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# Inspiring innovations for modern vehicle operational data collection

# Automotive industry is changing rapidly

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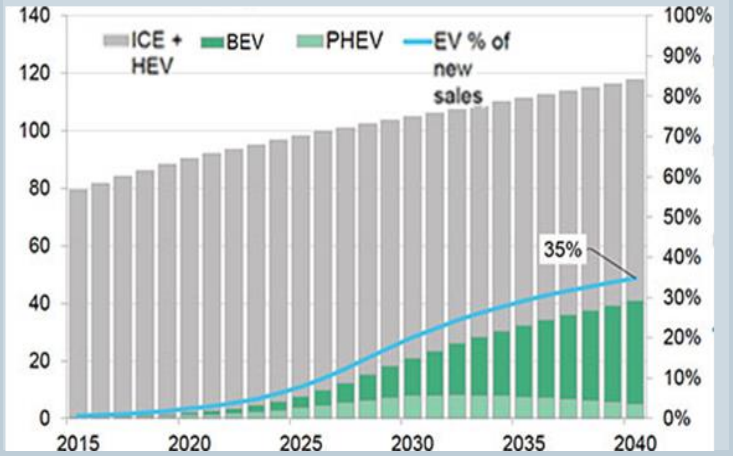
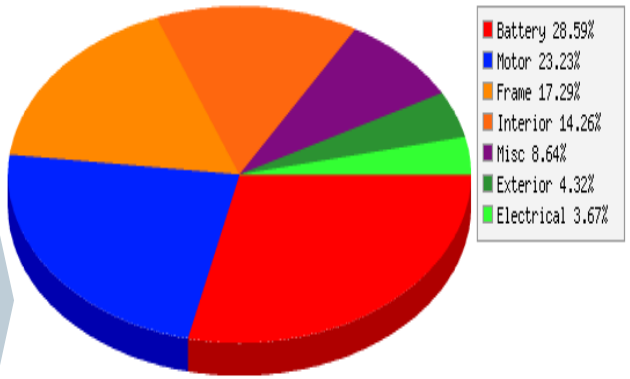



Bloomberg New Energy Finance

Electric vehicles share could range from 10-50% of new vehicle sold in 2030.

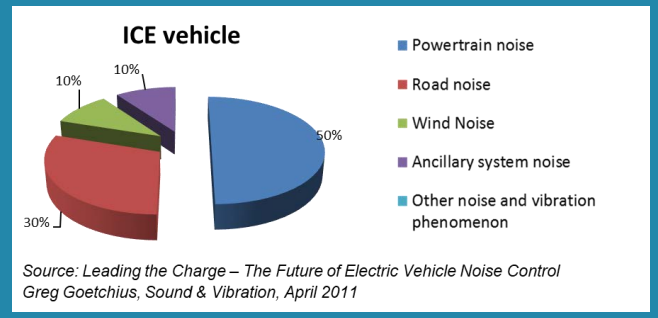
## New mass distribution



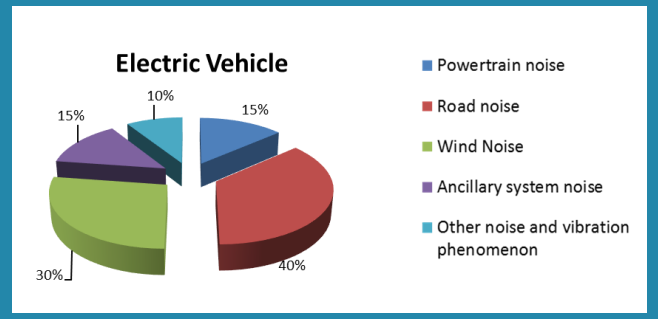

https://www.teslarati.com/tesla-model-s-weight/

- Different loading
- Different requirements in Body Design

## Change in NVH priorities




*Source: Leading the Charge – The Future of Electric Vehicle Noise Control Greg Goetchius, Sound & Vibration, April 2011*




Shift from powertrain NVH to other NVH contributions

**Introducing Uncertainties & change**

# … car development teams need to change rapidly

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| Be more flexible |
| --- |
| To test **when** needed |
| To test **what** you need |
| In **who** does the measurements |
| While being **confident** in what was measured |
| … |

**Develop Faster**

"Let's combine the available technologies to provide the best possible solution"

Increasing link between Test & Simulation
- ✓ Simulate **in service of testing**
- ✓ Provide **complete** data set **in service** of simulation
- ✓ Process **standardization** and acquire data anywhere in world
- ✓ **COMBINE** test & Simulation – More **polyvalent engineers**

# Typical challenges in operational NVH data collection

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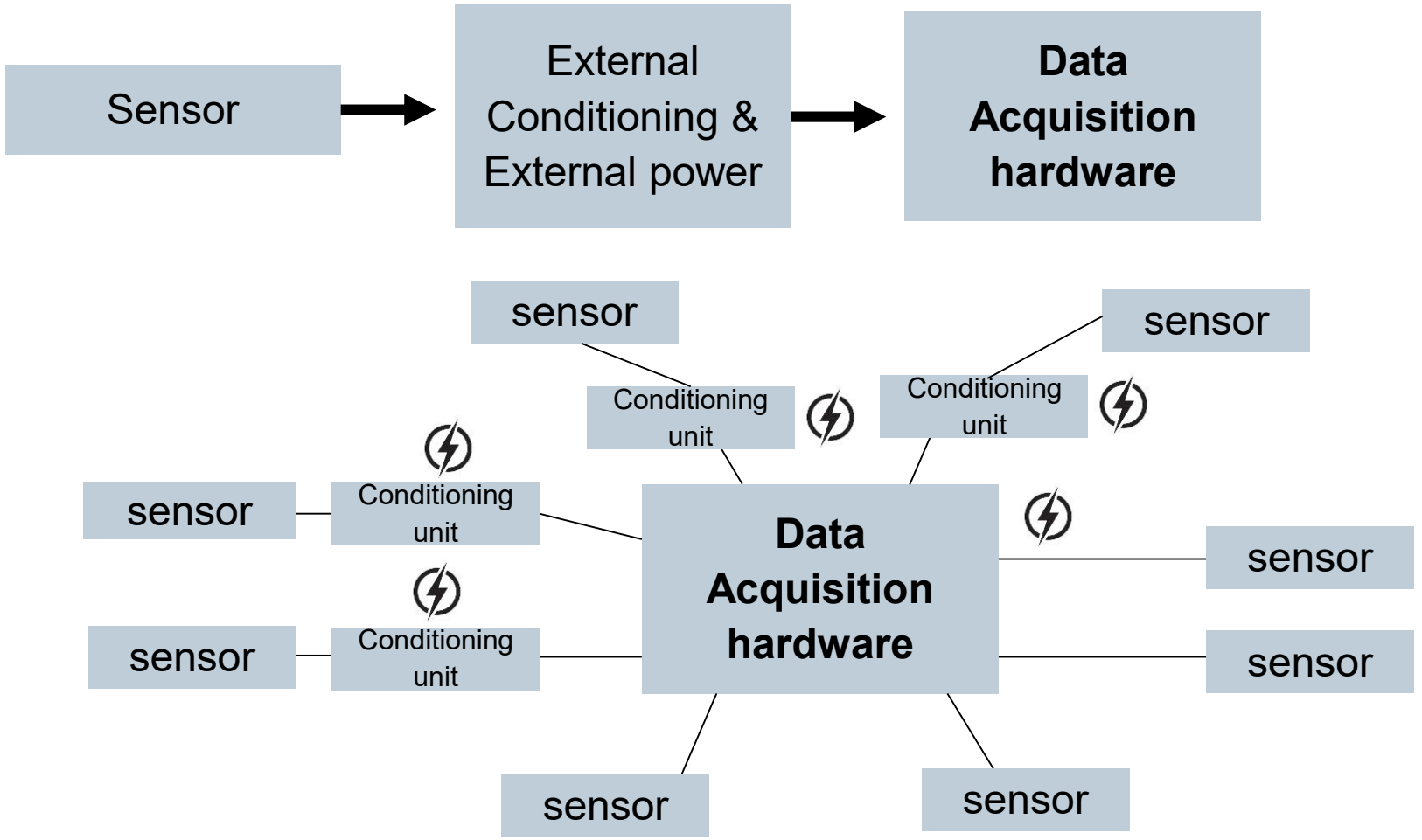
External conditioning units between sensors and hardware:
- Conditioning
- Power sensors
- Requires external power

Alternative:
✓ Direct connection & power sensors from hardware



# Typical challenges in operational NVH data collection

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Separate systems used for different applications

NVH system 1

NVH system 2

Use simulation software

Alternative
- ✓ One system
- ✓ Combining and linking all information by measuring together

Torsional vibration testing

Performance testing

Combustion analysis

Source localization

Sound Quality testing

# Typical challenges in operational NVH data collection

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Every CHAIN in the measurement Chain Counts

| INSTRUMENTATION | MEASUREMENT | DATA VALIDATION | DETAILED PROCESSING | REPORTING |
|---|---|---|---|---|
| Errors in instrumentation | Black box? | Overlooking errors | Time consuming/manual processing | Manual report creation |
| External boxes | Limited visibility in data? | Inefficient/manual process for validation | Import/export data | Static reports |
| Complicated Set up | Overlooking errors | | Synchronizing datasets | |

**Up 80% of the total measurement time lost in instrumentation, data validation, data clean-up & error correction, or even worst-case redoing measurements**

# Challenges

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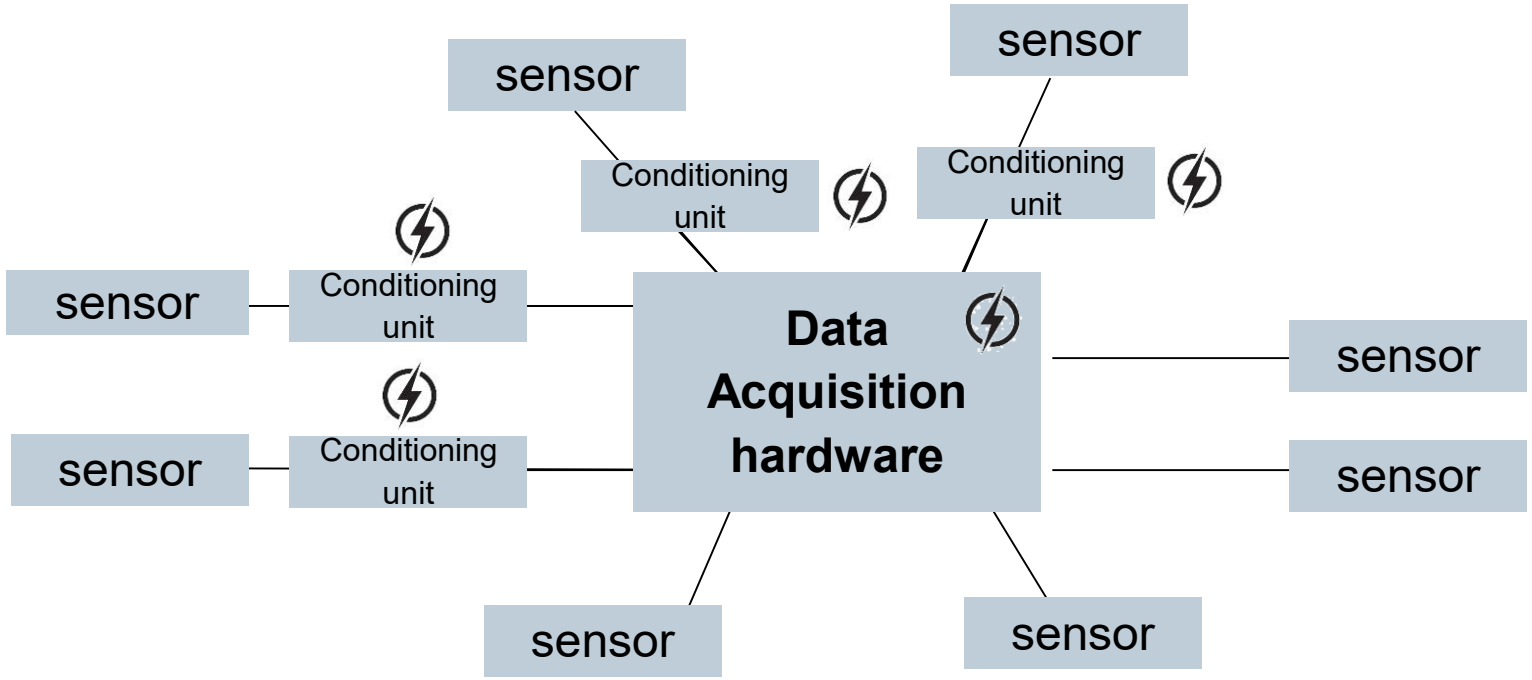
- ✓ High amount of external boxes between sensor & hardware
- ✓ Separated systems / set-ups
- ✓ Increasing Digitalization of sensors & signals
- ✓ Up 80% of the total measurement time lost in instrumentation, data validation, data clean-up & error correction, or even worst-case redoing measurements
- ✓ Test more in less amount of time
- ✓ Testing in service of simulation

