

BENTELER Engineering Durability Testing in automotive

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PLOT Conferentie
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BENTELER Engineering is part of the BENTELER Group with operations around the globe

Worldwide

79

Plants,

91

Branches / Trading
Companies

Sales of

7,556

billion Euro

28.000

Employees
worldwide

Branch Offices in

37

Countries

F&E at

32

Locations in

18

Countries



Automotive



Steel/Tube



Distribution



Engineering



Glass Processing
Equipment

The BENTELER Engineering Group comprises 11 locations in three countries



Germany

- Munich (Headquarter)
- Paderborn
- Wolfsburg
- Cologne
- Stuttgart
- Bremen
- Bremerhaven
- Hamburg

Sweden

- Gothenburg
- Trollhättan

The Netherlands

- Helmond

650 employees located in 11 locations create innovative engineering solutions for our customers

Revenue

60

million Euro

Locations

11

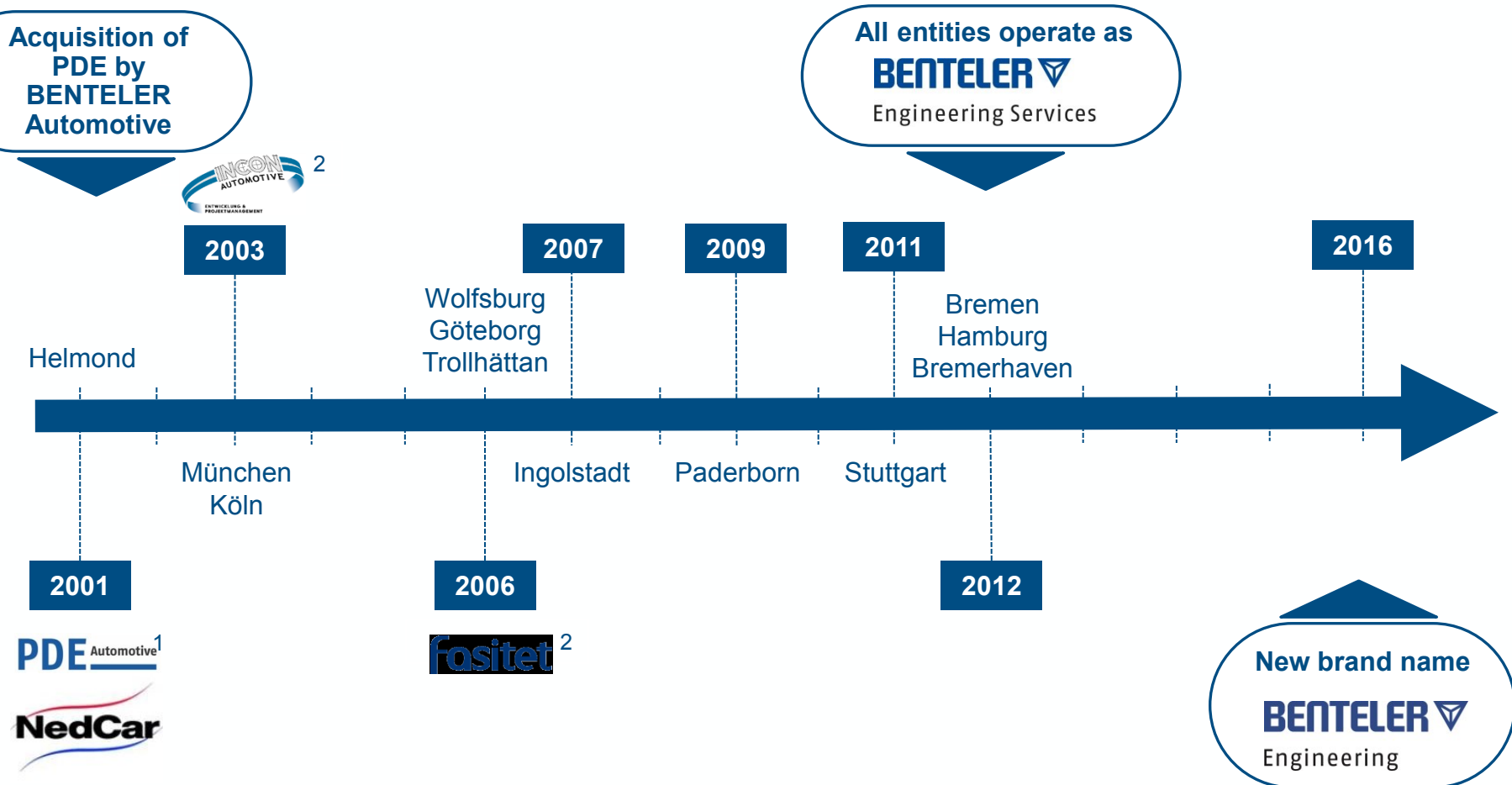
In 3 countries

Employees

650

FTE

From 2012 onwards, all entities operate as BENTELER Engineering



Source: BES; 1) established in 1958 as R&D center of DAF; 2) entrepreneurial, local/regional companies

Location Helmond @ Brainport Region



BENTELER Engineering covers all steps in the product development process



Product Development

- Concept Design
- Mechanical Design
- Electrics & Electronics
- Calculation & Simulation
- Armoring
- Prototyping
- Test & Validation
- Small Series Production

Process & Production Development

- Tool, Equipment & Fixture Design
- Automation
- Manufacturing Engineering

Supplier Development

- Supplier Evaluation
- Product Quality Assurance
- Production Efficiency & Process Improvements
- Cost Estimation

Supporting Services

- Project Management
- Quality Management
- Data Management & Logistics
- Production Support

				
Automotive	Public Transport	Commercial vehicles	Shipbuilding	Industry
      <p>DAIMLER</p>         	   	  <p>A PACCAR COMPANY</p>  	     	     

Broad Test Centre for durability testing on components, systems and modules

Customers: OEMs and Tier 1 suppliers world-wide

- Testing and validation of functions and durability
- Recommendations for product improvement
- Homologation/certification for vehicles and components
- Conformity Of Production testing



Testing departments:

- Prototype building
- Component Testing
- System Testing



Location Helmond , the Netherlands

Test facilities 2.500 m2 - 20 skilled testing professionals

Protobuild shop 2.500m2 - 20 skilled protobuild professionals -

Endurance testing at BENTELER Engineering



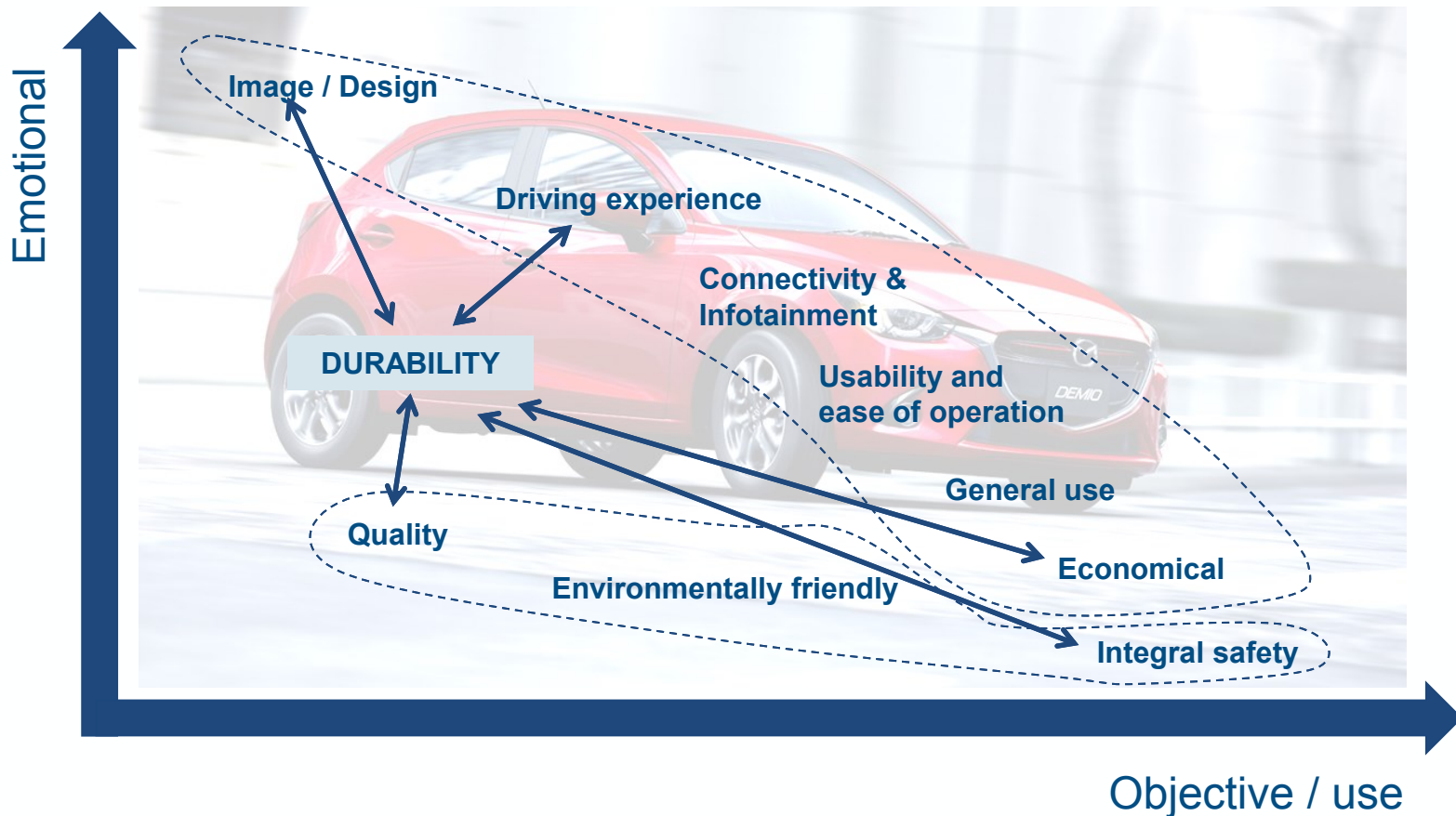
1. Durability Testing in Automotive

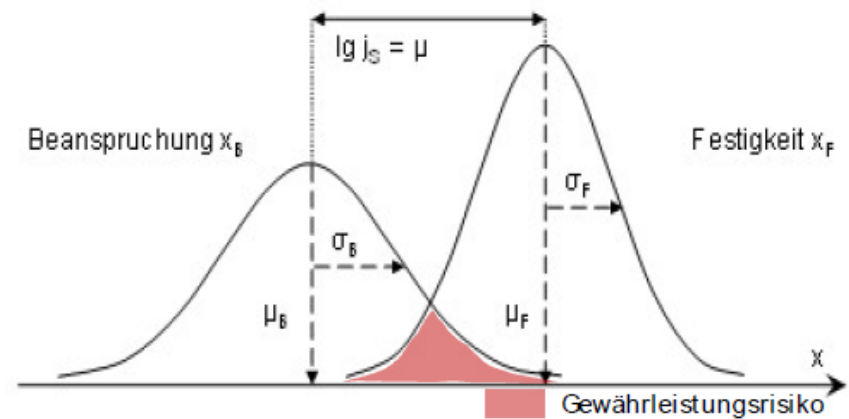
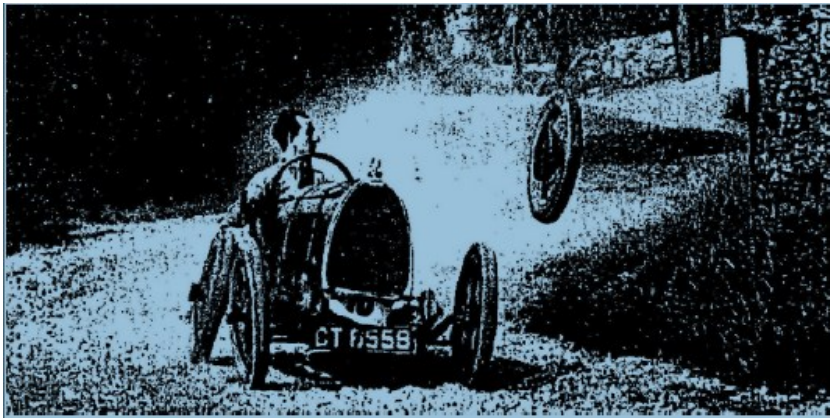
2. What are the reasons for testing?

