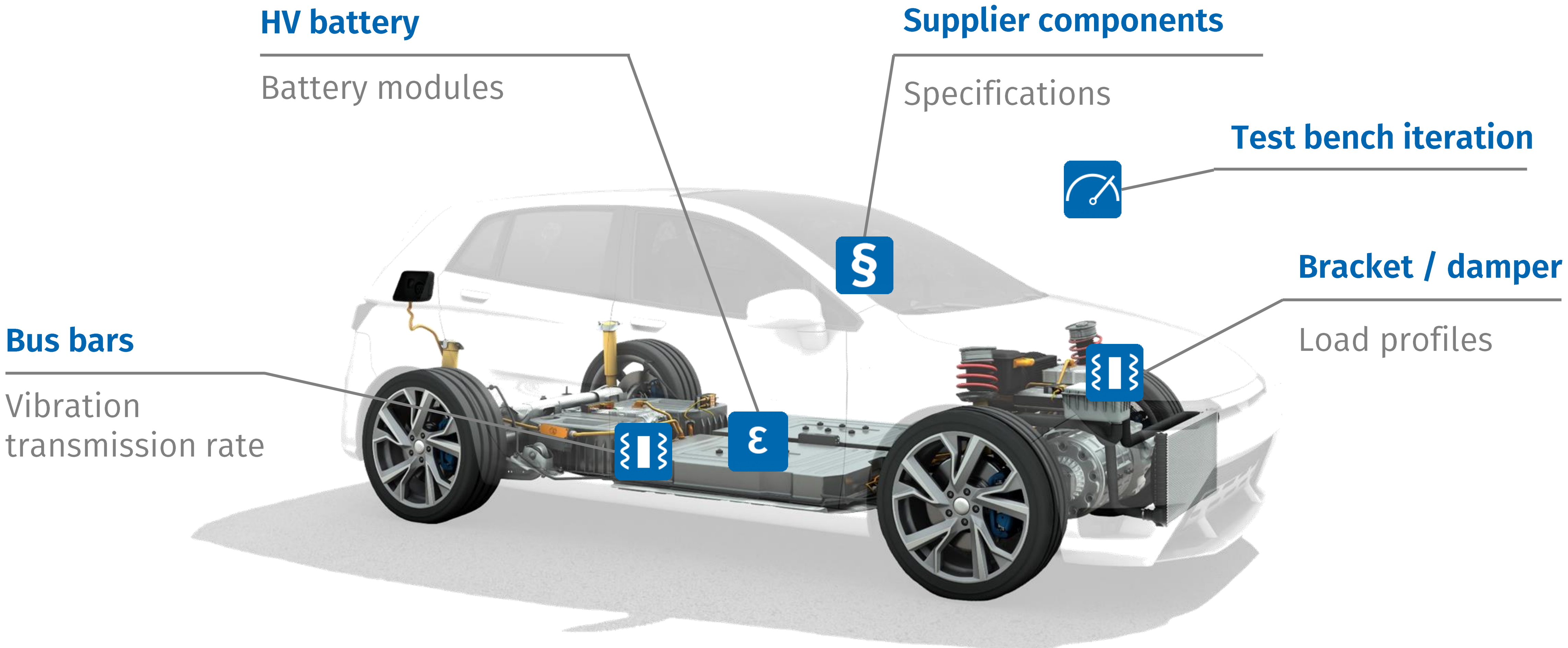
Durability measurement in e-mobility

CSM Web Seminars

CSM Xplained
measurement technology

Innovative Measurement and Data Technology

Durability measurement in e-mobility



Durability measurement in e-mobility

Objectives of durability measurements

- Reduction of the mass of a component
  - Less fuel consumption
  - Less material consumption
  - Lower manufacturing costs
  - More payload
- Ensuring the function of the component
- Reliable function of the component over the entire service life (no failures)

What are mechanical loads?

- In engineering mechanics, a load is the **sum of all forces** affecting a component from the outside.
- External forces always result in **internal stress.**
- Internal stress leads to mechanical tension or compression in the component.

Mechanical loads reduce the lifetime of a component.

What are r

▶ In engineeri

▶ External stre

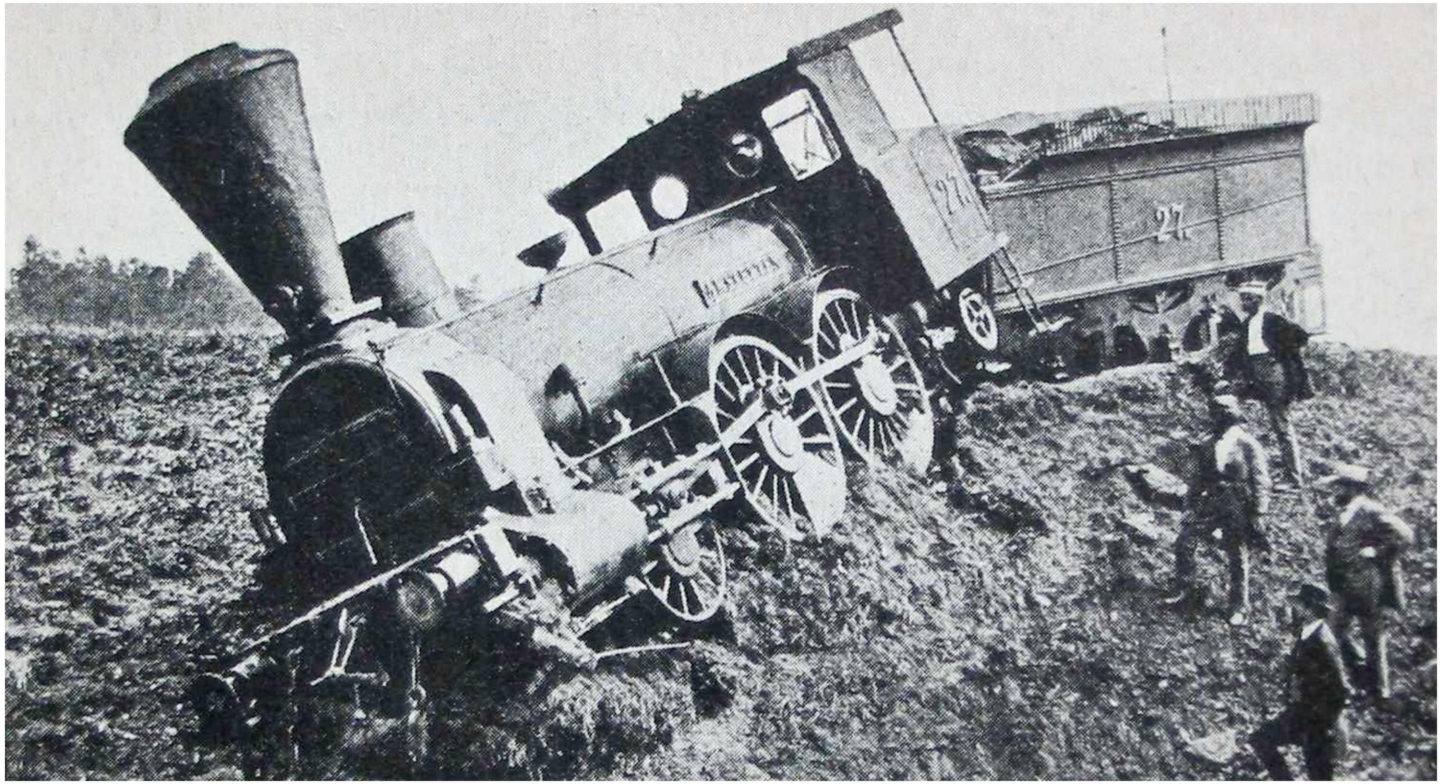
▶ Stress becor

Mechanical lo

Observation over time

Railroad accident at Timelkam, Germany (19th October 1875)

▶ Breakage of a wheel, which should have been able to withstand the (static) load



Railroad accident at Timelkam (Museumsführer des Deutschen Museums in München, https://upload.wikimedia.org/wikipedia/commons/4/46/Amstetten.jpg)

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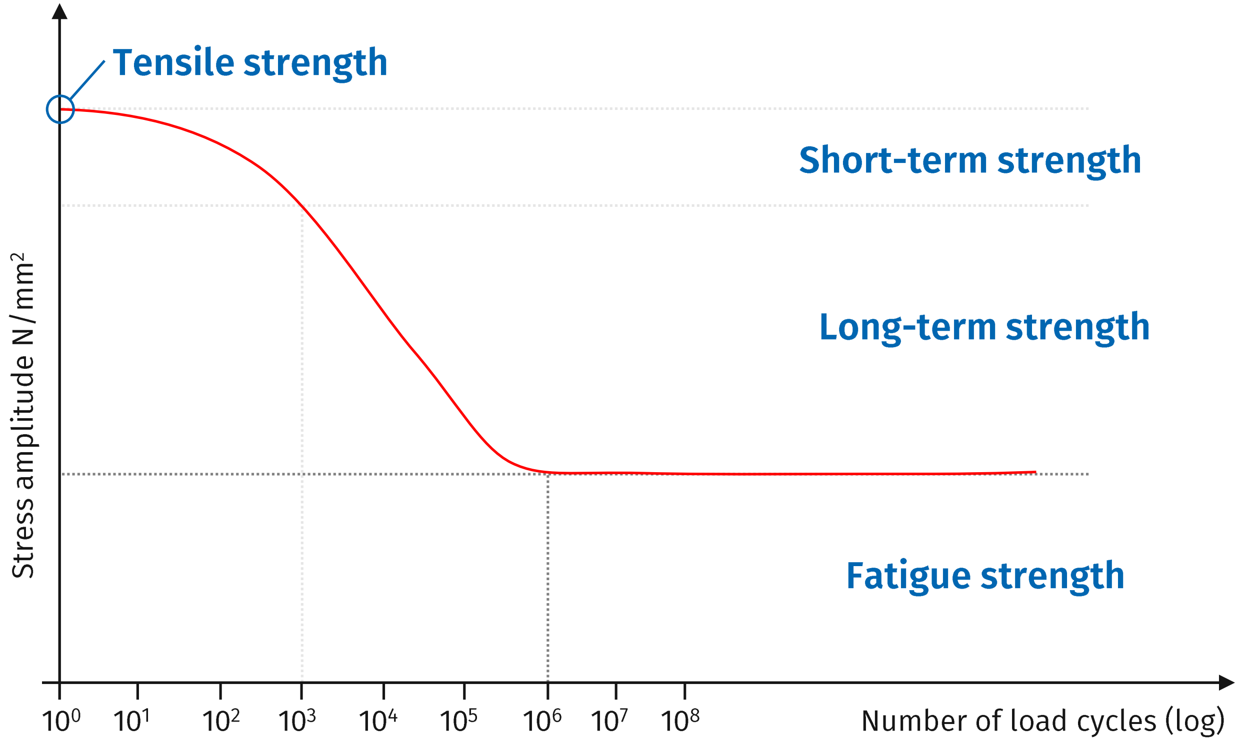
- Breakage of a wheel, which should have been able to withstand the (static) load
- Fatigue research by August Wöhler