**Increase Flexibility**

**Increase confidence**

**Be more efficient**

# Direct connection of all sensors to one hardware



# Be Flexible – Combine data streams from different sensors

## Connect wide range of signal types

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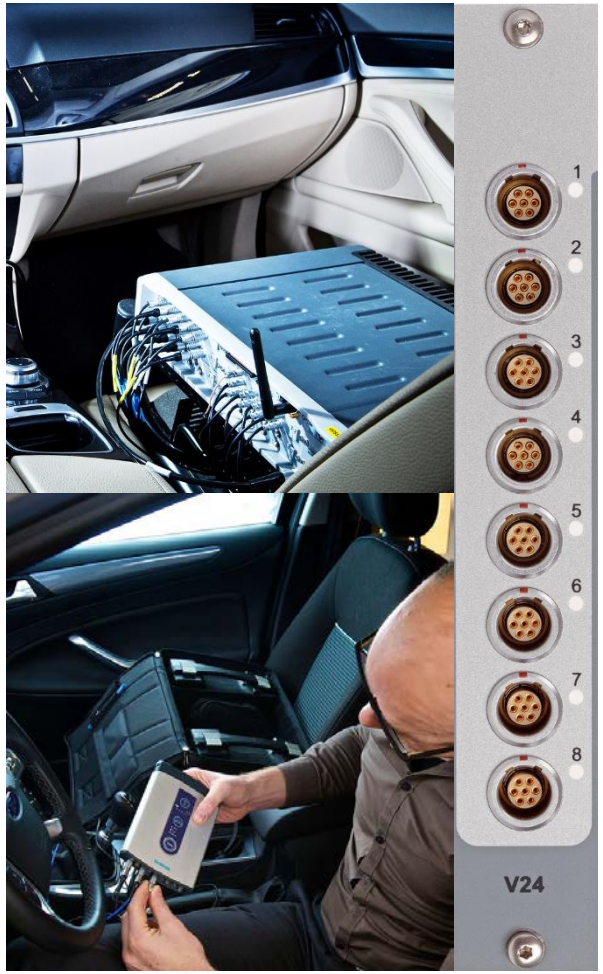
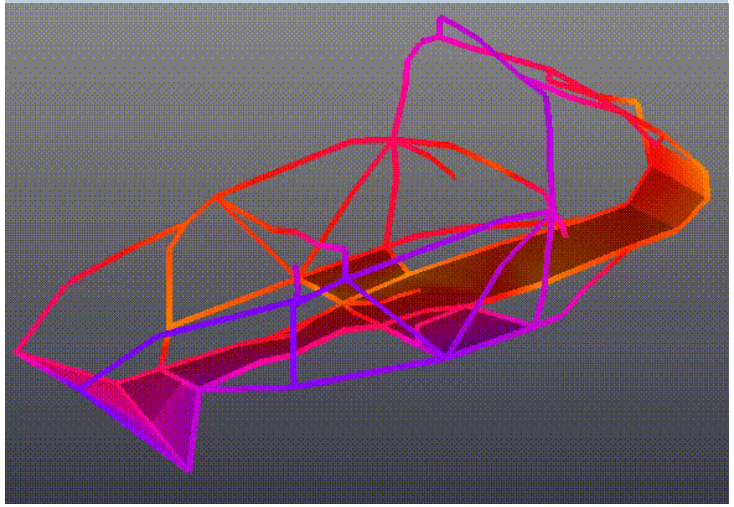



**Measure Vibrations**

- ✓ Mono-axial
- ✓ Tri-axial:
  - one cable connection
  - Define one tri-axial accelerometer as one sensor
- ✓ Measure DC vibrations (MEMS) – e.g. for assessment of driving maneuvers
- ✓ From small, to more complex setups
- ✓ Read TEDs

Visualize vibrations
Detect instrumentation errors



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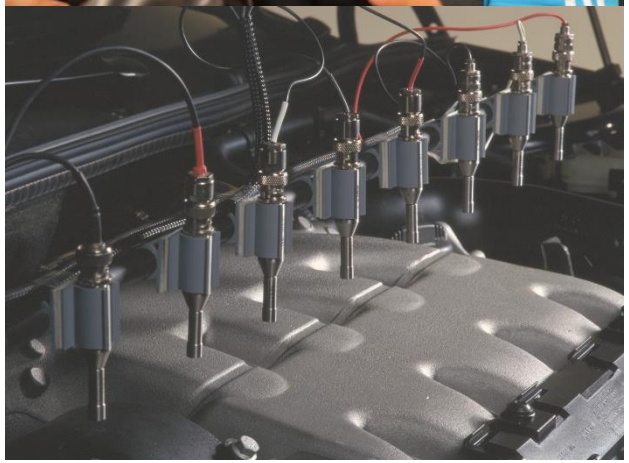
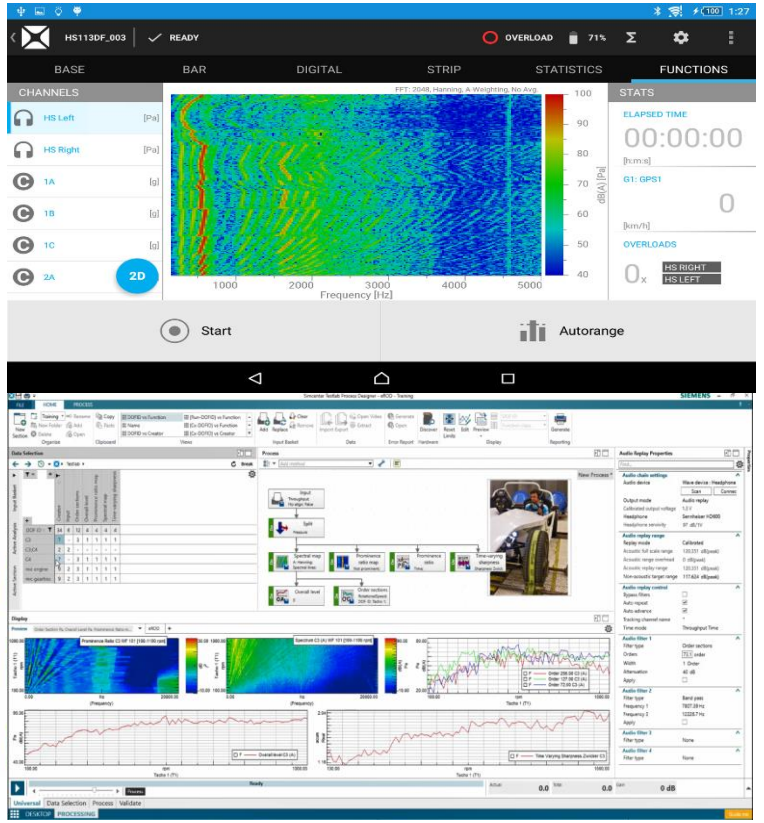


### Measure Sound Pressure

- ✓ Single microphones
- ✓ Or Binaural:
  - Binaural Heads
  - 3D Binaural Headset
- ✓ On the spot replay of acoustics
- ✓ Evaluate instantaneous Sound Quality metrics
- ✓ Including high channel counts:
  - Wind tunnel
  - Acoustic modal



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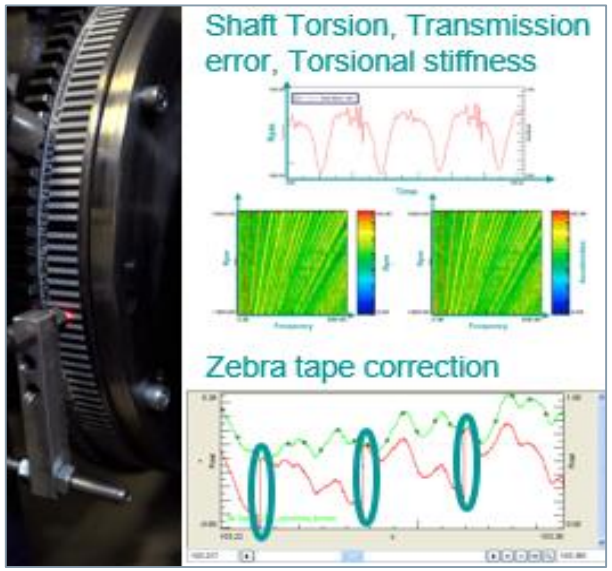
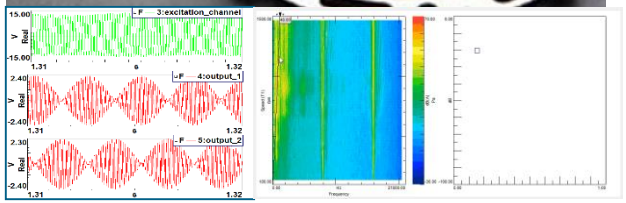
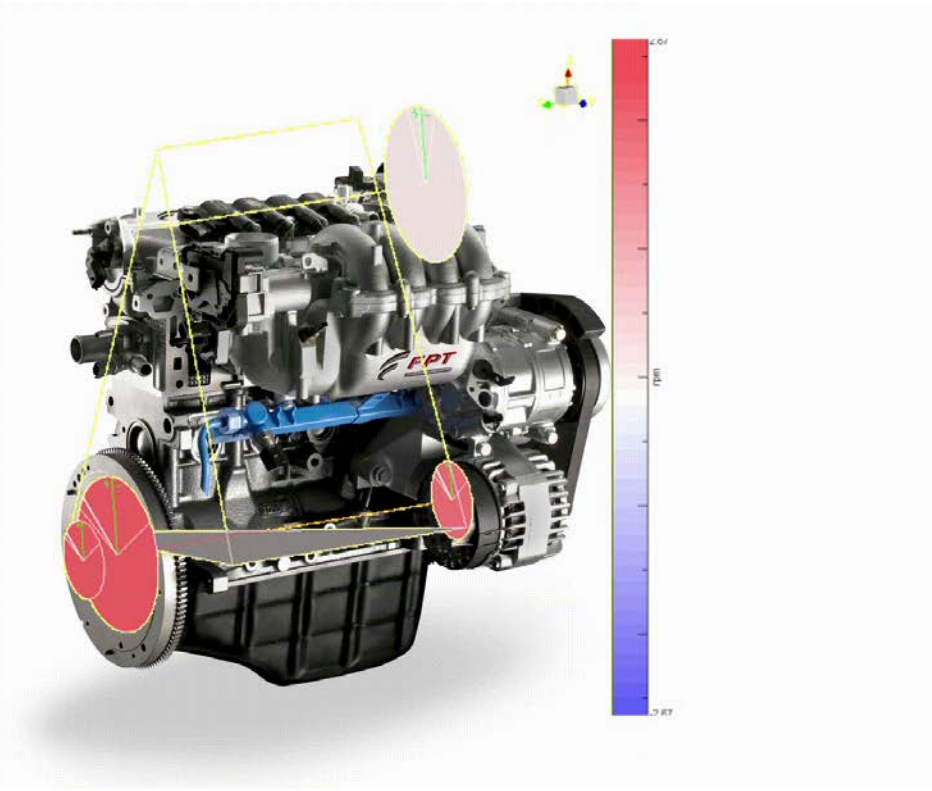


**Rotational speed**

Incl. High dynamic Torsional vibrations and resolver signals for electric motor

- ✓ **Direct** connection of wide range of sensors
  - Magnetic pickups
  - Optical coders
  - Incremental encoders
- ✓ From order tracking to torsional vibrations
- ✓ Link torsional vibrations to NVH
- ✓ Capture resolver signals for electric motor



# Be Flexible – Combine data streams from different sensors

## Connect wide range of signal types

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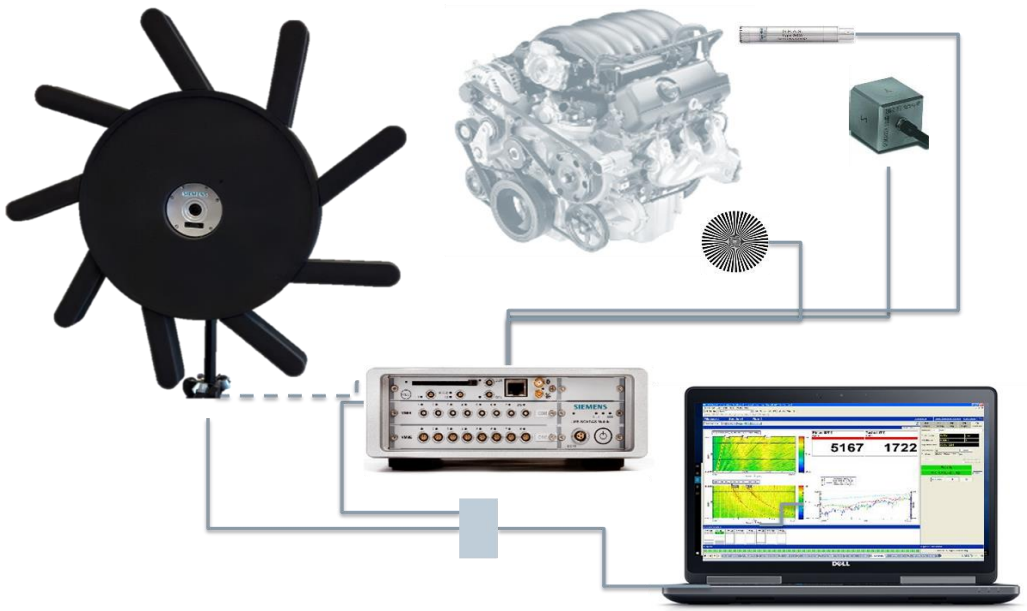
Locate **Sound Sources**

