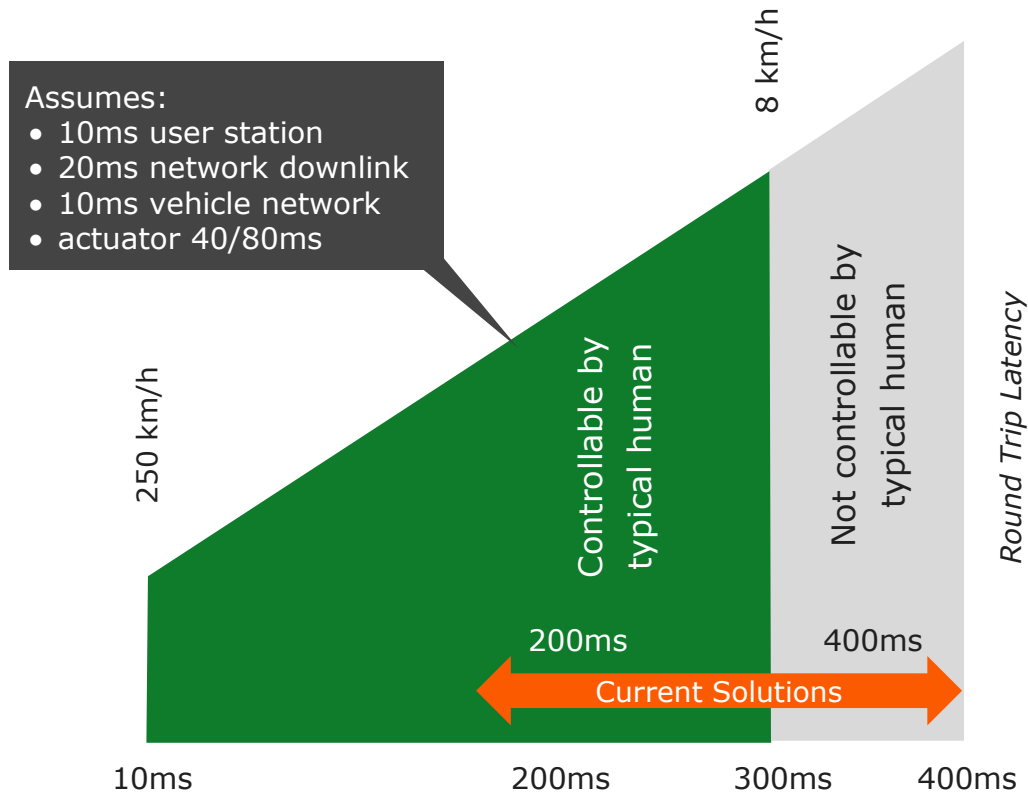


Typical Downlink Latency [ms]