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Observation over time

Railroad accident at Timelkam (19th October 1875)

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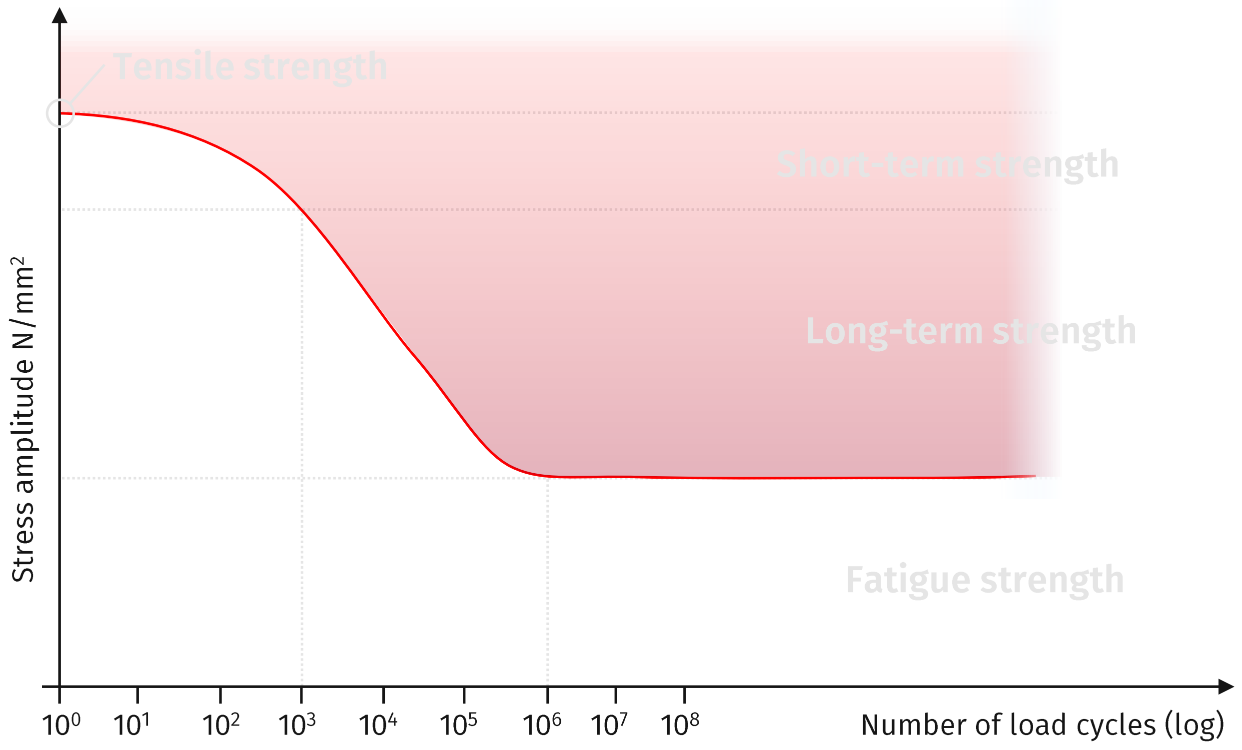
Load above the Wöhler line:

- Material breakage



Component loads

How do I classify mechanical loads and their influence on components?

How do I design components?

- Short-term strength
- Long-term strength
- Fatigue strength

Screw with predetermined breaking head

Paper clip

HV-safe connector

Roman Bridge at Nebi Huri (Bertramz, https://commons.wikimedia.org/wiki/File:Afrin,Huri.jpg)

Roman bridge

Requirements for the strength of a component

The assignment to the categories results from the following requirements:

- **Design specifications of the component (size, mass, appearance, material)**

Requirem

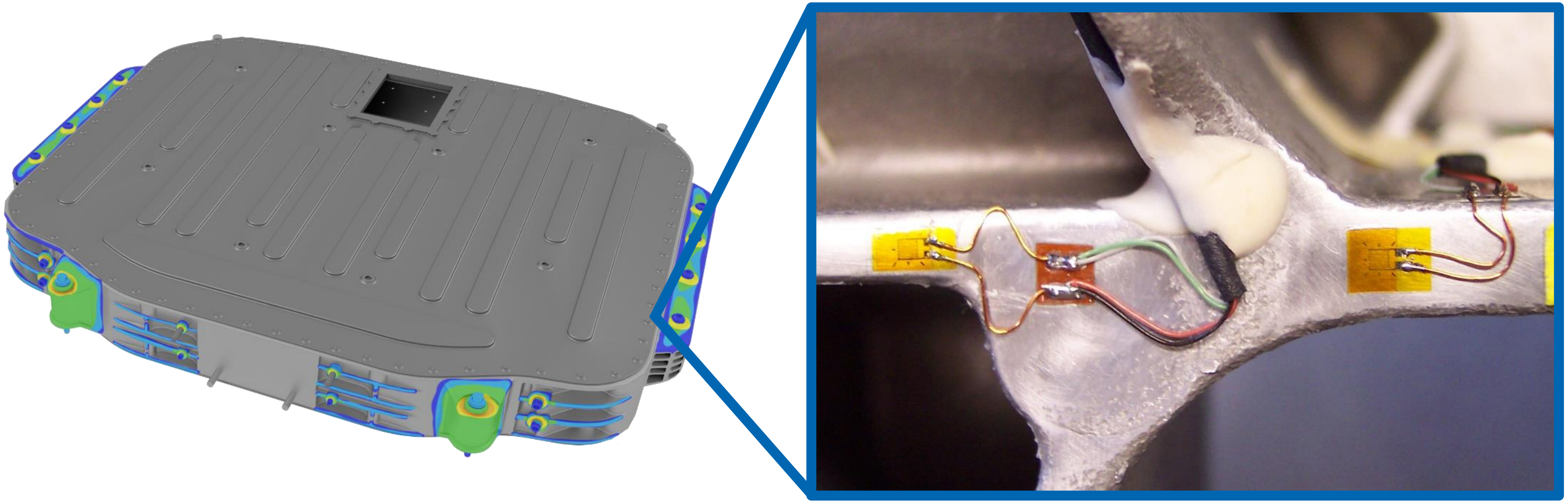
The assignment

▶ Design speci

Material and construction of the component

Example of a target design: Lightweight and stable

- Interaction of calculation and measurement results in the usable overall picture



Requirements for the strength of a component

The assignment to the categories results from the following requirements:

- Design specifications of the component (size, mass, appearance, material)
- **Use of the component**

Requireme

The assignmen

- Design speci
- Use of the c

Use of the component

Example: Footbridge Max-Eyth-See

Max-Eyth-Steg (kanakari, https://upload.wikimedia.org/wikipedia/commons/2/26/Max-Eyth-Steg%2C_Stuttgart.JPG)

Requirements for the strength of a component

The assignment to the categories results from the following requirements:

- Design specifications of the component (size, mass, appearance, material)
- Use of the component
- **Stress generated by the user**

Requirem

The assignment

- Design speci
- Use of the c
- Stress gener

Stress generated by the user

Example: "Automotive user" customer profiles

Type	Characteristics
Urban commuter	Stop and go, low speeds, AC on, electrical consumers on
Highway Commuter	High speeds, high gears
Leisure athlete	High trailer use, high load
Sports driver	Mostly on race tracks
Off-Road Drivers	Intended use ? (abuse limit)

Requirements for the strength of a component

The assignment to the categories results from the following requirements:

- Design specifications of the component (size, mass, appearance, material)
- Use of the component
- Stress generated by the user
- **How much overload (misuse) is allowed, respectively must the component withstand?**

Requirements for the strength of a component

The assignment to the categories results from the following requirements:

- Design specifications of the component (size, mass, appearance, material)
- Use of the component
- Stress generated by the user
- How much overload (misuse) is allowed, respectively must the component withstand?
- **Load duration and service life of the component**