- ✓ Connect Acoustic Array as sensor and measure together with other NVH
- ✓ Localize where sound is being radiated



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## Connect wide range of signal types

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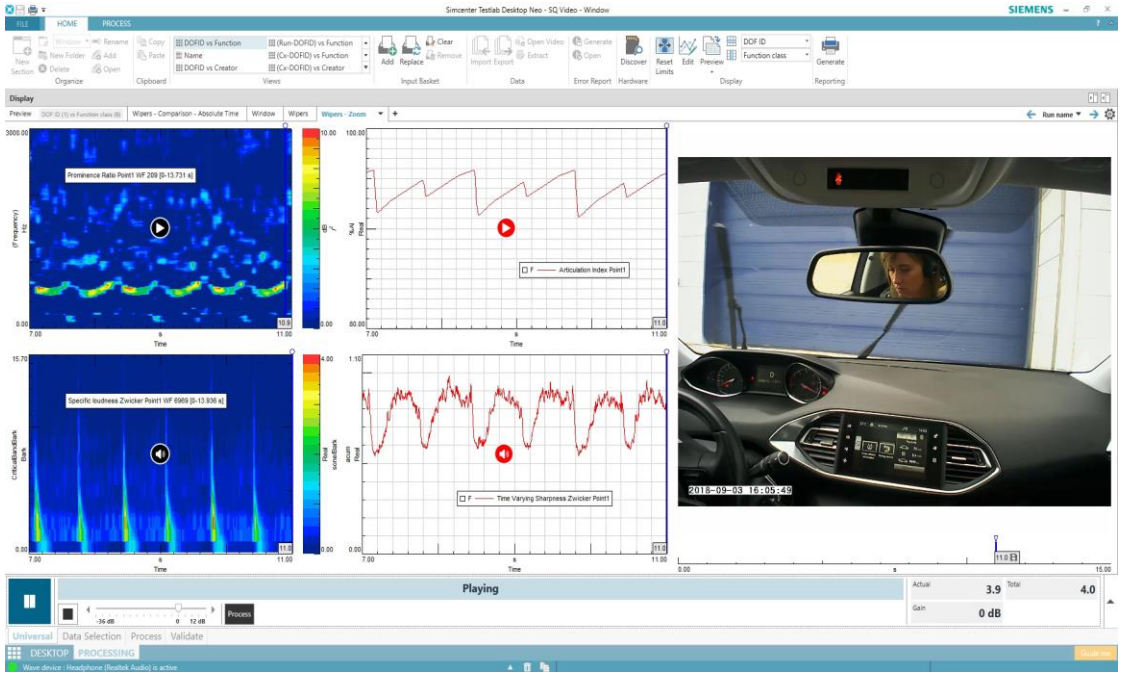
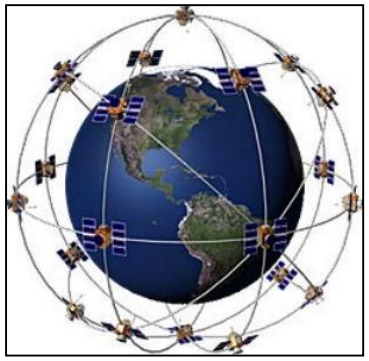



Vehicle **location & Speed & Video**
Capture location of measurement

- ✓ Measure GPS (& Navstar)
- ✓ Be sure to know where events were measured
- ✓ Capture video data stream
- ✓ Trigger start/stop of measurements based on position

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## Connect wide range of signal types

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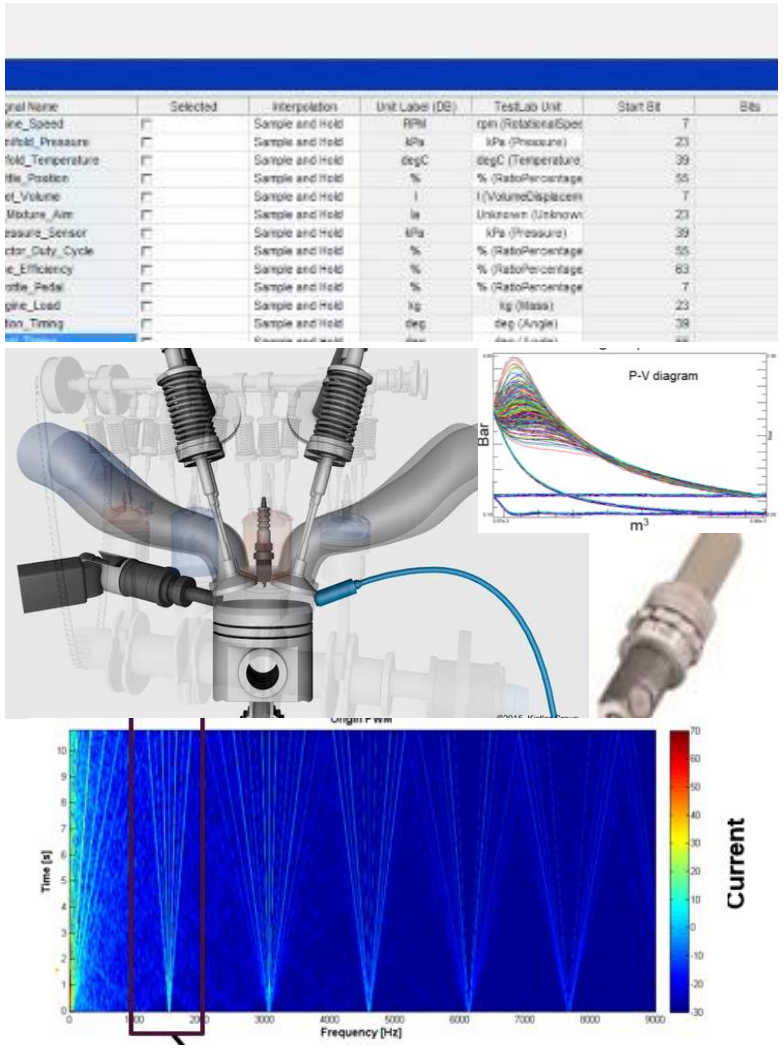


Acquire Digital Information from **vehicle buses**
CAN, CAN FD, Flexray, … CCP/XCP

Measure **Cylinder pressure**, e.g. for combustion Metrics
(without external conditioning)

Current & Voltage signals

Temperature

…

# Be Flexible – Combine data streams from different sensors

## Connect wide range of signal types

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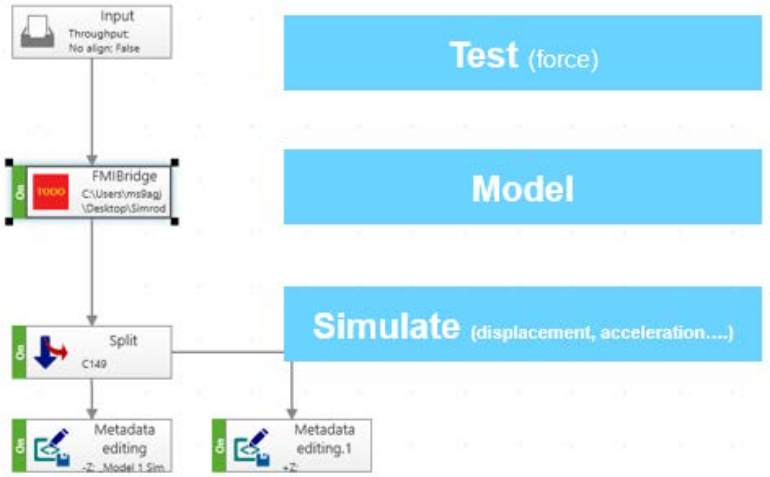
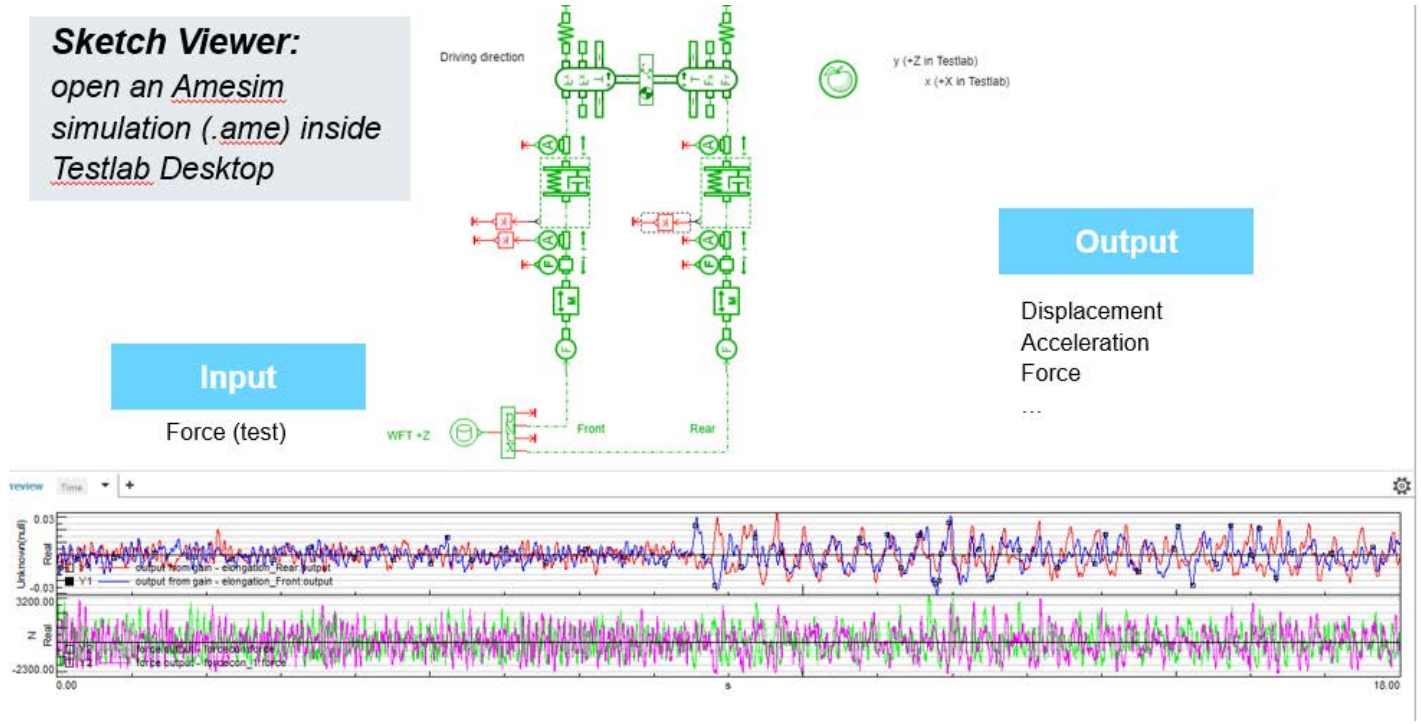
- ✓ Derive signals from other sensors
- ✓ Simple calculations or Use Simcenter Amesim models to derive hard-to-measure signals




**Virtual sensors**

***Sketch Viewer:*** *open an Amesim simulation (.ame) inside Testlab Desktop*



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## Connect wide range of signal types