Latency

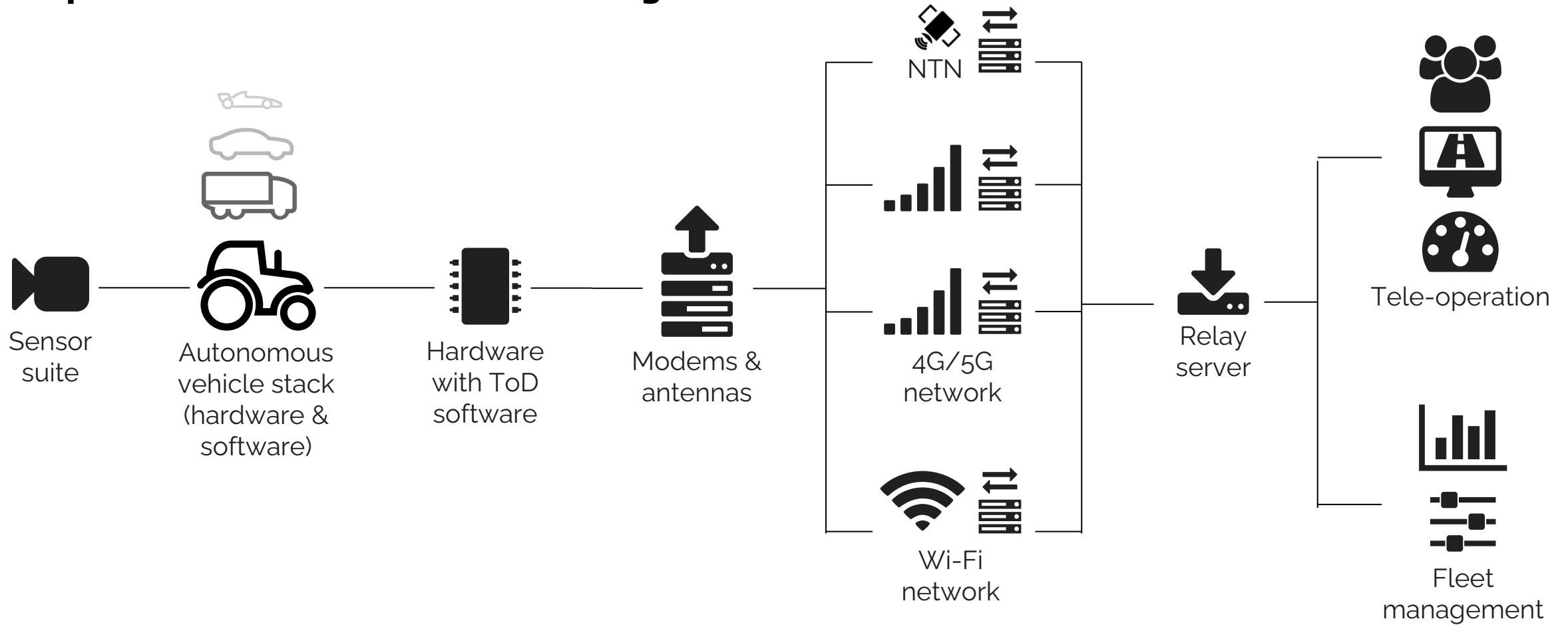
Requirements for ToD



*Qualcomm simulation of the 5G sub-6GHz band performance compared to LTE in Frankfurt