Fatigue strength HV battery housing

Objectives

- ▶ Ensuring safety
- ▶ Optimal material design

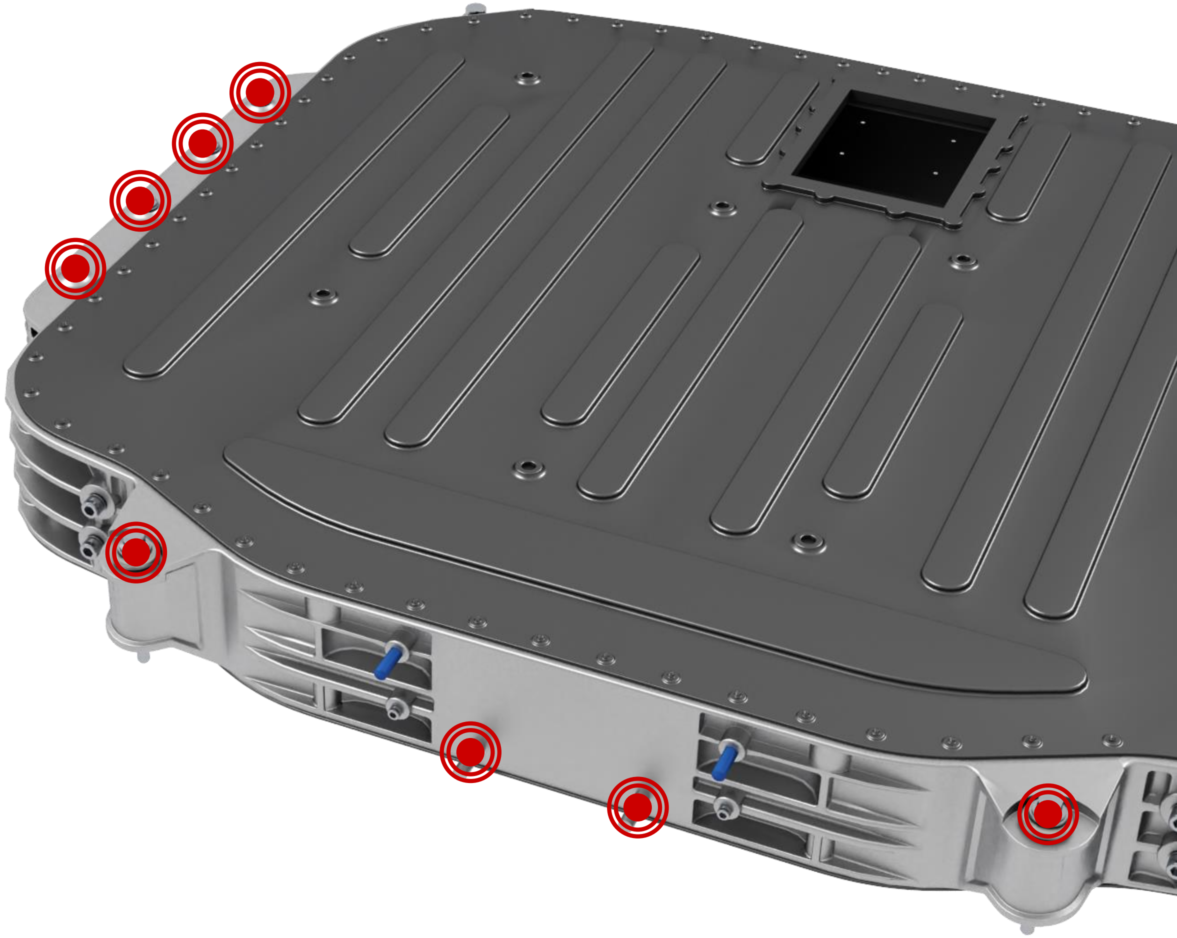
Fatigue strength HV battery housing

Objectives

- Ensuring safety
- Optimal material design

Mechanical stresses

- Outside
  - Torsion caused by stresses in the vehicle frame



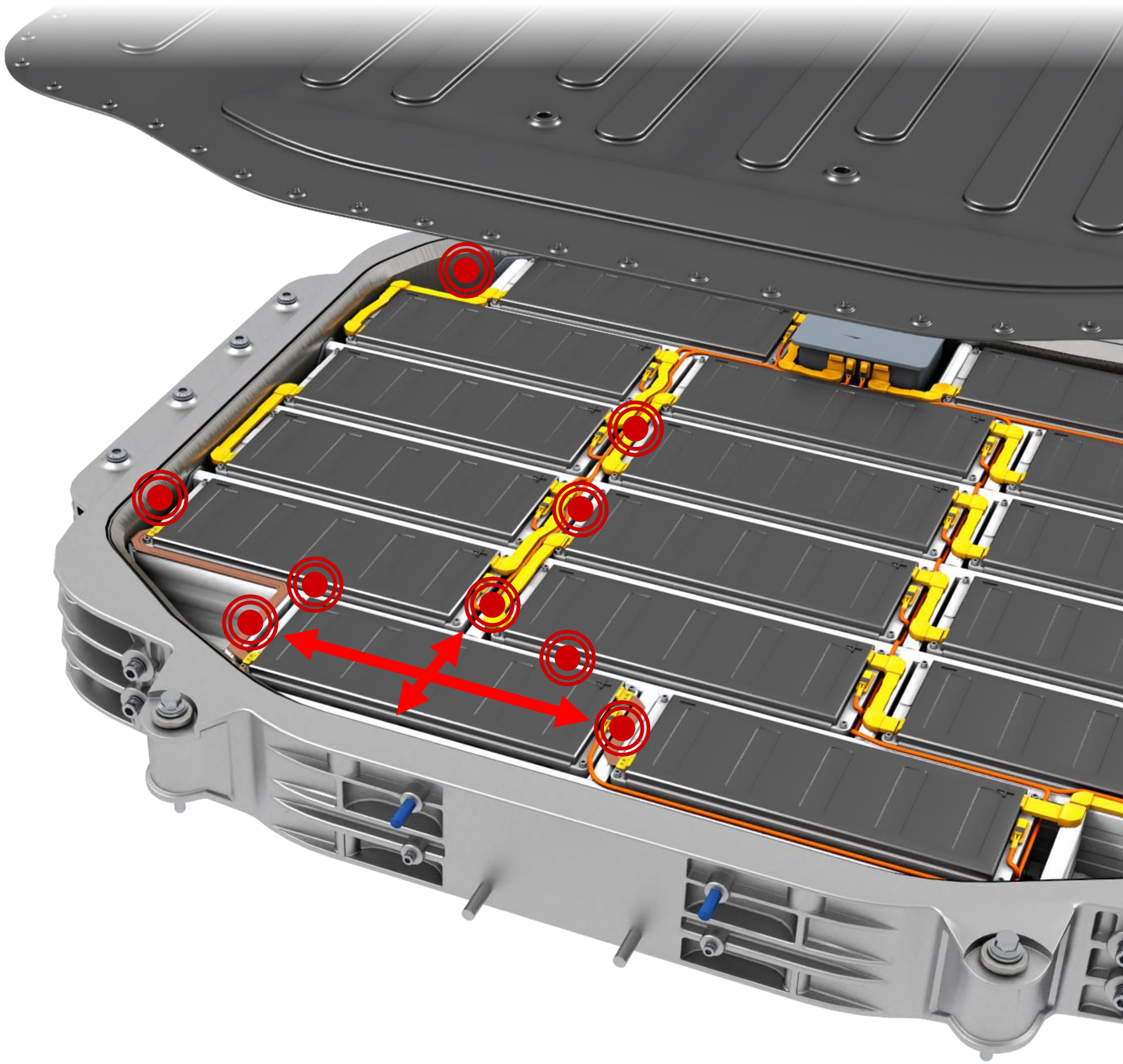
Fatigue strength HV battery housing

Objectives

- Ensuring safety
- Optimal material design

Mechanical stresses

- Outside
  - Torsion caused by stresses in the vehicle frame
- Inside
  - Expansion of the battery cells during operation