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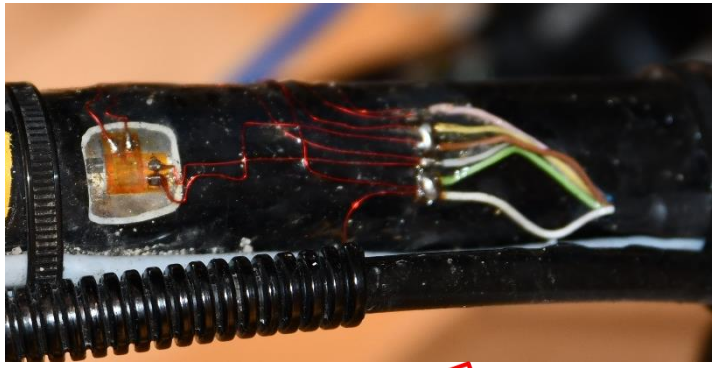
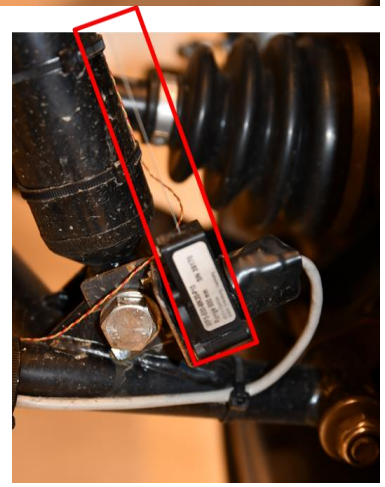
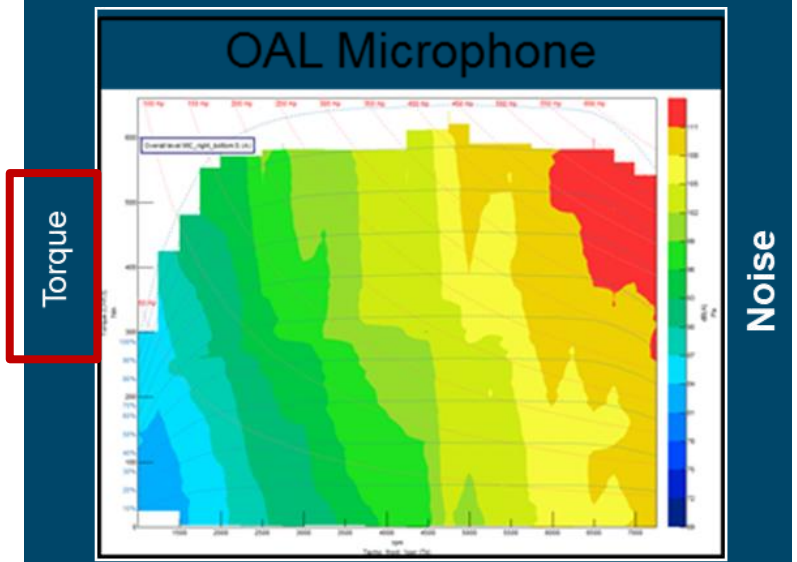




Acquire **Strain, Loads, Forces, displacement**

- ✓ Measure NVH performance with other performance metrics
- ✓ Measure Strain (Quarter, Half & Full Bridge)
- ✓ Measure Loads & Torque
- ✓ Displacement (LVDT, RVDT, Stringpod) e.g. Throttle, suspension system, …



# What is the value of combining data streams into one?

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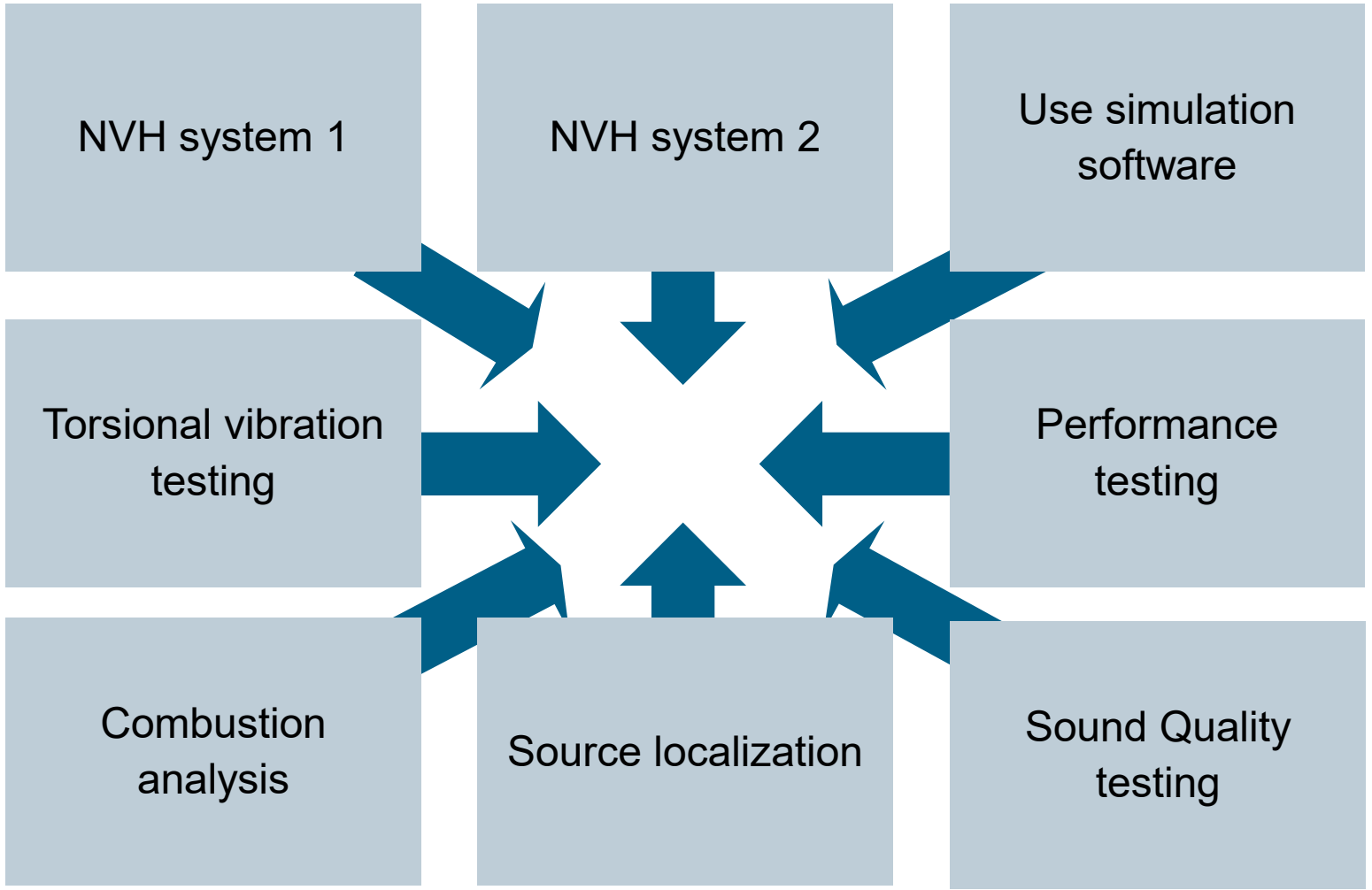

Simcenter Testlab Desktop Neo - SimRod video - Section1

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FILE | HOME | AUDIO REPLAY | PROCESS

New | Open | Save | Save as | Load | Export as Image | Accept: Manual | Save into: New run | Troubleshoot — Process

Paste | Cut | Copy — Clipboard

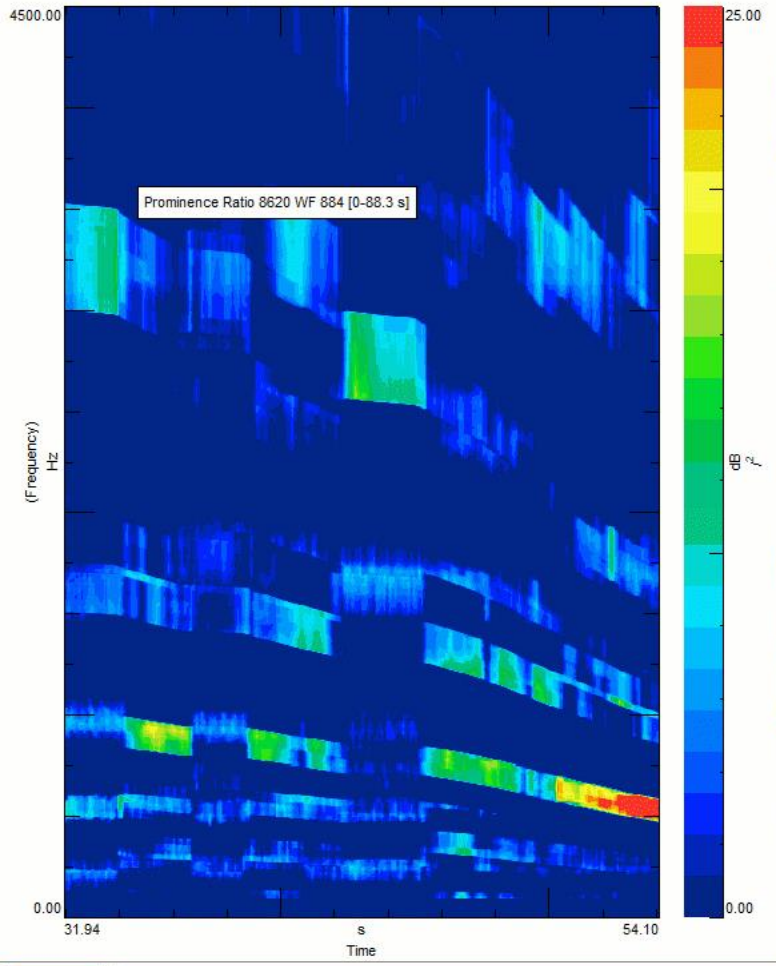
Select All | Delete | Undo | Redo | Status | Set Default Parameter Values — Methods

New | Edit | Share on User | Overwrite on User | Share on Group | Overwrite on Group | Make Editable | Create Local Copy | Updates | Back to Higher Level — Combined Methods

Fit to View | Auto Arrange | Arrange | Group | Ungroup | Parameters | Method Status | Show Parameters — Show

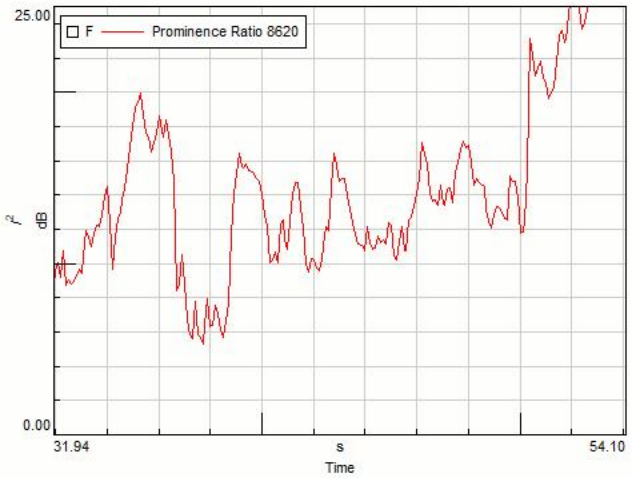
Display

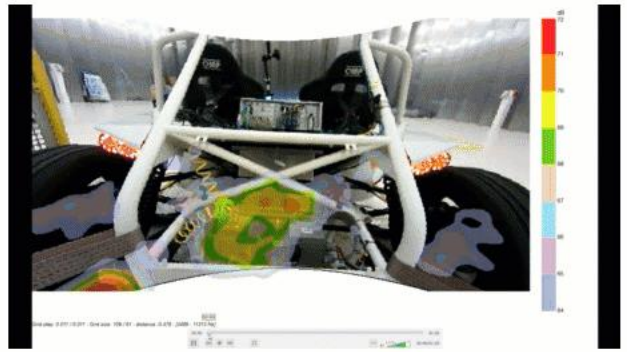
Preview | Time Varying Loudness | Run-down | +

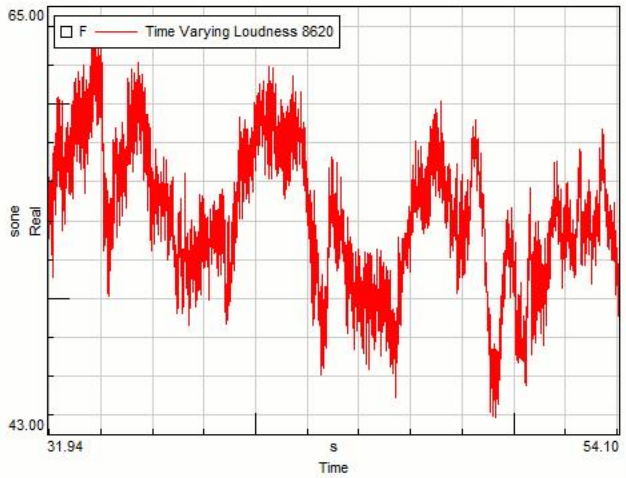


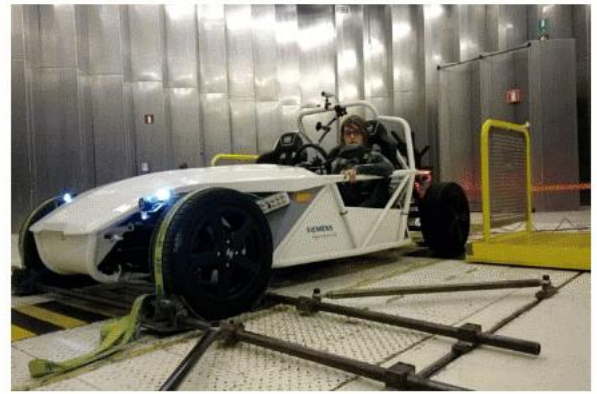






0.64 s 77.12 | 0.64 s 77.12 | -0.65 s 79.35 | 0.66 s 88.42

Ready

-36 dB | 0 | 12 dB | Process

Actual 0.0 | Total 0.0 | Gain 0 dB

Universal | Data Selection | Process | Validate

DESKTOP | PROCESSING | Guide me

1 cell selected, with a total of 1 results.