Teleoperated Driving

Requirements for automated driving



DTM Race Car

Teleoperated Driving



Source: <https://youtu.be/uh9Pp6wHho8>

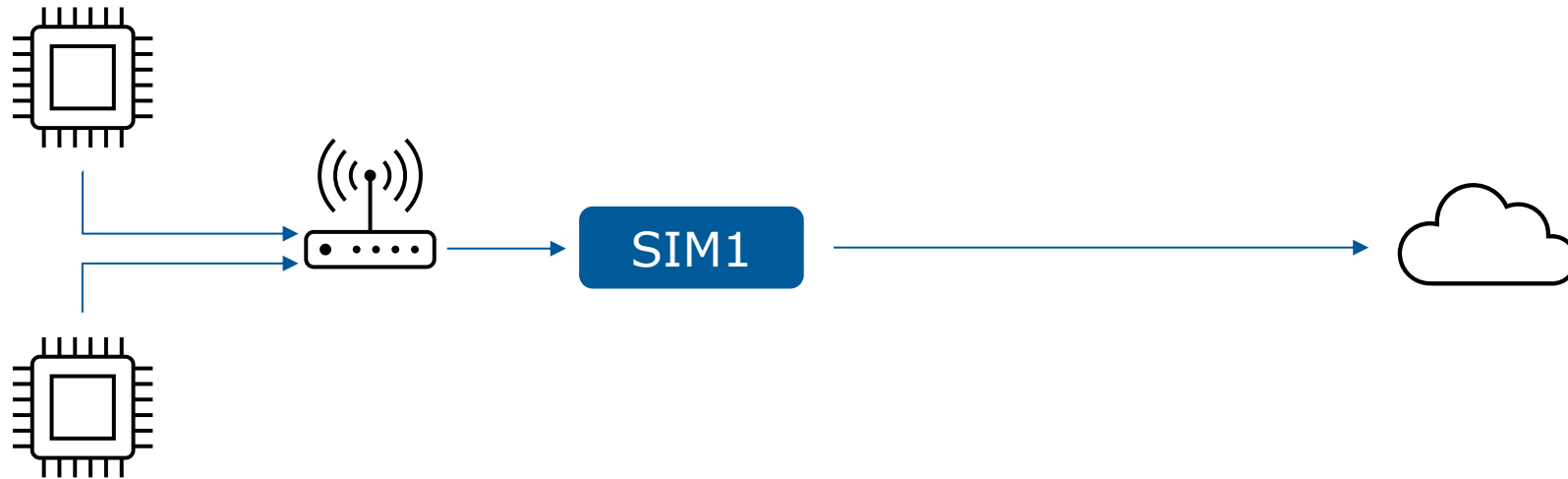


Overcoming Connectivity Challenges in ADAS/AD

Seamless connectivity with multi-WAN

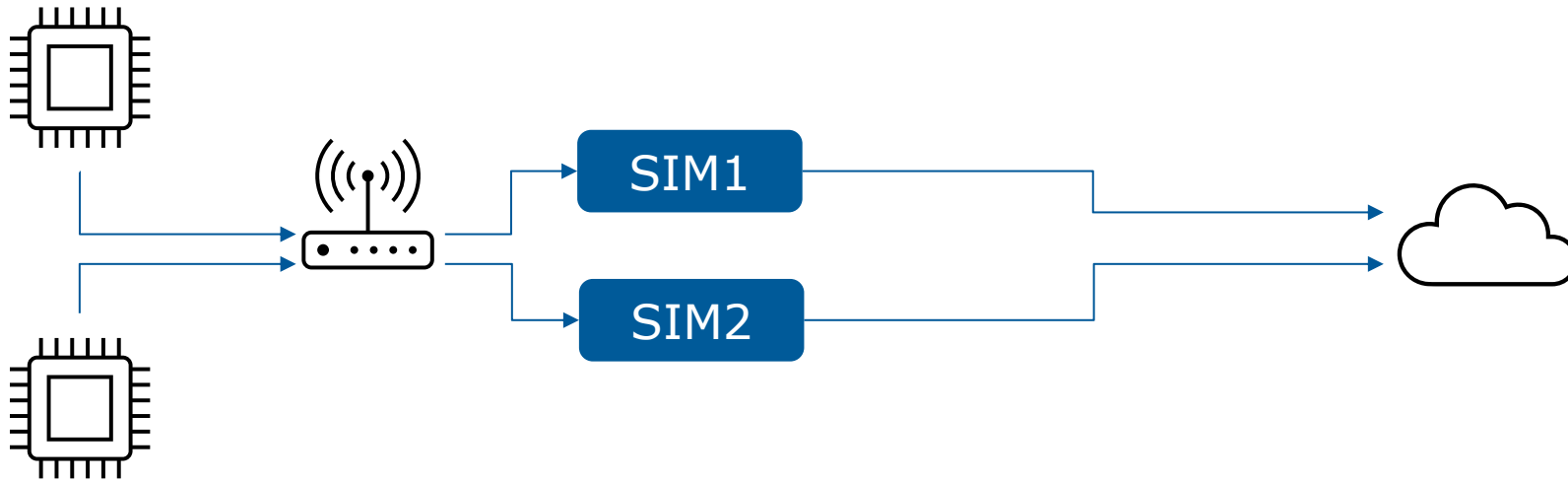
Multi WAN Strategies