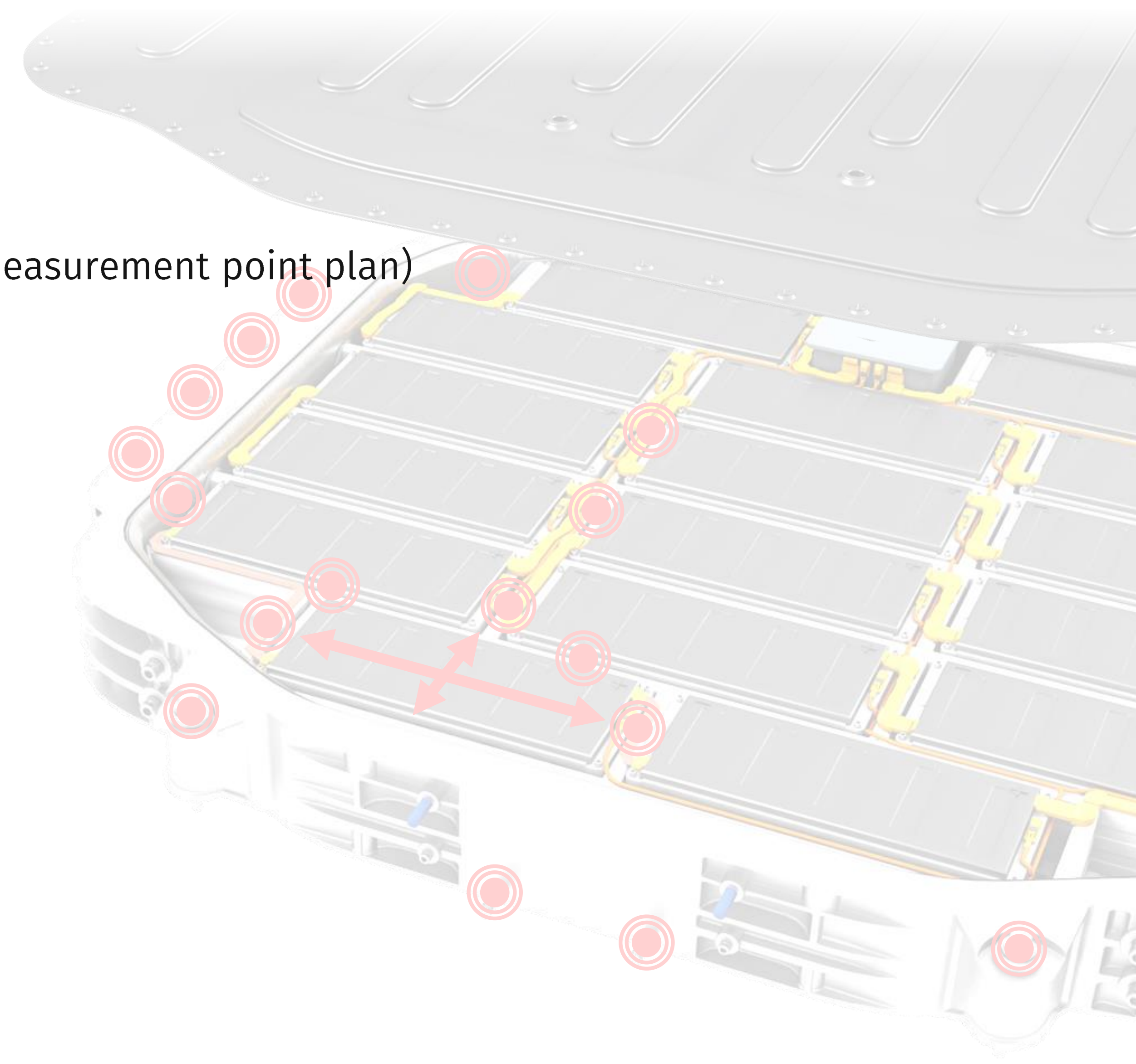
Determining the component loads

Approach

- Installation of sensors at defined measurement points (measurement point plan)
- Test profiles for the road test
- Comparison of the measurement data

Thus

- Comparison of test drives
- Statement about the service life of components
- Iteration on the test bench
- What is the benefit of a constructive modification?



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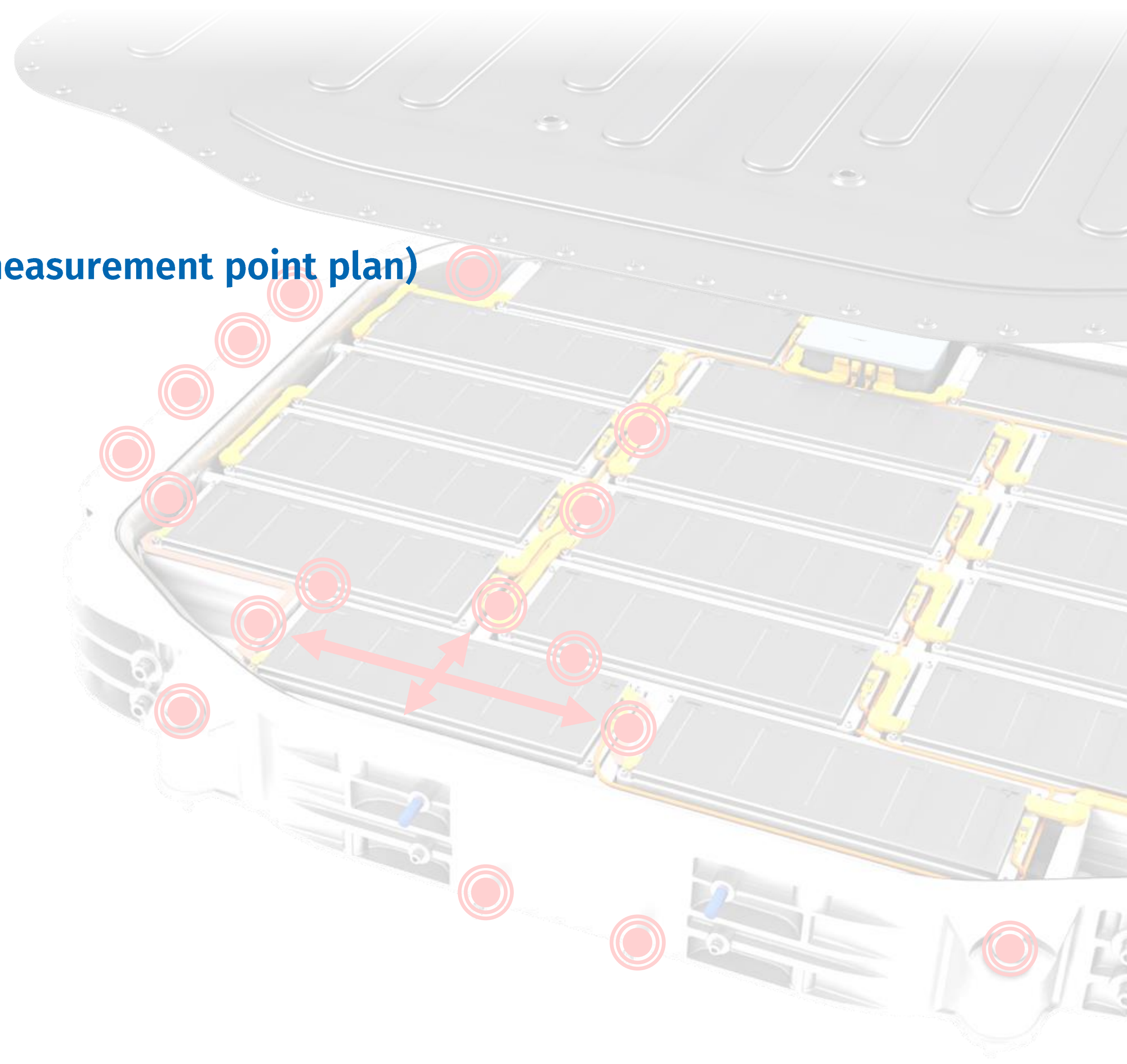


Sensor technology - How do I measure component loads?

Values affecting the component :

- Temperatures
- Acceleration
- Forces

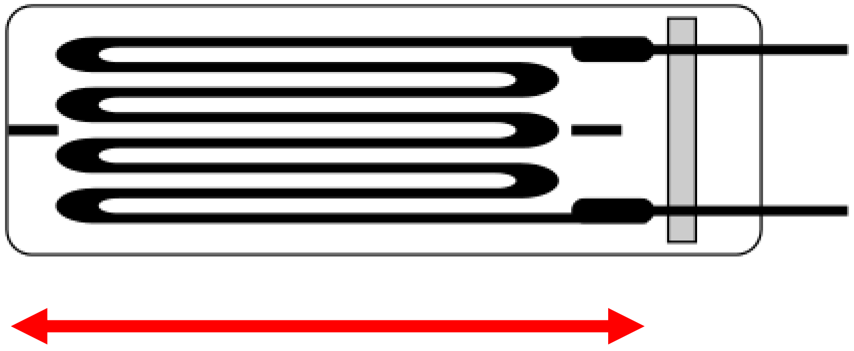
Values for the determination of the load:

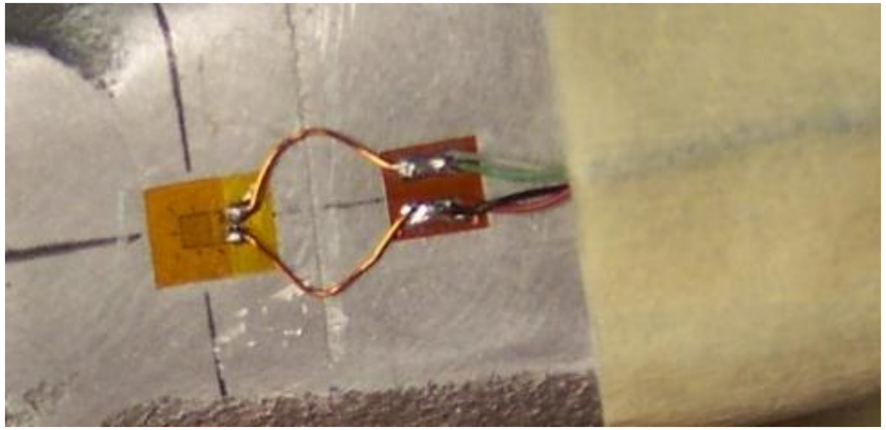
- Strain
- Acceleration
- Forces
- Distance

Operational or secondary measurands

(Temperatures, RPM, load, speed, loading, GPS, weather,...)