3. How are tests performed?

4. What's the correlation to reality?

Customer Selection Criteria



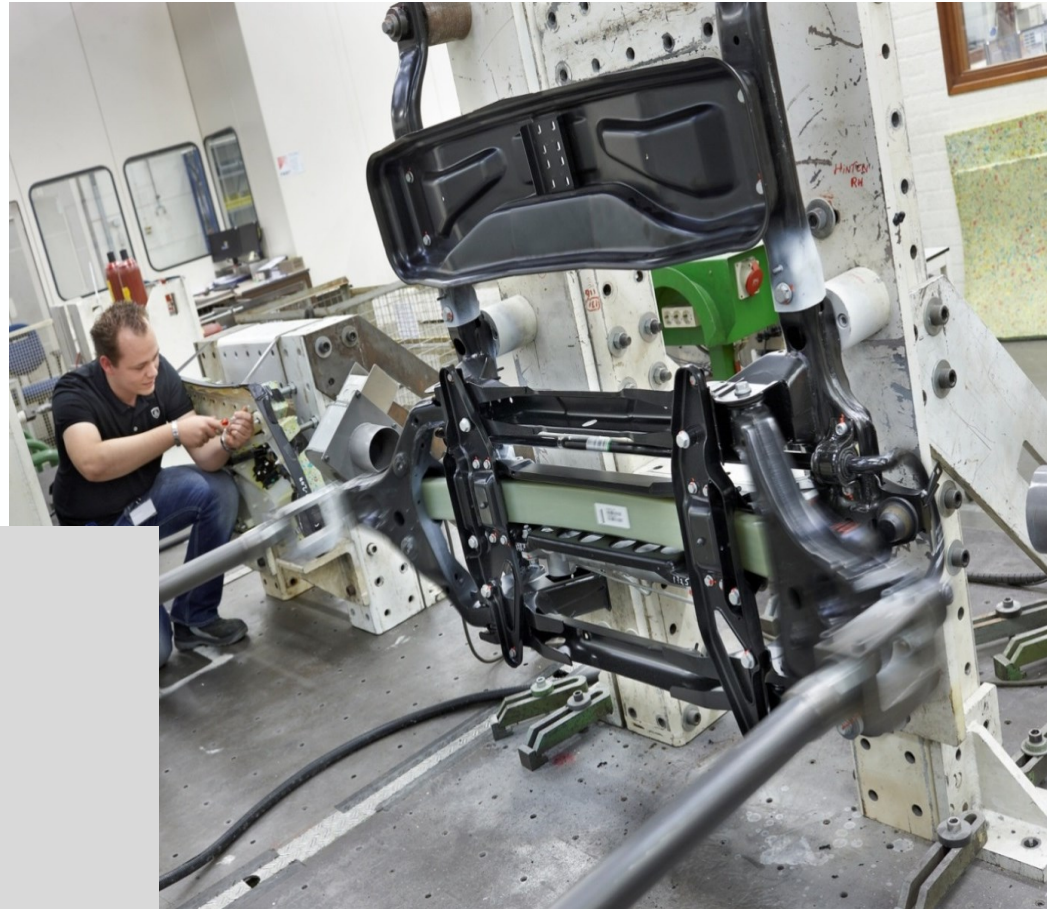


Definition:

Probability of no product failure
after a certain operating time
in a certain environment

Steps:

- Development analyses methods Boole/FMEA
- Test planning and process (Weibull)
- Production specification
- Production check



Development

- Verification of design / prototypes
- Optimization of design
- Verification of CAD / CAE models



Production

- Check on production parts (COP/IP)
- Investigate Field problems

New chassis designs over the years

Reasons in the past

- Improve endurance
- Improve handling/ dynamics
- Decrease cost price



- Improved design
- New materials



Current reasons

- CO₂ reduction
- Reduction operating costs



- Lightweight design
- New powertrain concepts
- Suspension and body optimization

Testing possibilities / overview

Test track (OEM)

- Long time experience > 50 years
- Known correlation to customer use

Lead time \leq 6 months

CAE tools

- Fast improvement steps possible
- Correlation with test track (and test results) is a challenge

Lead time < 1 week

Test rig

- Stable and reliable test results; excellent A/B comparison
- Correlation to the test track is a challenge

Lead time \geq 2 months

Public road by customer(s)

- High risks due to late failures
- Unknown effects of misuse

Lead time > 6 years

Specialised on Durability (fatigue) and Strength testing

Capable to carry out tests on:

- Chassis
- Suspension
- Complete vehicle
- Components
- Body parts / Body in white
- Closures
- Engine / gearbox mounts

Specialised on Durability (fatigue) and Strength testing

Competencies:

Load definition:

- (Road load) data acquisition
- Instrumentation with WFT/Strain gauge/ LVDT's etc

Verification tests: Test rig design

- Test rig build (standard system)
- Defining test procedures
- Iteration
- Running test/ Daily checks

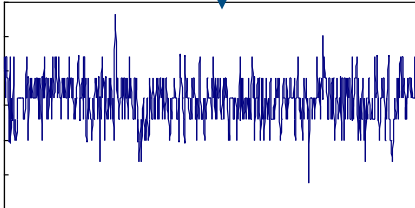
Reporting:

- Iteration/ Status reporting
- Result evaluation

Work flow (Sinusoidal or real time tests)



ROAD LOAD DATA



RESPONSE DATA



RECORDING DATA

Statistical data check



RLD - Wheel Force Transducers 6DOF (WFT)

Aluminium(2x)

MTS Swift 30A

Fx	+/- 25 kN
Fy	+/- 20 kN
Fz	+/- 25 kN
Mx	+/- 3,5 kN·m
My	+/- 4,5 kN·m
Mz	+/- 3,5 kN·m
Angle	0 - 360°
Weight	4,5 kg

Titanium(2x)

MTS Swift 30T

Fx	+/- 45 kN
Fy	+/- 35 kN
Fz	+/- 45 kN
Mx	+/- 8 kN·m
My	+/- 11 kN·m
Mz	+/- 8 kN·m
Angle	0 - 360°
Weight	6,8 kg



Transducer interface

I/O	Analog	Analog
Output:	+/- 10 V	+/- 10 V
Delay:	12µs	12µs

Performance Accuracy

Nonlinearity:	1,0% Full Scale
Hysteresis:	≤ 0,5% Full Scale
Modulation	≤ 3,0% Full Scale
Cross talk	1,5% Full Scale