# How to balance NVH against performance & Efficiency?
## Solution: Combine 5 traditionally separate systems into one synchronized measurement on the powertrain test bench

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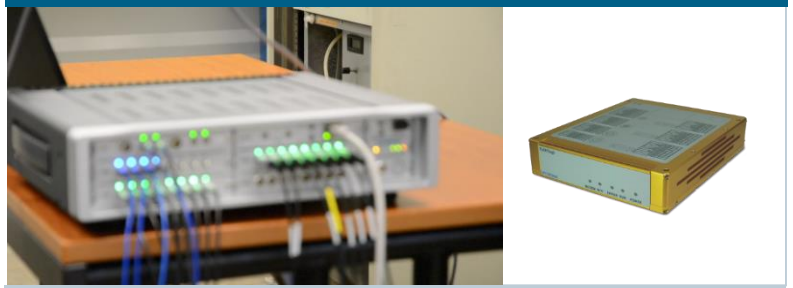
### NVH assessment

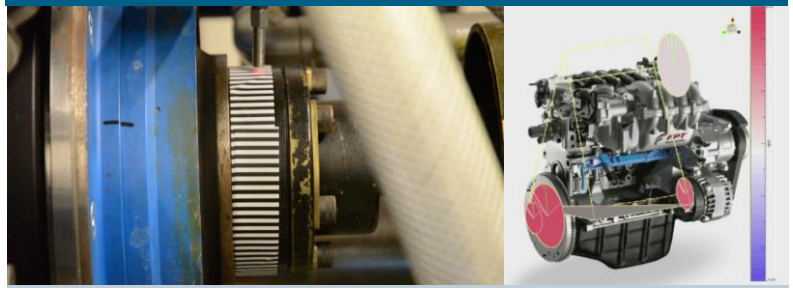

Orders, ODS, Sound Power, …

### Access data from ECU



Assess any parameter from ECU through support of CCP or XCP

### Torsional Vibration Assessment

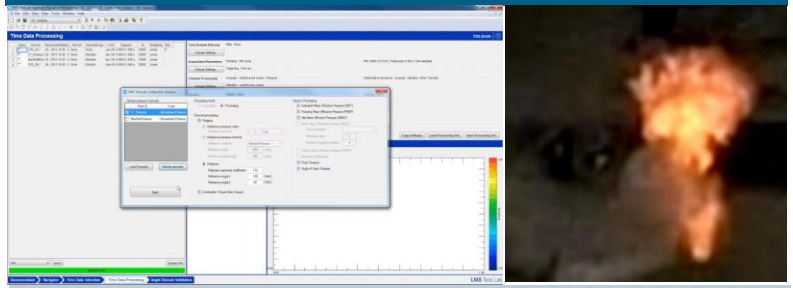


Torsional Resonances, Front-end Accessory drive performance, …

### Localize Sound Source

Gain insight in weak acoustic spots & components

### Combustion Analysis



Assess engine performance (e.g. IMEP) & efficiency

# Value of integrating systems together …
# Balancing NVH against other attributes

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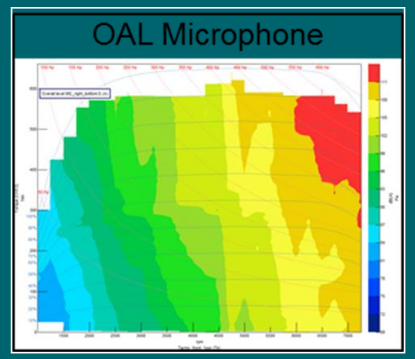
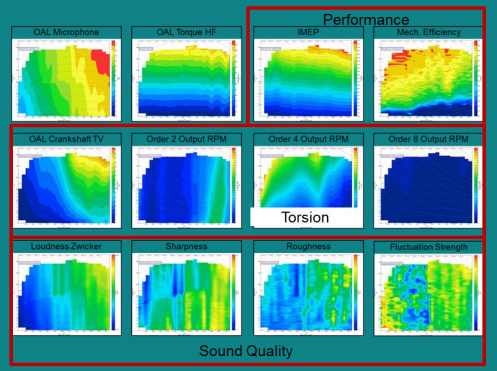
## Example 2
Assess Engine map for not only NVH but also Performance metrics, torsional …

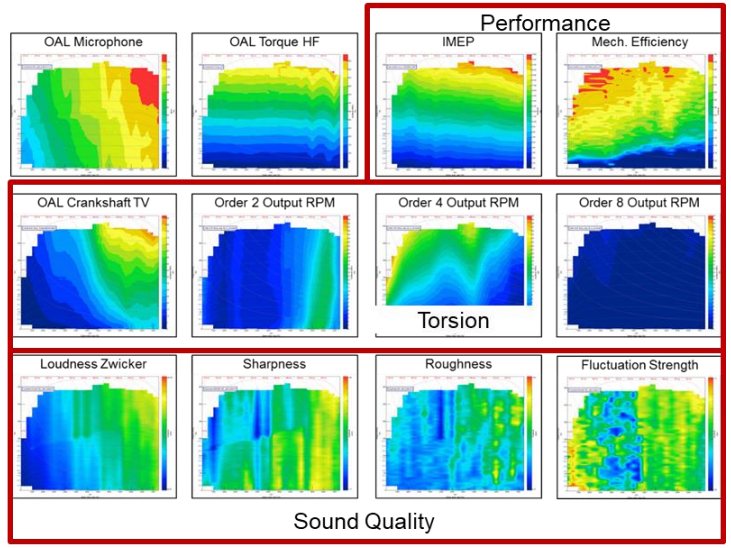
From pure NVH assessment




To Assessment of many metrics in parallel




1. Measure NVH
2. Assess IMEP & Powertrain Efficiency
3. Assess Torsional Vibration orders




# Value of measuring all 5 systems together …
# Balancing NVH against other attributes

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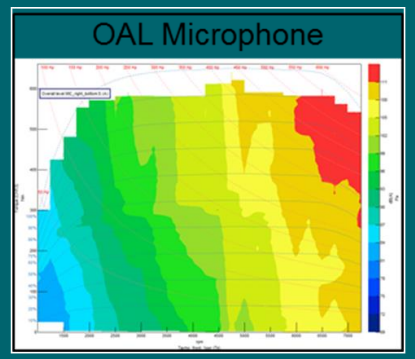
From pure NVH assessment

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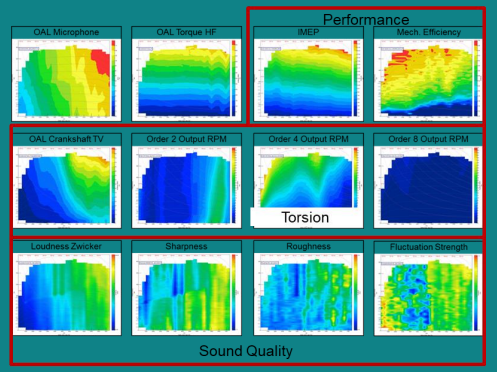
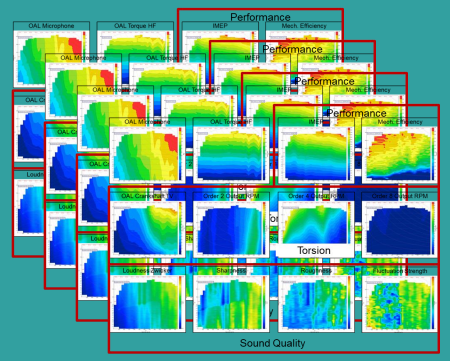
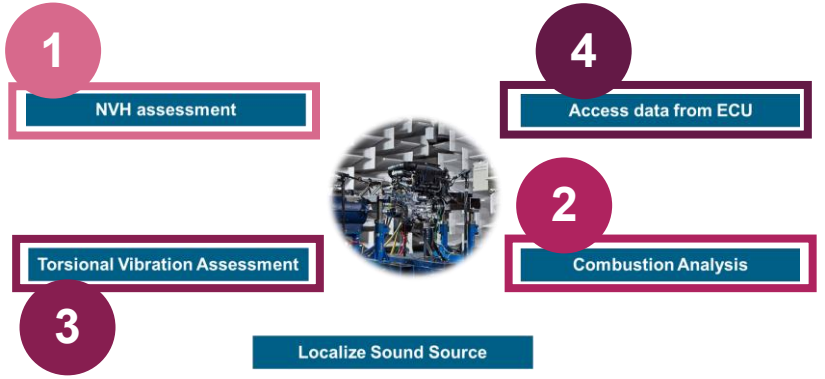



To assessment for different variations in control strategy




1. Measure NVH
2. Assess IMEP & Powertrain Efficiency
3. Assess Torsional Vibration orders
4. Assess ECU parameters



# Value of measuring all 5 systems together …
# Balancing NVH against other attributes

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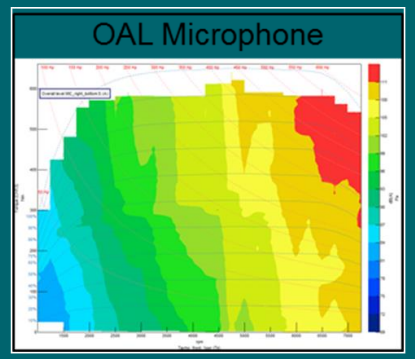
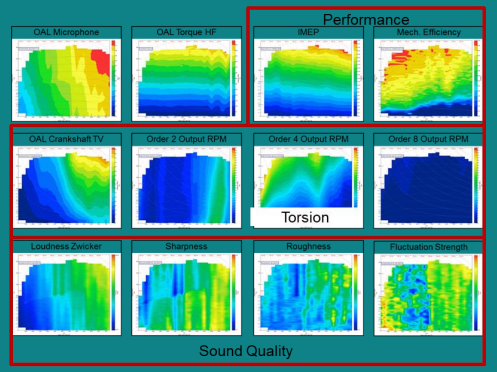
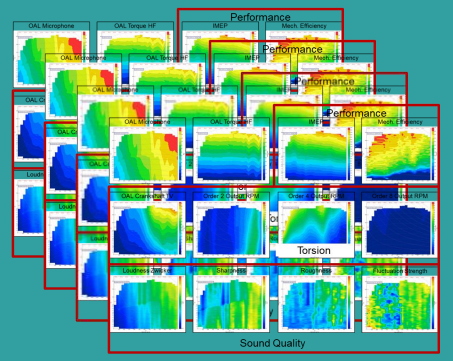
From pure NVH assessment



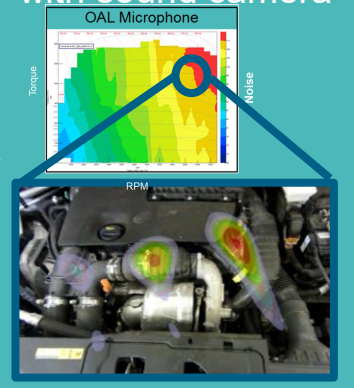

To Assessment of many metrics in parallel



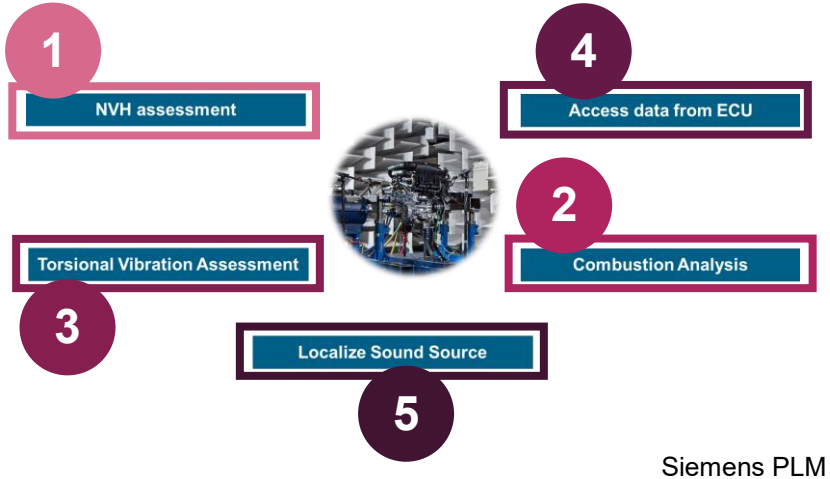

To assessment for different variations in control strategy




Analyze specific conditions with sound camera




1. Measure NVH
2. Assess IMEP & Powertrain Efficiency
3. Assess Torsional Vibration orders
4. Assess ECU parameters
5. Localize Sound Sources for certain conditions