Seamless connectivity with multi-WAN



Multi WAN Strategies

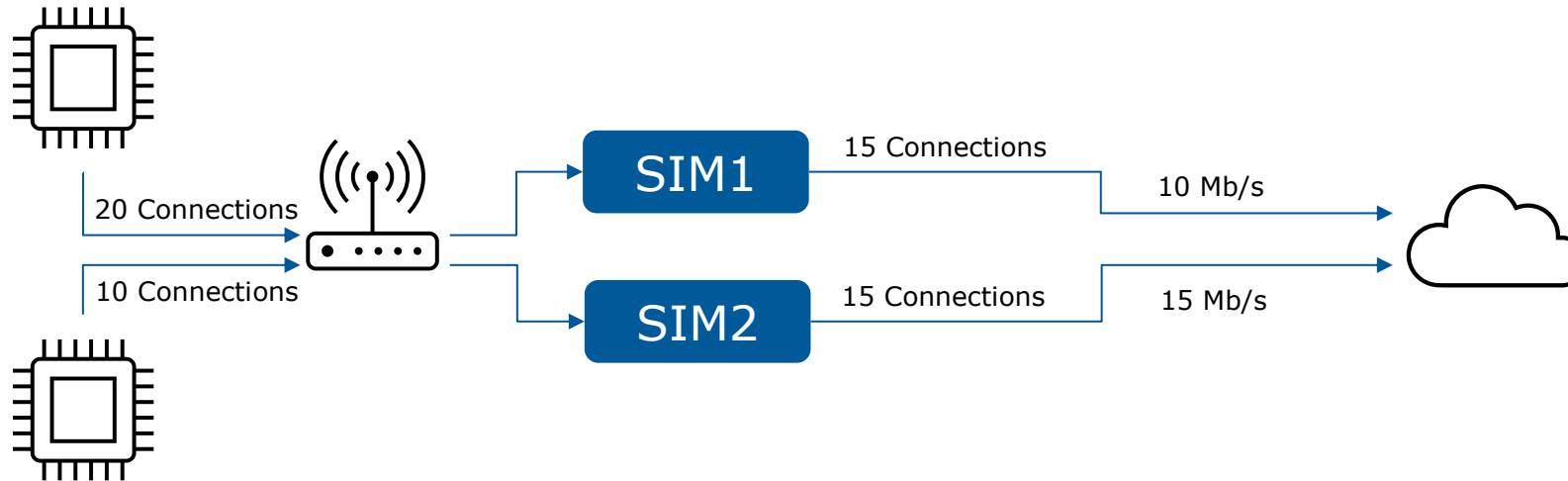
Seamless connectivity with multi-WAN



Load Balancing

Seamless connectivity with multi-WAN

Load Balancing

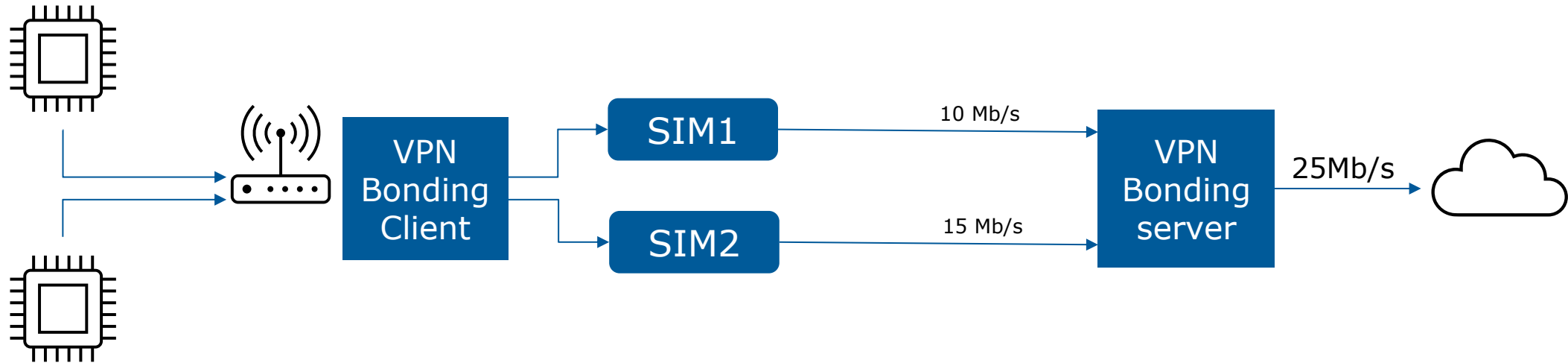


Problems when one connection brakes.
Max speed limited by used connection.