RLD - Other transducers

Displacement transducers

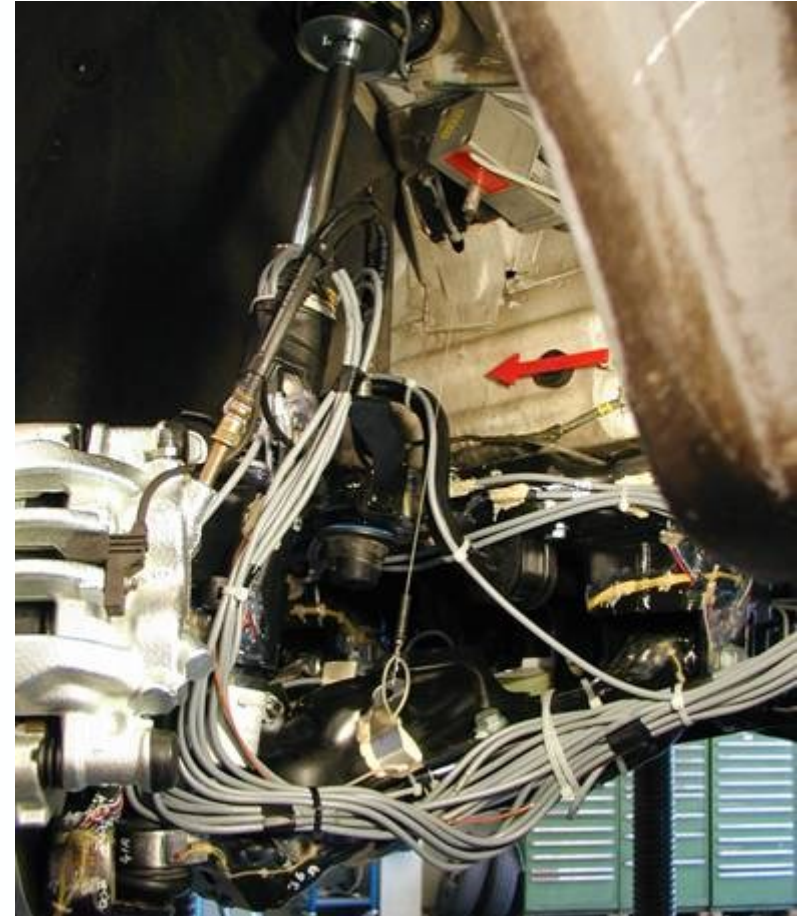
- Potentiometric
- Inductive

Acceleration transducers

- Charge based
- Strain gauge based

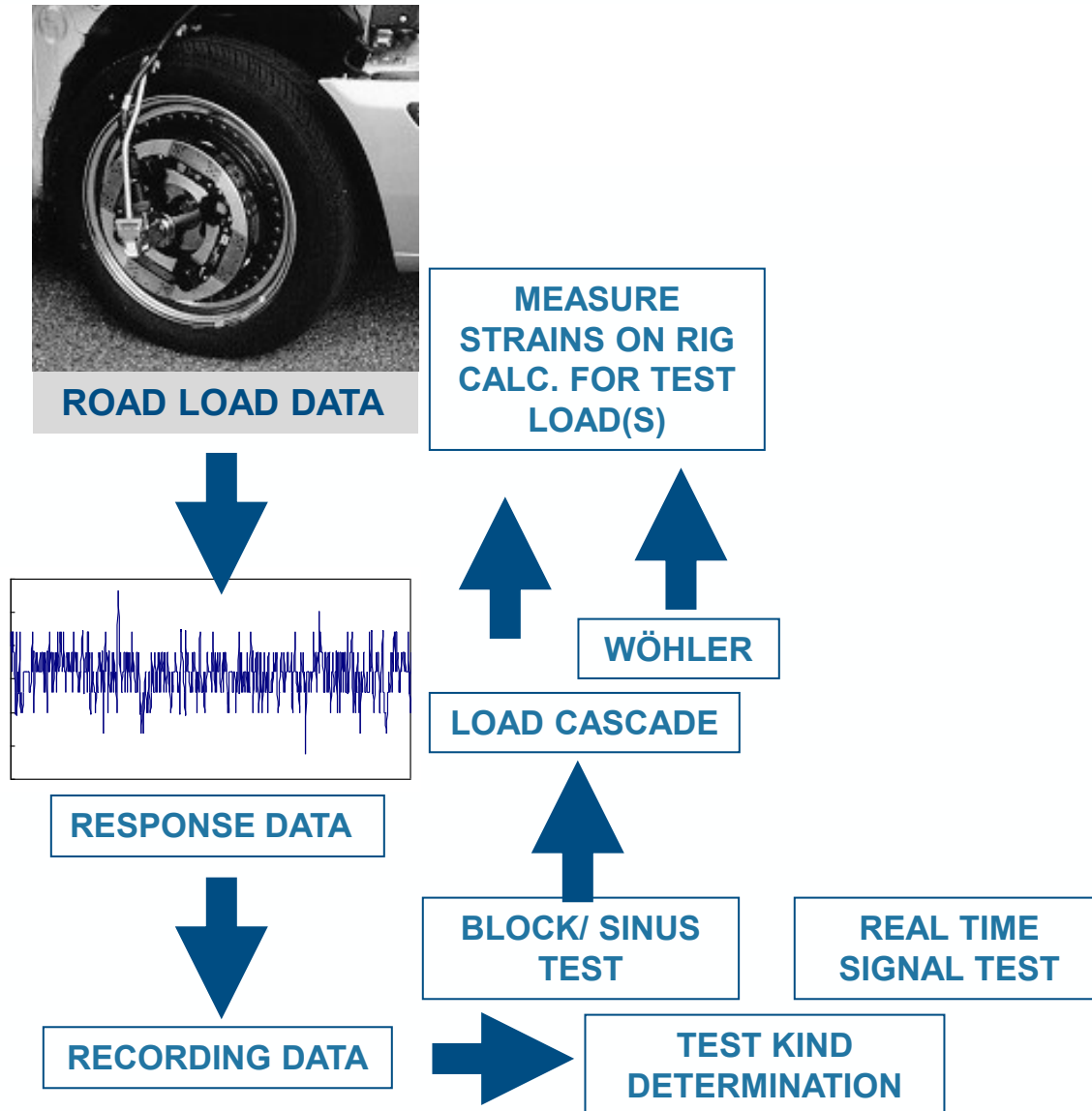