Sensors - Strain gauges





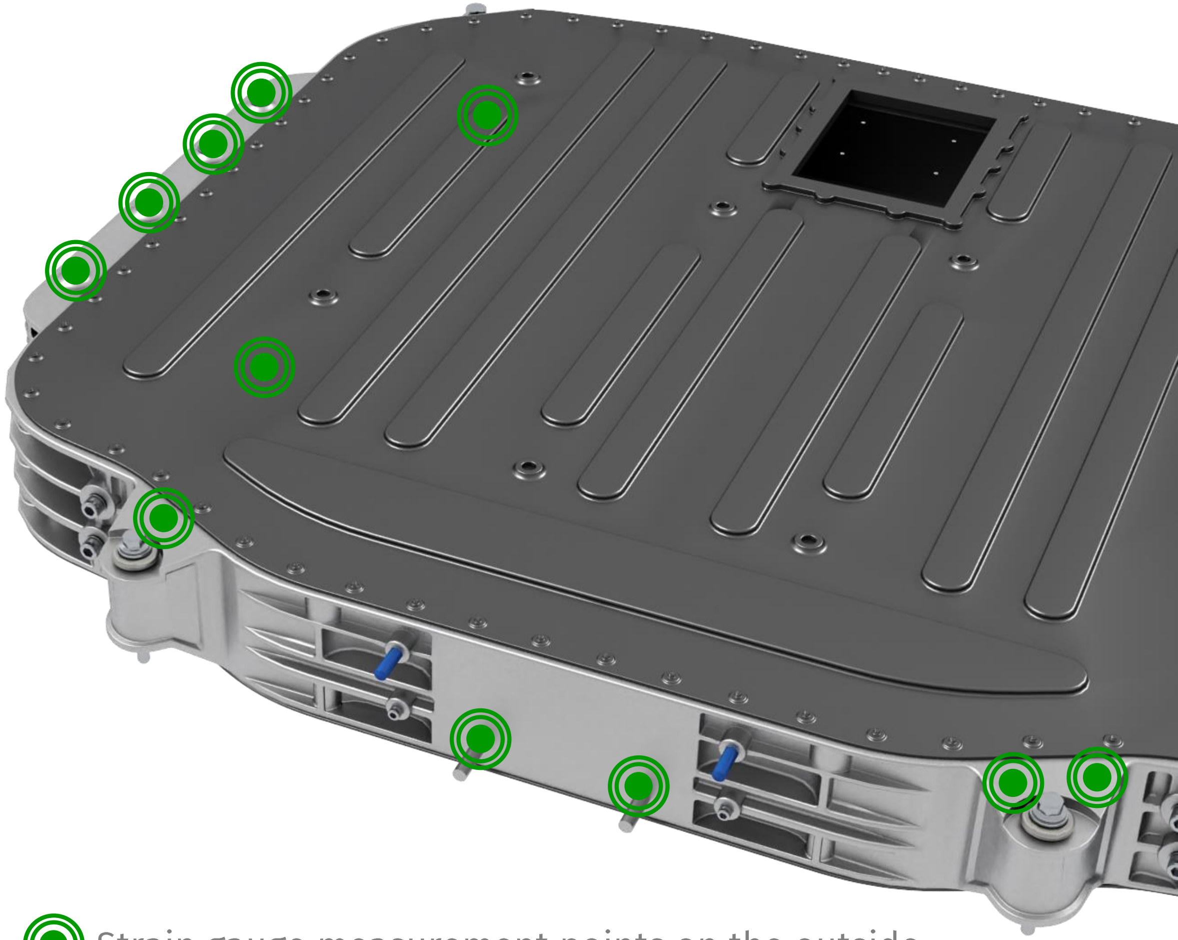
Compressed: R becomes smaller

Initial state: R = R0

Stretched: R becomes larger

Durability HV battery housing

- Mech. Strains
  on the outside



Strain gauge measurement points on the outside

Suitable measurement modules for strain (in environments up to 60 V)

Example: CSM STG measurement modules

ε

- Quarter, half and full bridges
- Measuring unit: mV/V, µm/m, µε
- Measurement data rate (per channel): Up to 20 kHz
- IP67
- TEDS

- EtherCAT®: many synchronized measurement channels

STG6 BK10

CAN STG
Mini Modules on
www.csm.de

ECAT STG6 pro BS20

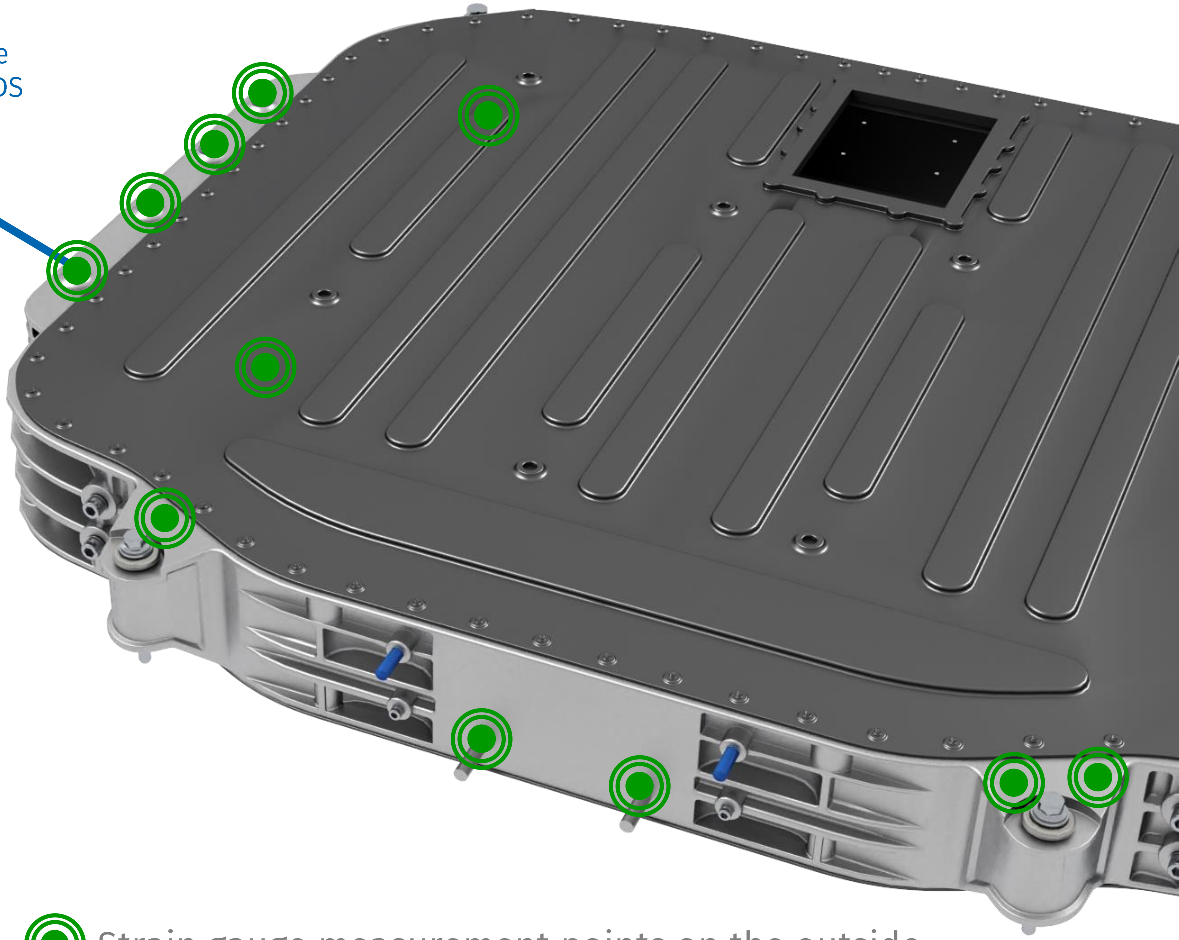
ECAT STG
Mini Modules on
www.csm.de

Durability HV battery housing

- Mech. strains on the outside

ECAT STG6 pro BS20

Sensor cable
K356 with TEDS



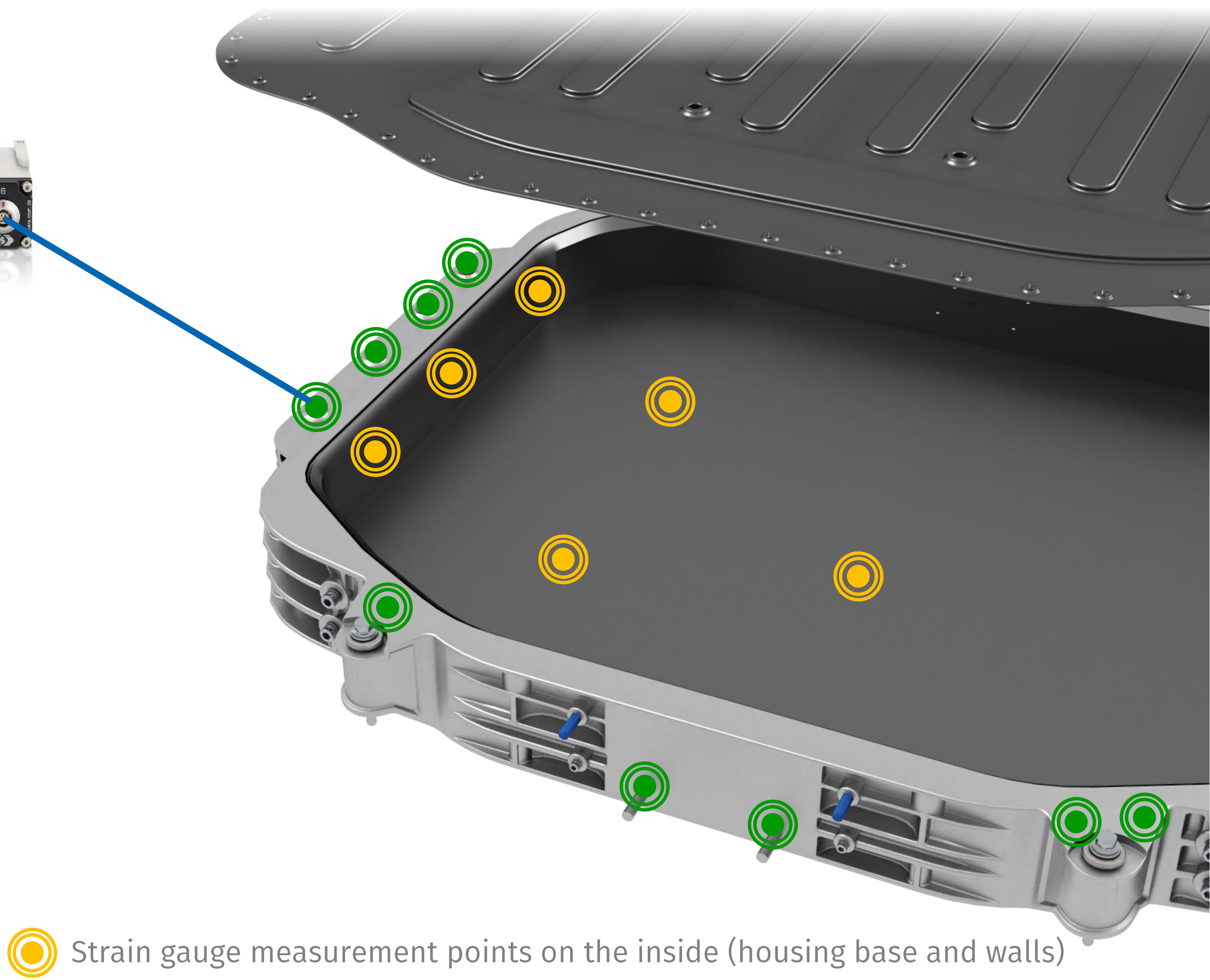
Strain gauge measurement points on the outside