# Be Flexible
## Scalable hardware devices to cover different applications

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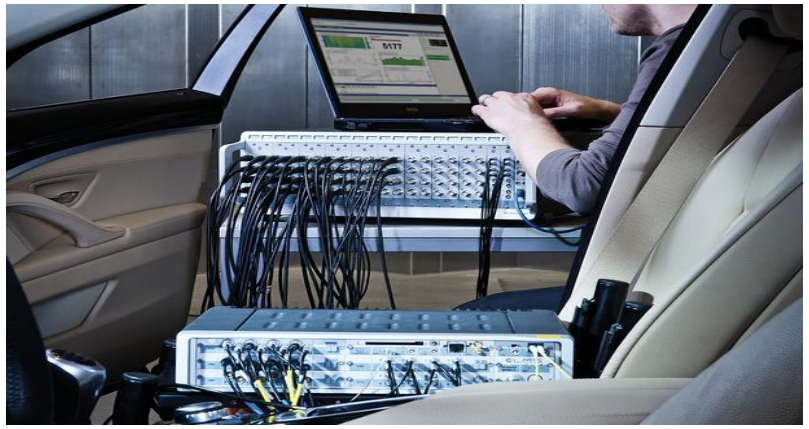
In-field operational measurements
DIRECT connection of all sensors


… towards high channel counts
Lab Based

Combine hardware to
- ✓ avoid re-instrumentation
- ✓ Optimize hardware investments



# Increase confidence
# Simcenter Instrumentation app to help preparing large test setups

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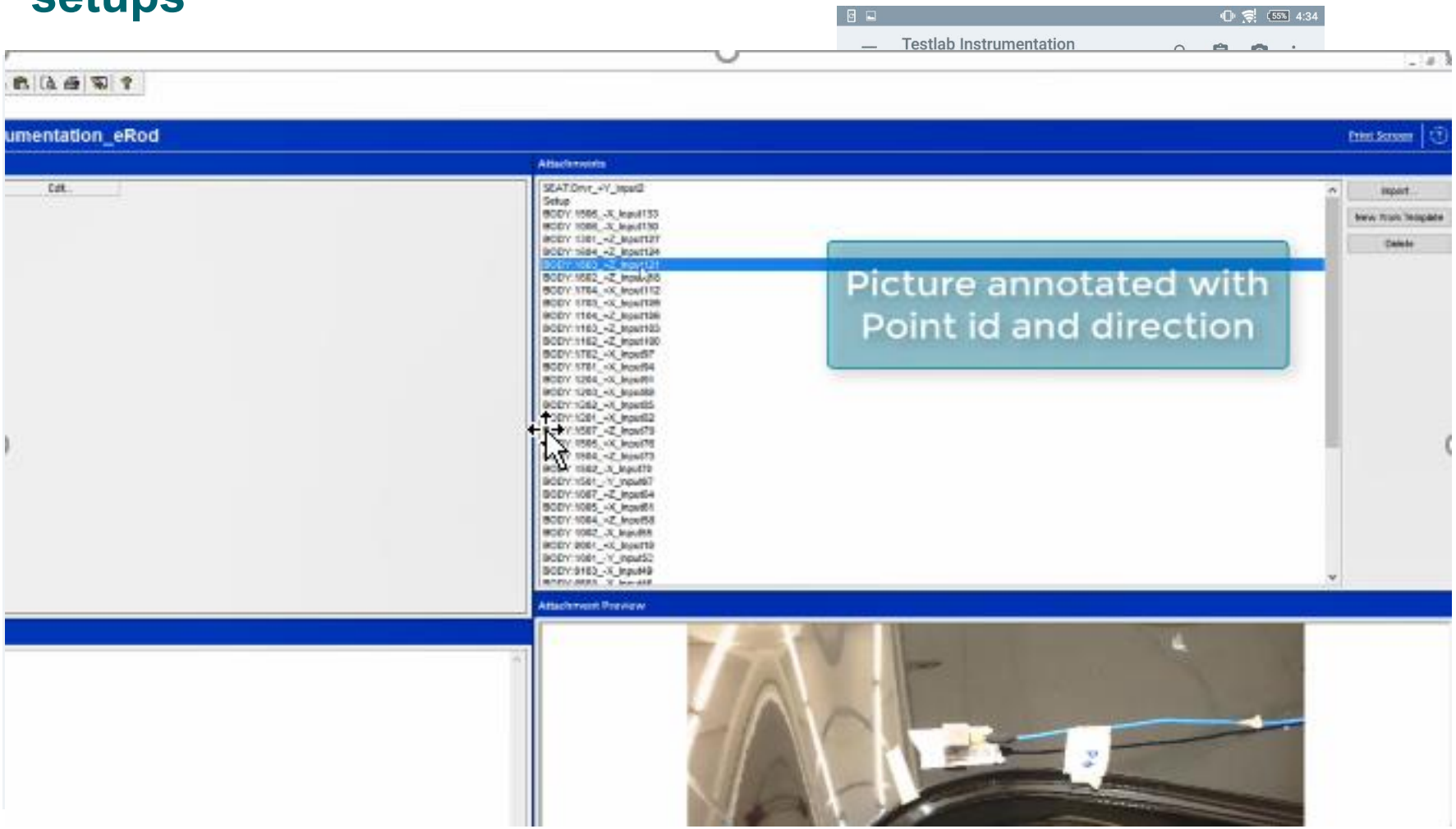


Reduce risk for time-consuming instrumentation errors for large instrumentations

E.g. instrumentations for Transfer Path Analysis

# Increase confidence
# Simcenter Testlab Scope App to provide instant validation

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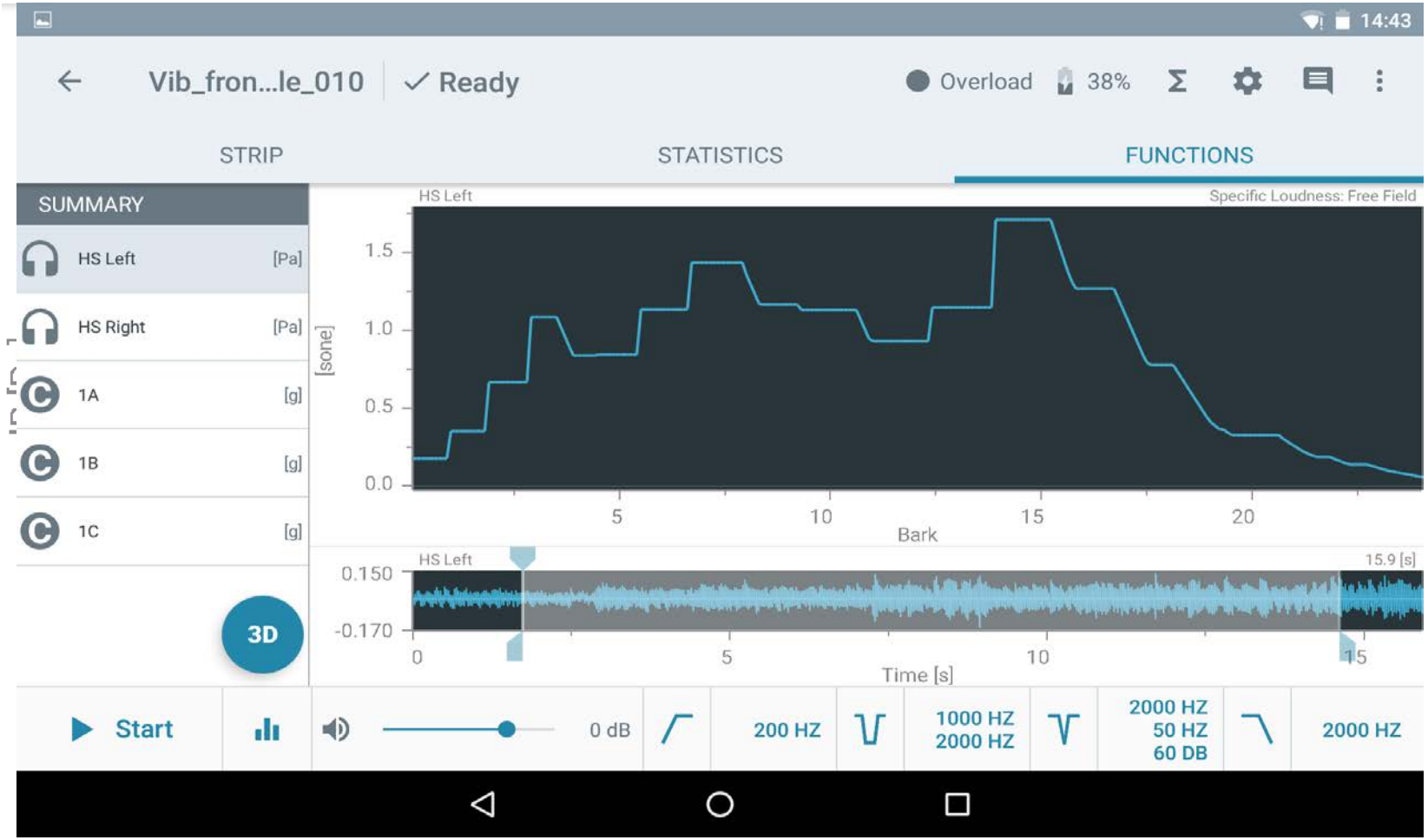


Perform **stand-alone recording**
**BUT**
with tablet based **data validation :**

- ✓ Check/modify set up
- ✓ Real-time processing
- ✓ Real-time peak cursor
- ✓ Data processing & validation
- ✓ Audio replay & filtering

# Increase confidence

## Boosting data analysis/validation process through Simcenter Testlab comparison app

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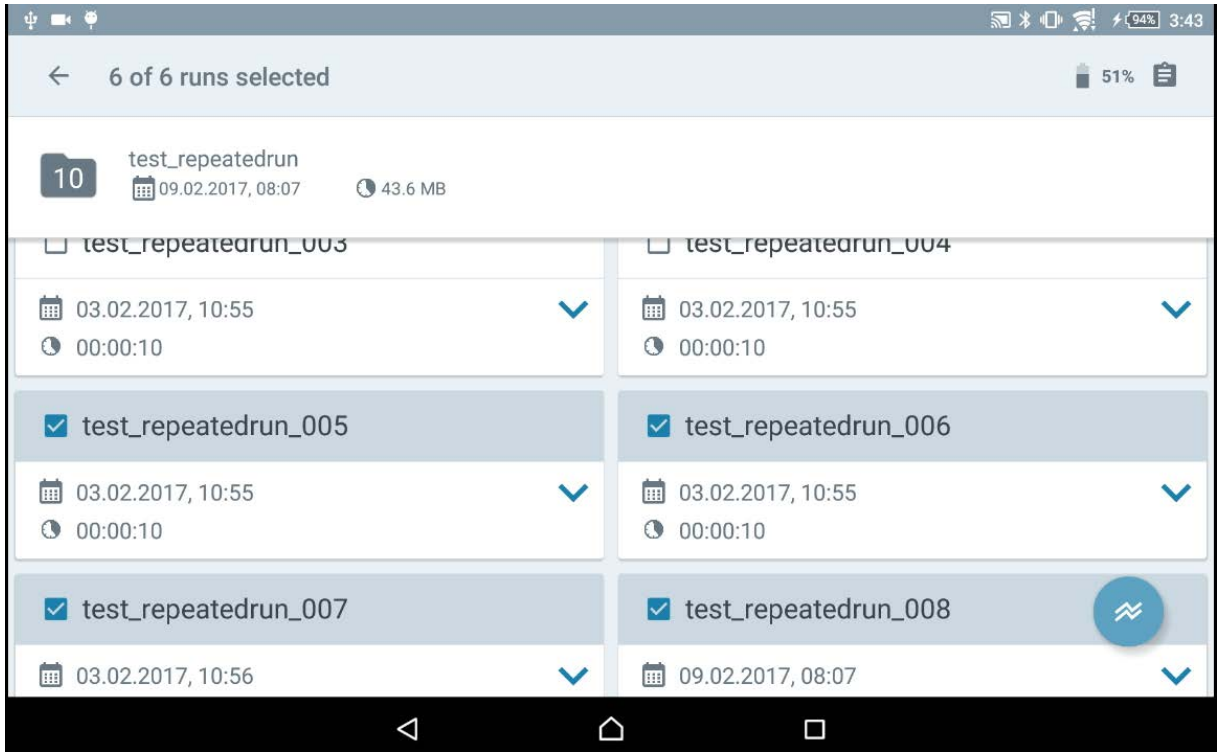
Perform **stand-alone recording**
**BUT**
with tablet based **data validation** across runs prior to going to the office for processing