Bonding

Seamless connectivity with multi-WAN

Load Balancing



- No connection loss if a connection brakes
- Combines throughput
- QoS with route selection



Overcoming Connectivity Challenges in ADAS/AD

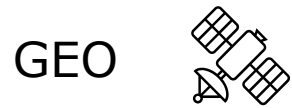
Satellite networks for vehicles

Satellite networks for vehicles

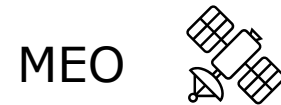
WHY?

For example, it is estimated that on main European roads **~12.4% of the time drivers have no connectivity**, especially in sparsely populated, often rural, areas. Broadband (4G+) coverage in Europe is not fully available within cellular coverage i.e., close to 7% of the time, drivers had no broadband (2G and 3G) service when travelling through rural areas.

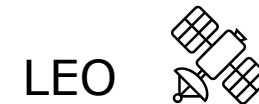
* ESA Automotive White Paper



Geostationary Earth Orbit
- 250 – 600ms



Medium Earth Orbit
- 100 – 150ms



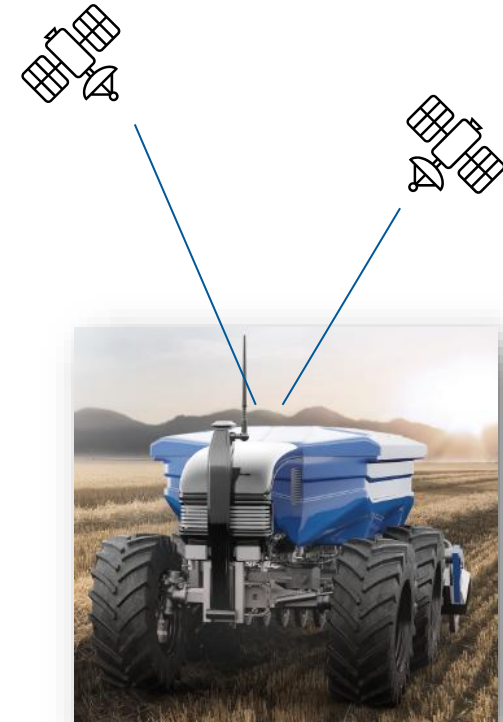
LOWER Orbit → lower latency and
more bandwidth → bigger antennas

Low Earth Orbit
- 20 – 40ms

Project

Satellite based Teleoperated Driving

- Add a seamless connectivity solution with satellite and mobile network to our eTractor platform
- Status:
 - Project have a delay – so I can't show results now. But soon ;)
- Project support partner:
 - Unio Enterprise for the sat communication system





Overcoming Connectivity Challenges in ADAS/AD

Key Take aways

Key finding

Overcoming Connectivity Challenges in ADAS/AD

- **Seamless and fast connectivity is a must have for:**

- ADAS / AD features like Teleoperated Driving
- Satisfying user experience

- **It can be achieved with:**

- Multi mobile connection
- Additional satellite connectivity
- Multi WAN handling

- With the best Engineering Service by AVL

AVL Benefits

Benchmarking incl. Market Trend

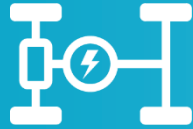


ECU and Vehicle
Benchmarking
Incl. Paper based
analysis



Worldwide Network

Development Prototypes / SOP



Prototype and
Concept
Development



Definition and
development of
Connectivity SOP
solutions

Integration and Testing



ECU and vehicle,
integration and
testing



System and sub-
system testing, incl.
automation

Accompanying Items



Wireless
certification and
homologation



Safety and Security
architecture for
complete vehicle



Overcoming Connectivity Challenges in ADAS/AD

Q&A

Contact



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