Durability HV battery housing

- Mech. strains on the outside

ECAT STG6 pro BS20

- Mech. strains in battery housing



Suitable measurement modules for strain (in environments up to 1,000 V DC)

Example: CSM HV STG measurement module

ε

- Quarter, half and full bridges
- Measuring unit: mV/V, µm/m, µε
- Measurement data rate (per channel): Up to 20 kHz
- Extended input voltage range
- IP67

HV STG4 pro BS20

HV STG Measurement Modules on www.csm.de

- HV-safe connector
- Mechanical connector routing for tightness and bend protection
- Reinforced insulation 1,000 V
- Type-tested according to safety standard EN61010 by accredited test laboratory
- Unit test with certificate
- 3,100 V ramp 5 sec each

Durability HV battery housing

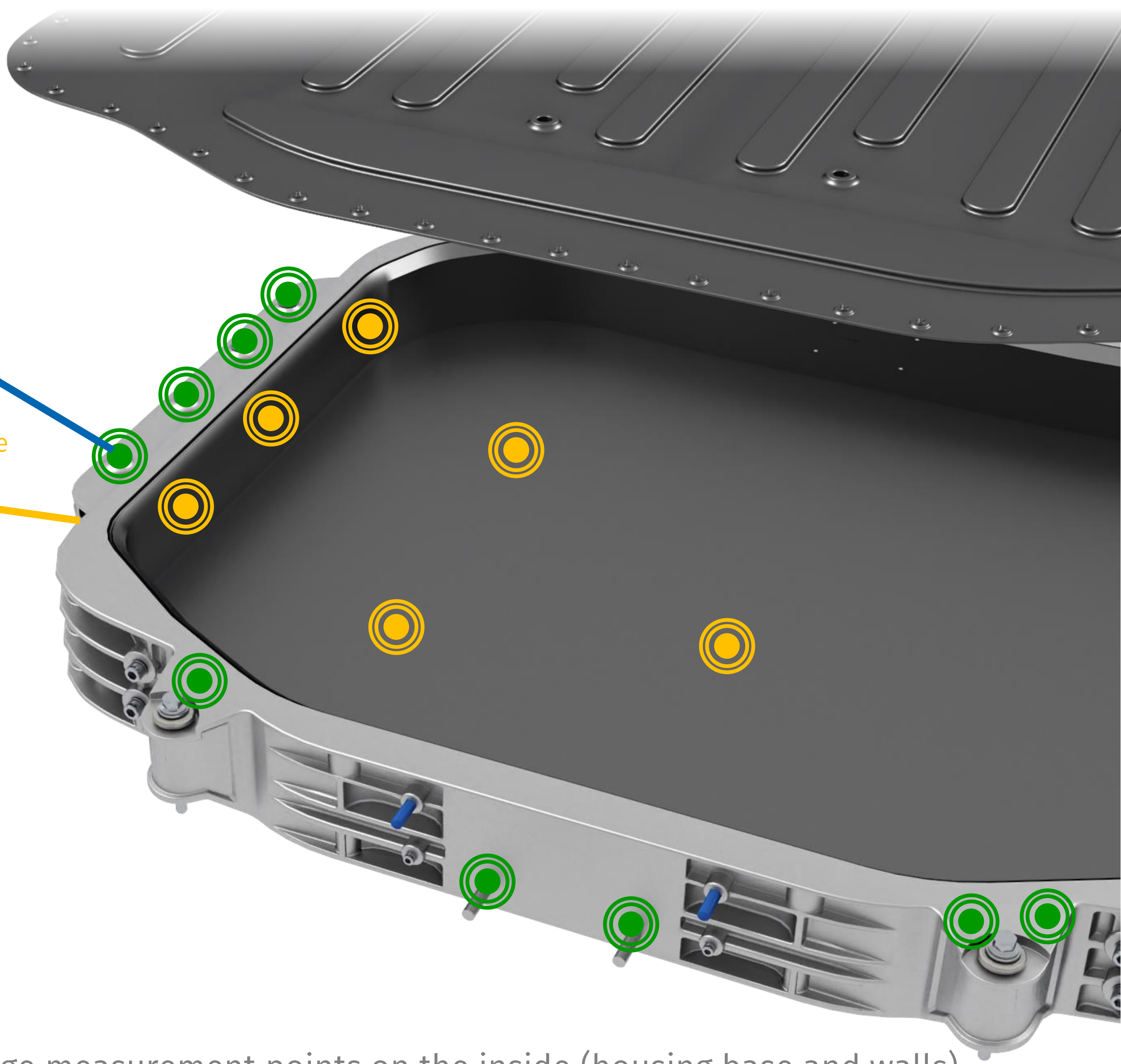
- Mech. strains on the outside

ECAT STG6 pro BS20

- Mech. strains in battery housing

HV STG4 pro BS20

HV-safe cable K980



Strain gauge measurement points on the inside (housing base and walls)

Durability HV battery housing

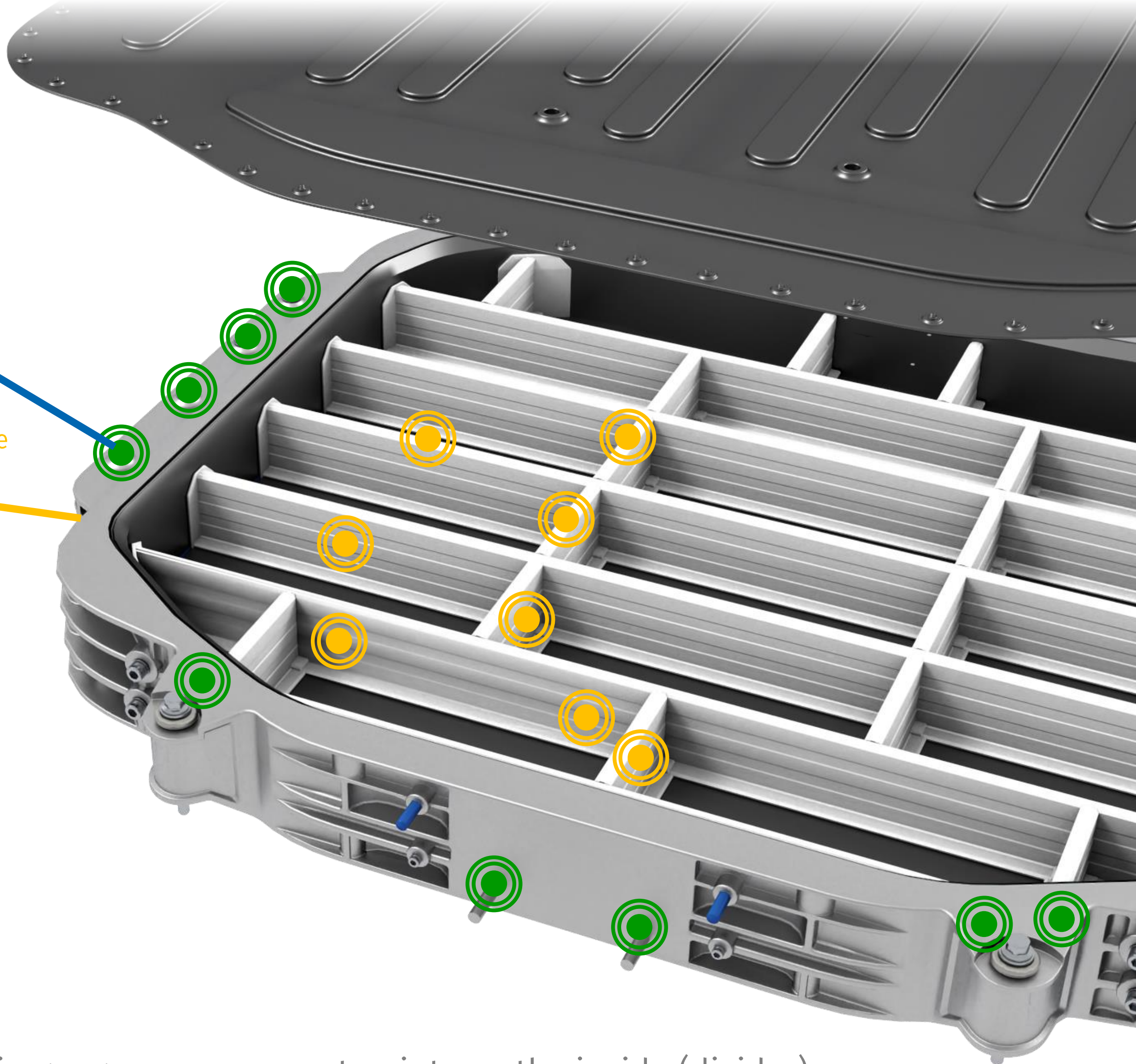
- Mech. strains
  on the outside

- Mech. strains
  in battery housing

ECAT STG6 pro BS20

HV STG4 pro BS20

HV-safe cable
K980



Strain gauge measurement points on the inside (divider)