- ✓ Quality check
- ✓ Repeatability check
- ✓ Target comparison




**Assessment & benchmarking** → **Troubleshooting** → **Immediate data validation**

# Increase confidence
## PC-Based Real-time processing & Analysis

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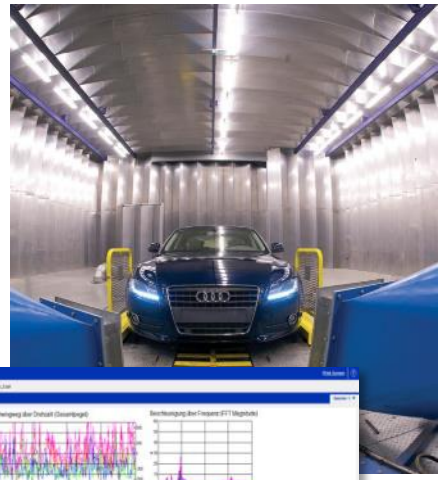
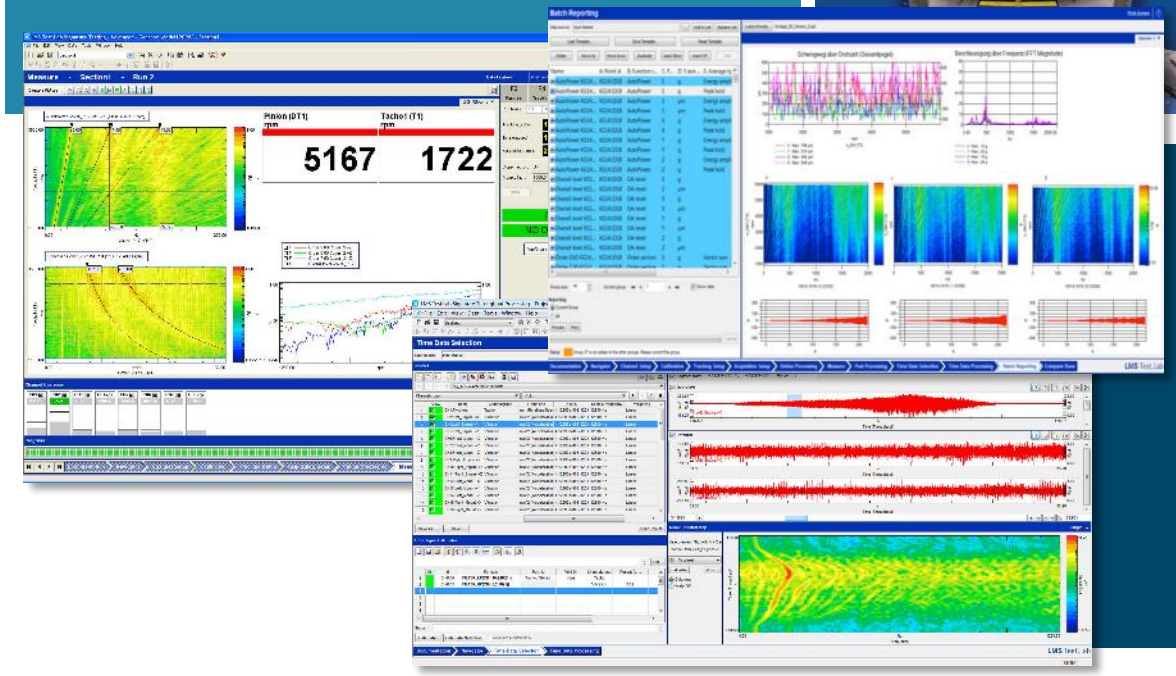
**Testing productivity built-in**

- Measure all signals in parallel
- Online displays for immediate feedback
- Flexible data processing in real-time
- Direct insight in operation conditions that cause noise and vibration issues



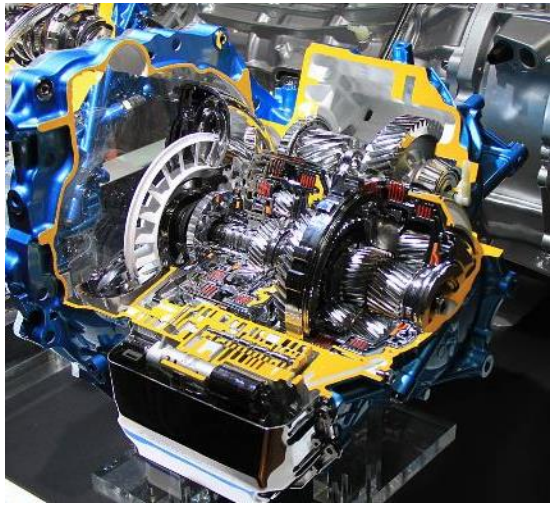
Advanced tools for

- Angle domain processing
- Running mode analysis
- Operational deflection shapes
- Offline RPM extraction
- Torsional vibration analysis




**Complete testing toolbox**

- Online and post-processing
- Fixed Sampling order tracking
- synchronous order tracking
- ANSI-IEC real time octave
- Audio replay and filtering
- Sound Quality metrics



# Be Efficient
## Be able to troubleshoot when needed with your personal Frontend

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This vehicle makes sometimes a strange noise while I am driving at the 130 kph.

Look for hardware to acquire data

I take my SCADAS XS to acquire data

# Be efficient
# Customize towards your own in-house processes
## Example 2 of *Simcenter Testlab Automation & Deployment Service*

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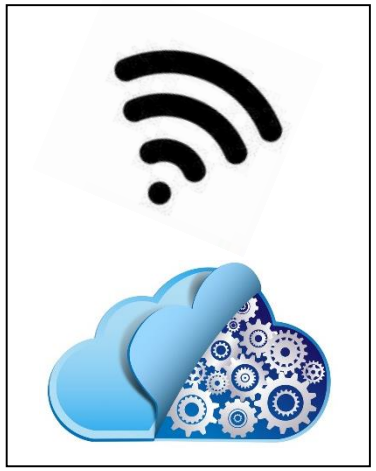
### End of Production Quality Testing

Process for efficient automatic test execution, server based processing, check against reference curves, …

Concluding with OK/NOK on screen



Car, driver & SCADAS XS (around neck) → Drive & automatic measure → Wireless transfer data & Automatic Processing → OK/NOK

- ✓ Automatic vehicle quality testing at end of production
- ✓ Remove subjective aspect of quality assessment
- ✓ Test every manufactured vehicle

# How to develop powertrains faster?
# Test Faster by customizing/optimizing processes

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## Unification of testing Example

**Old Process**

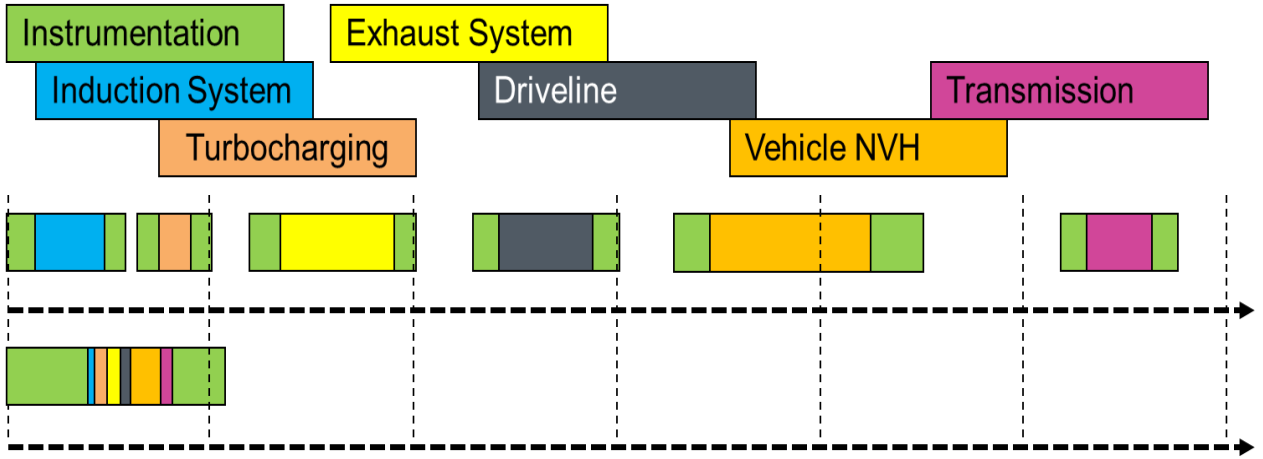
1. First Prototype test to identify which subsystems cause problem
2. Instrument & test different subsystems and acquire data
3. Analysis one by one

Total time to go through process > 2 weeks

**New Process**

1. Instrument complete vehicle (120 channels)
2. Perform all test
3. **Automatic** processing for each subsystem

Total time 3 hours




**"Our design verification process is now 5 times shorter and the processing of data has gone from 2 weeks to 3 hours."**

Result of unified testing:

- ✓ High reduction in total measurement time
- ✓ Always availability of ALL data
- ✓ Ideal first step towards automation of data collection too (e.g. testing without driver)

**Dedicated customization team in Siemens**

# Ultimate dream?
# Unified testing, combining NVH, Durability & other attributes, …

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**Multi-physics hardware**
**Connection of any sensor**
Analog – Digital
NVH – Durability
Real – Virtual Sensor
…

# Ultimate dream?
# Unified testing, combining NVH, Durability & other attributes, …

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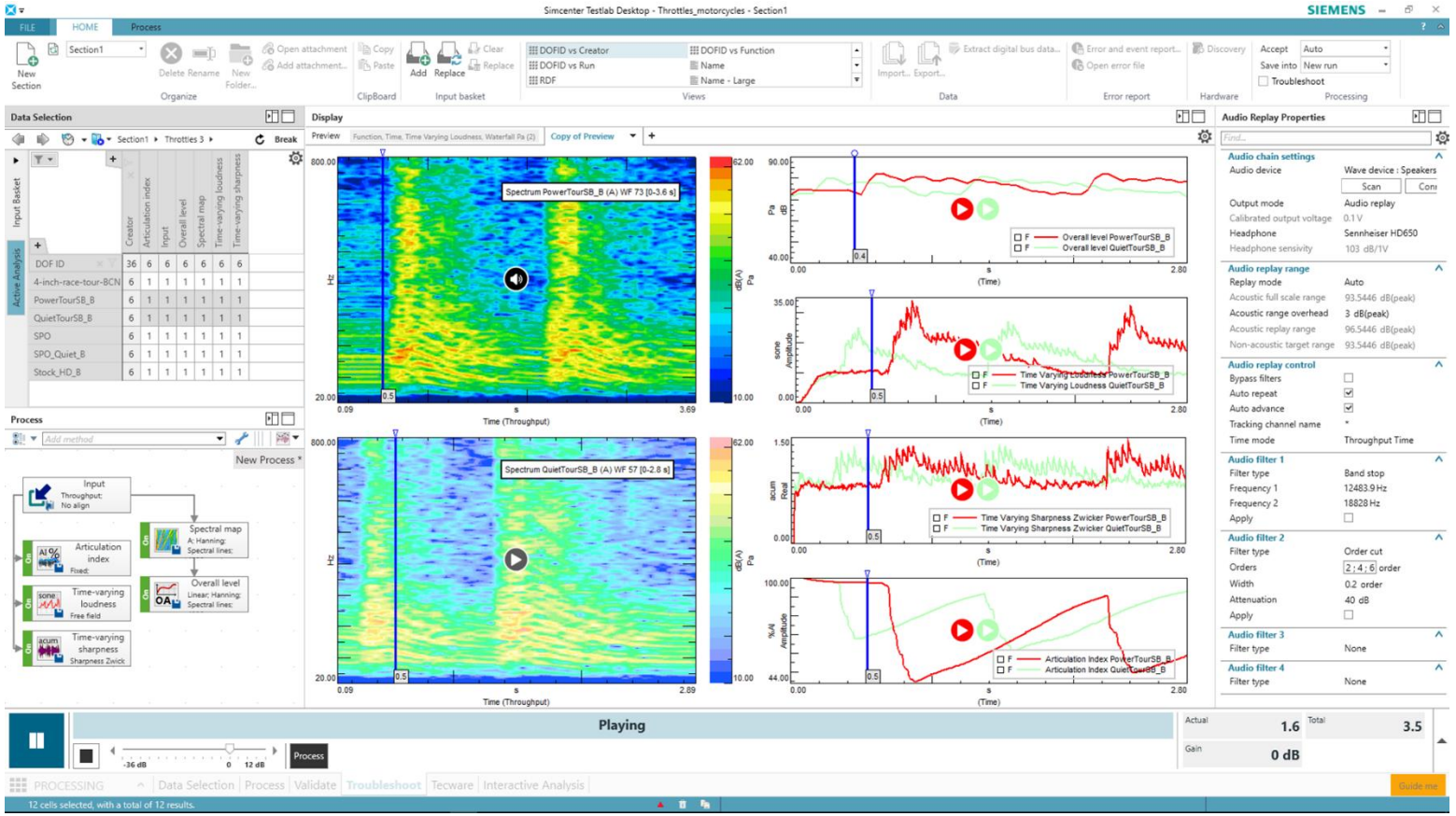
**Multi-physics software**