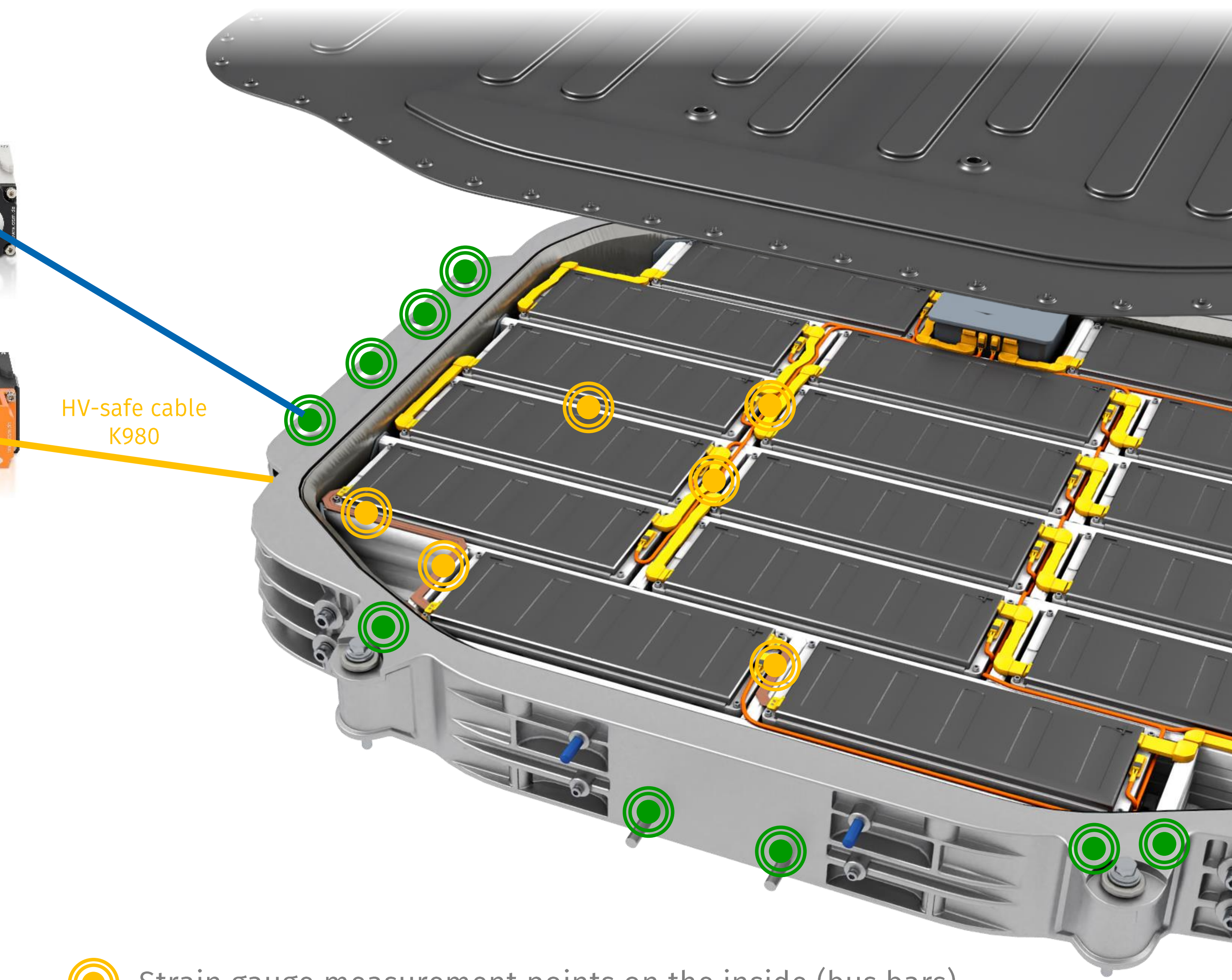
Durability HV battery housing

- Mech. strains
  on the outside

ECAT STG6 pro BS20

- Mech. strains
  in battery housing

HV STG4 pro BS20



Strain gauge measurement points on the inside (bus bars)

Sensor technology - How do I measure component loads?

Values affecting the component :

- Temperatures
- Acceleration
- Forces

Values for the determination of the load:

- Strain
- Acceleration
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- Distance

Operational or secondary measurands

(Temperatures, RPM, load, speed, load, GPS, weather,...)

Durability HV battery housing

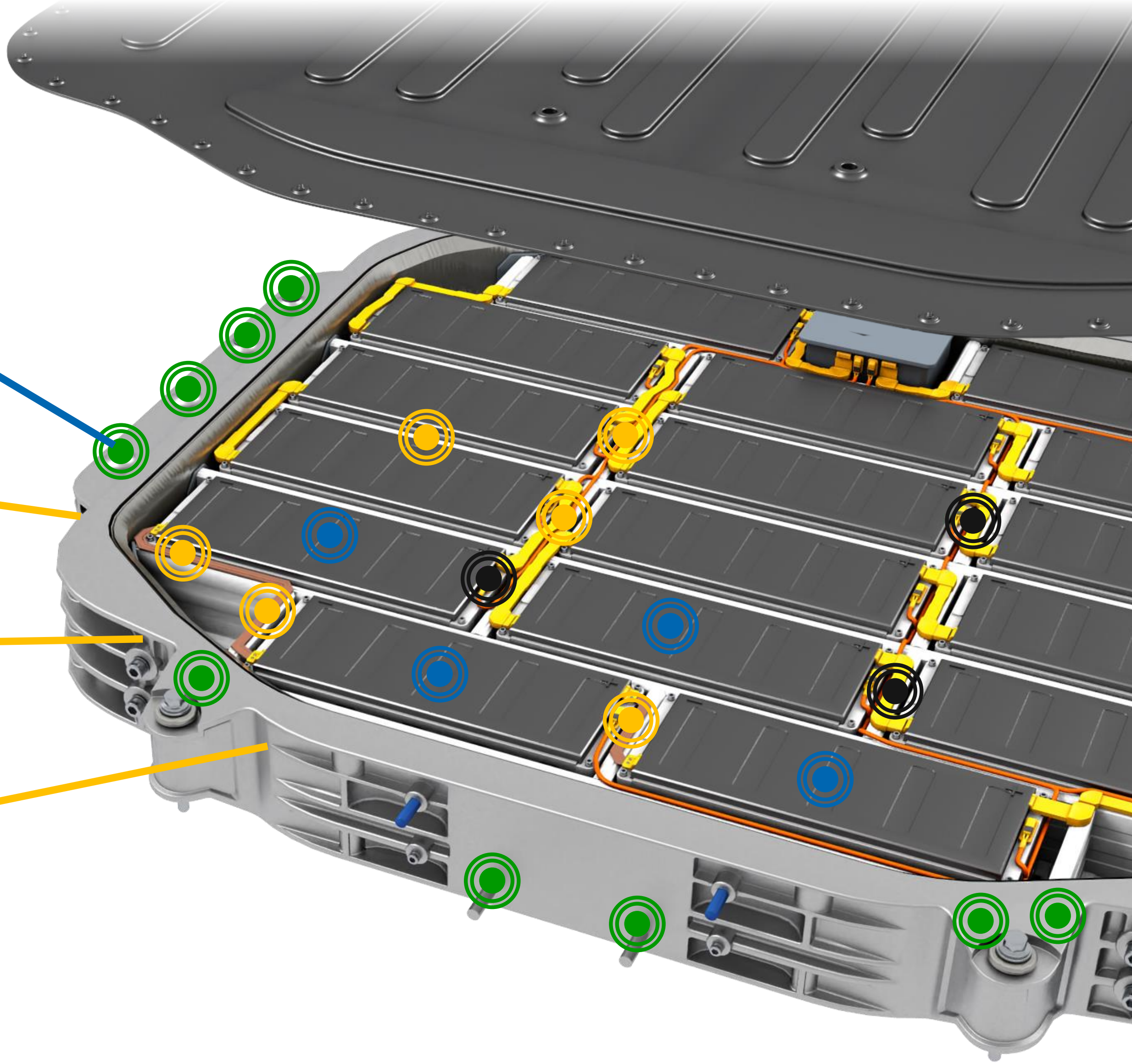
- Mech. strains
  on the outside
- Mech. strains
  in battery housing
- Acceleration
  inside the housing
- Temperatures
  inside the housing