NVH Processing

FFT, Waterfall, Orders, Sound Quality …



# Ultimate dream?
# Unified testing, combining NVH, Durability & other attributes, …

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**Multi-physics software**

Durability Processing

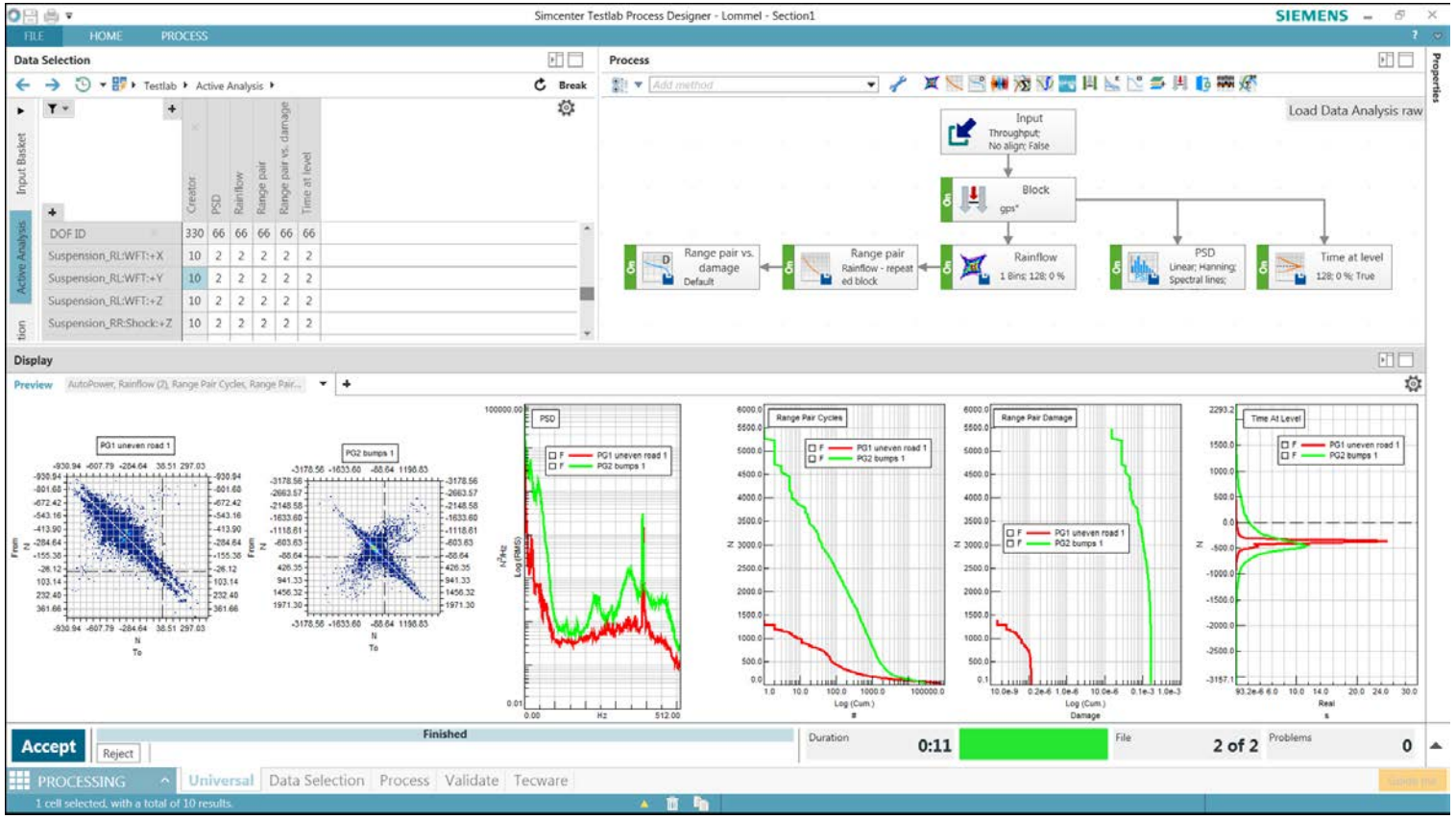
Strain-gauges …

Rainflow matriches

Rangepair

Level crossing

…



# Ultimate dream?
# Unified testing, combining NVH, Durability & other attributes, …

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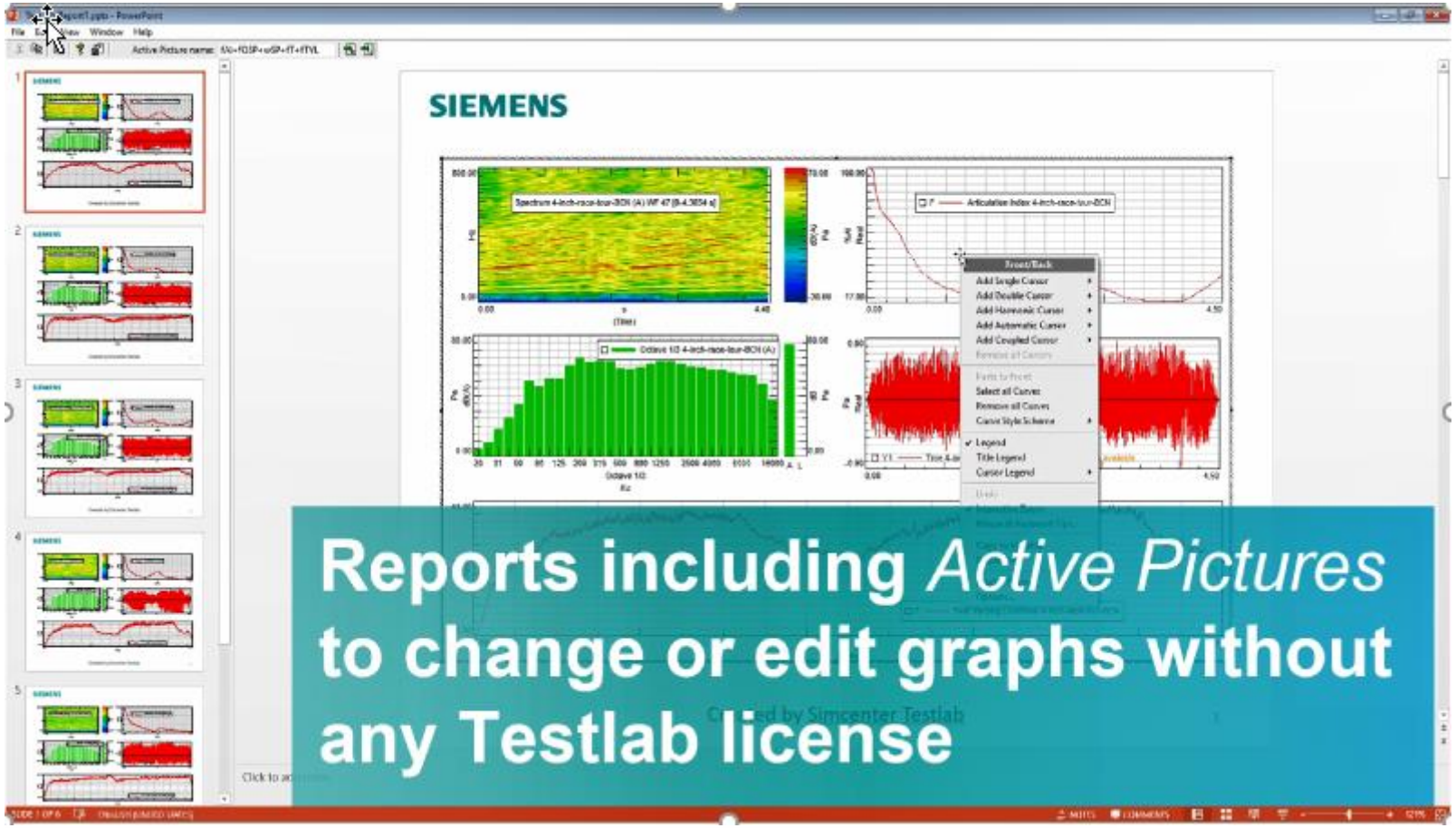
**Smart Actionable Reports**



# Ultimate dream?
# Unified testing, combining NVH, Durability & other attributes, …

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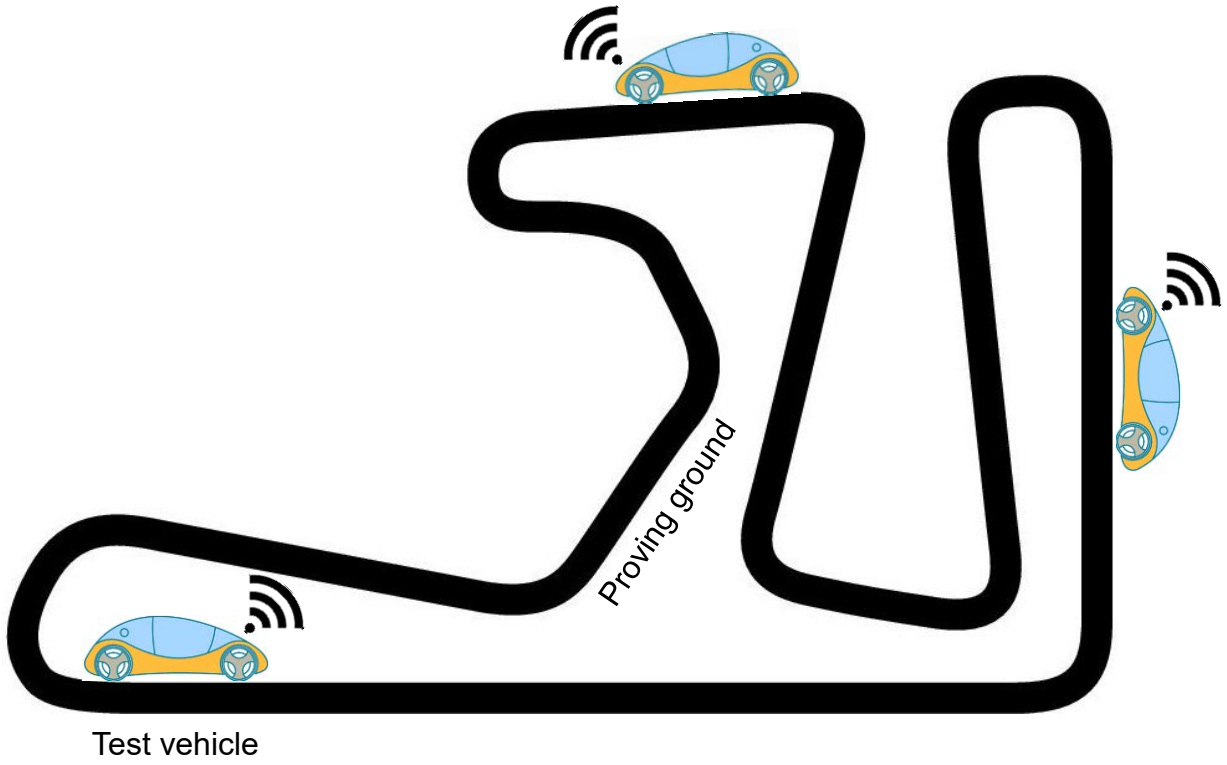
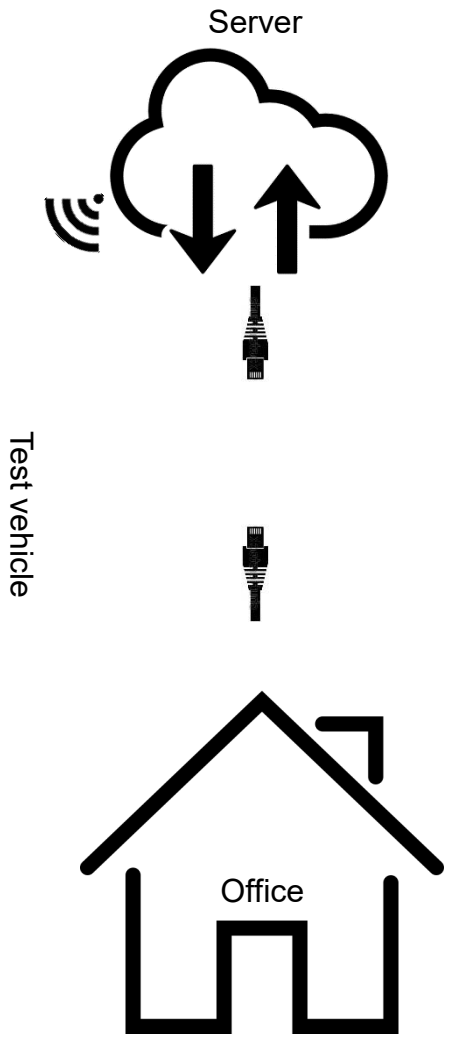
**Automated**
**&**
**remote**



# Conclusions

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| Increase Flexibility | Increase confidence | Be more efficient |
| --- | --- | --- |
|  |  |  |

# Thank you! Want to know more?

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## Read more

## Explore, share and learn

## Watch videos


## Contact the expert


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Thank you