ECAT STG6 pro BS20

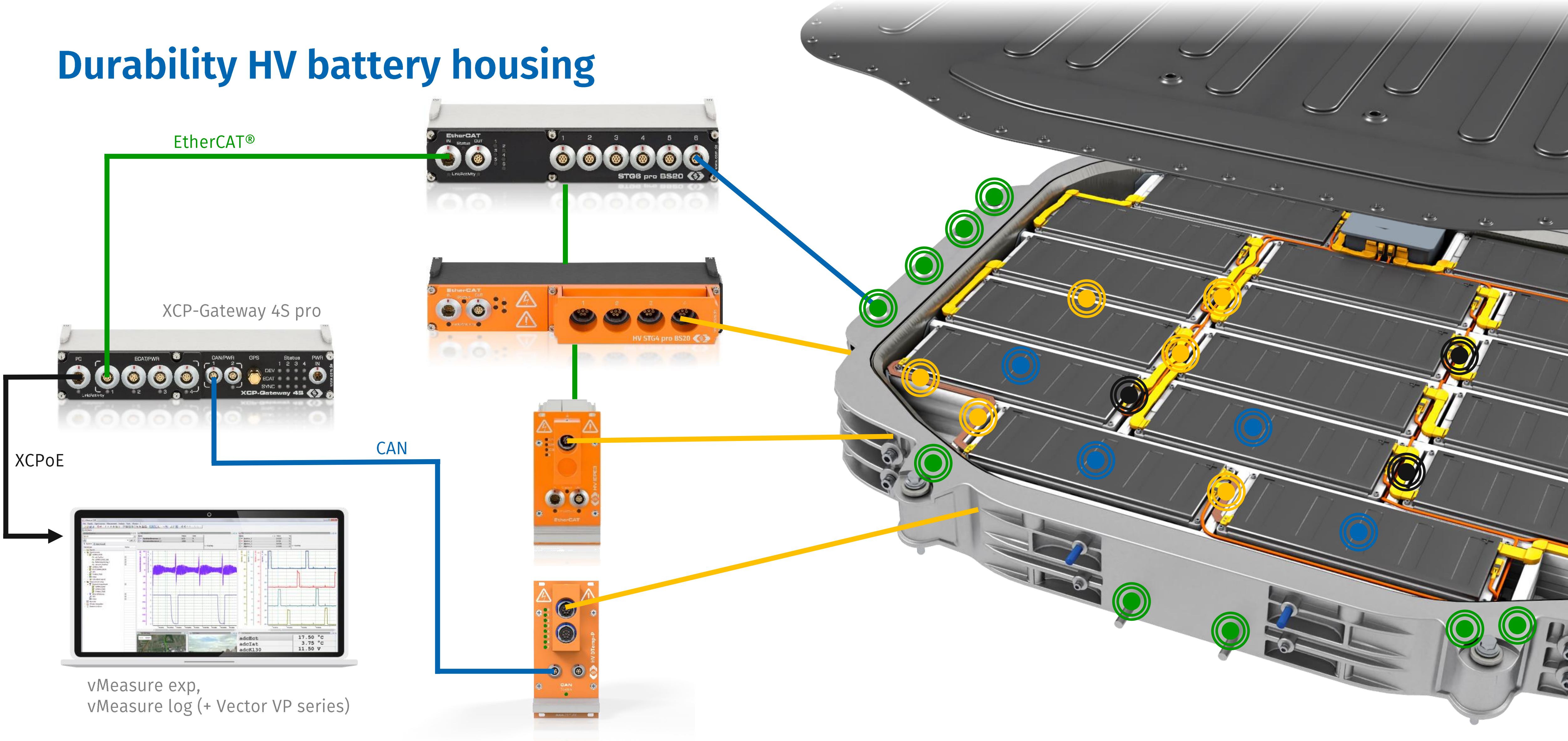
HV STG4 pro BS20


HV IEPE3 FL100


HV DTemp measurement system



Durability HV battery housing



Sensor technology - How do I measure component loads?

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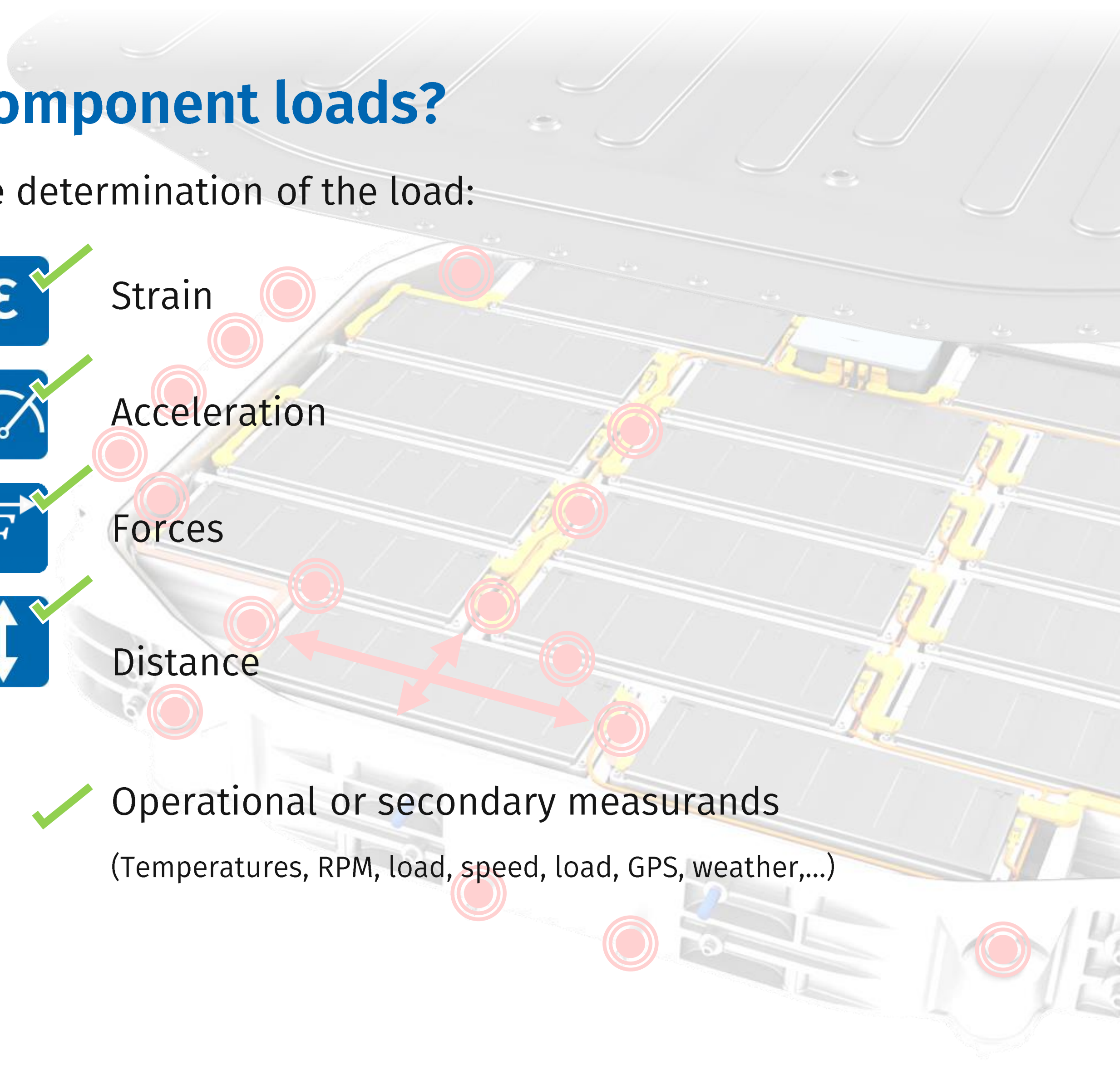
Values for the determination of the load:

- ✓ Strain
- ✓ Acceleration
- ✓ Forces
- ✓ Distance



✓ Operational or secondary measurands

(Temperatures, RPM, load, speed, load, GPS, weather,...)

Determination of the component loads

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Typical measurement parameters of a fatigue strength test

	Measurement ranges	Measurement frequency	Filter settings
Strain	±500 µm/m to ±2,500 µm/m	100 Hz - 500 Hz	20 Hz - 200 Hz
Force	±0.5 mV/V to ±2 mV/V	100 Hz - 500 Hz	20 Hz - 200 Hz
Acceleration	±1 g to ±50 g	100 Hz - 500 Hz	20 Hz - 200 Hz
Distance	1 mm to 1,000 mm	100 Hz - 500 Hz	20 Hz - 200 Hz
Temperatures	-20 °C to +200 °C	1 Hz - 10 Hz	
Vehicle values	CAN / Flexray	10 Hz	

Number of channels for a typical setup: approx. 20 to 100 measurement channels

Application Example on www.csm.de

Measurement technology for durability measurements

Suitable measurement technology for durability measurements:

Conventional and HV-safe.

Strains and forces

Accelerations

Temperatures

About CSM

CSM has been setting technological standards for decentralized measurement technology in vehicle development for over 35 years. Our CAN bus and EtherCAT® measurement devices support worldwide renowned vehicle manufacturers, suppliers and service providers in their developments.

Continuous innovation and long-term satisfied customers are our guarantee for success. Together with our partner Vector Informatik, we have developed an easily scalable and powerful E-Mobility Measurement System for hybrid and electric vehicles and are constantly expanding the areas of application. With our high-voltage safe measurement systems designed for fast and synchronous measurements and power analyses, we actively accompany the change to E-Mobility.

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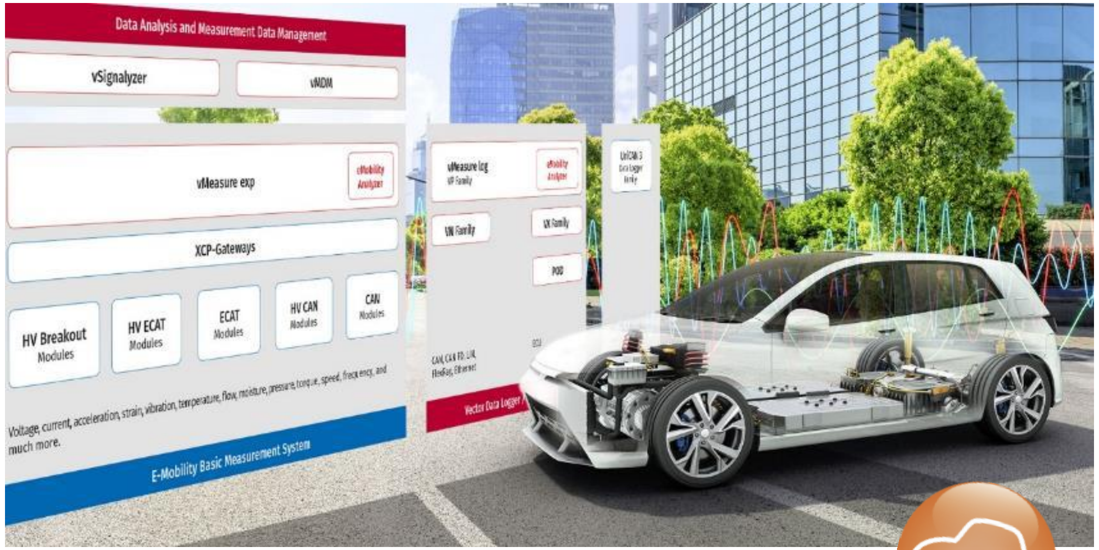

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www.csm.de/webseminars

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measurement technology