Strain gauge applications

- Full and half bridge applications
- Three and 4 wire applications



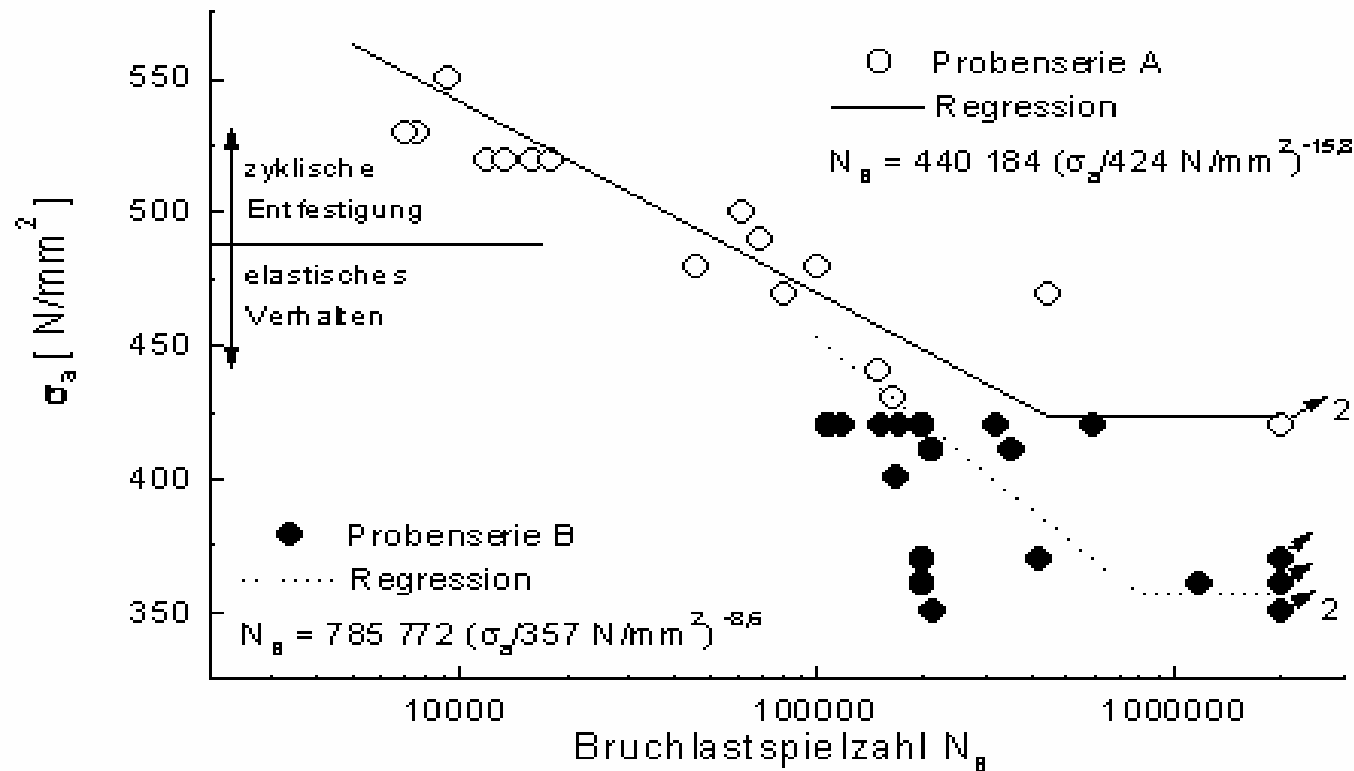


Work flow (Sinusoidal or real time tests)



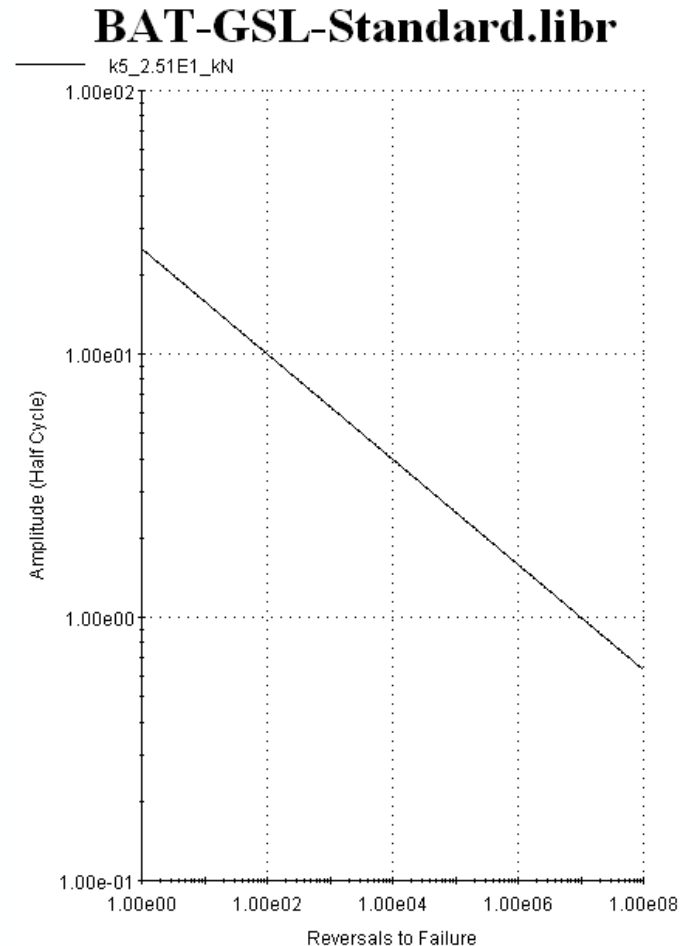
August Wöhler

22 June 1819 - 21 March 1914



Durability Testing

Damage calculation



Damage Cycle - Automated Iteration Response Damage Calculations

Inputs
Time History: A-11-059645_PA-424_F11_550xdA_NR_BES_27_RSP

Outputs
Histogram: _dmc

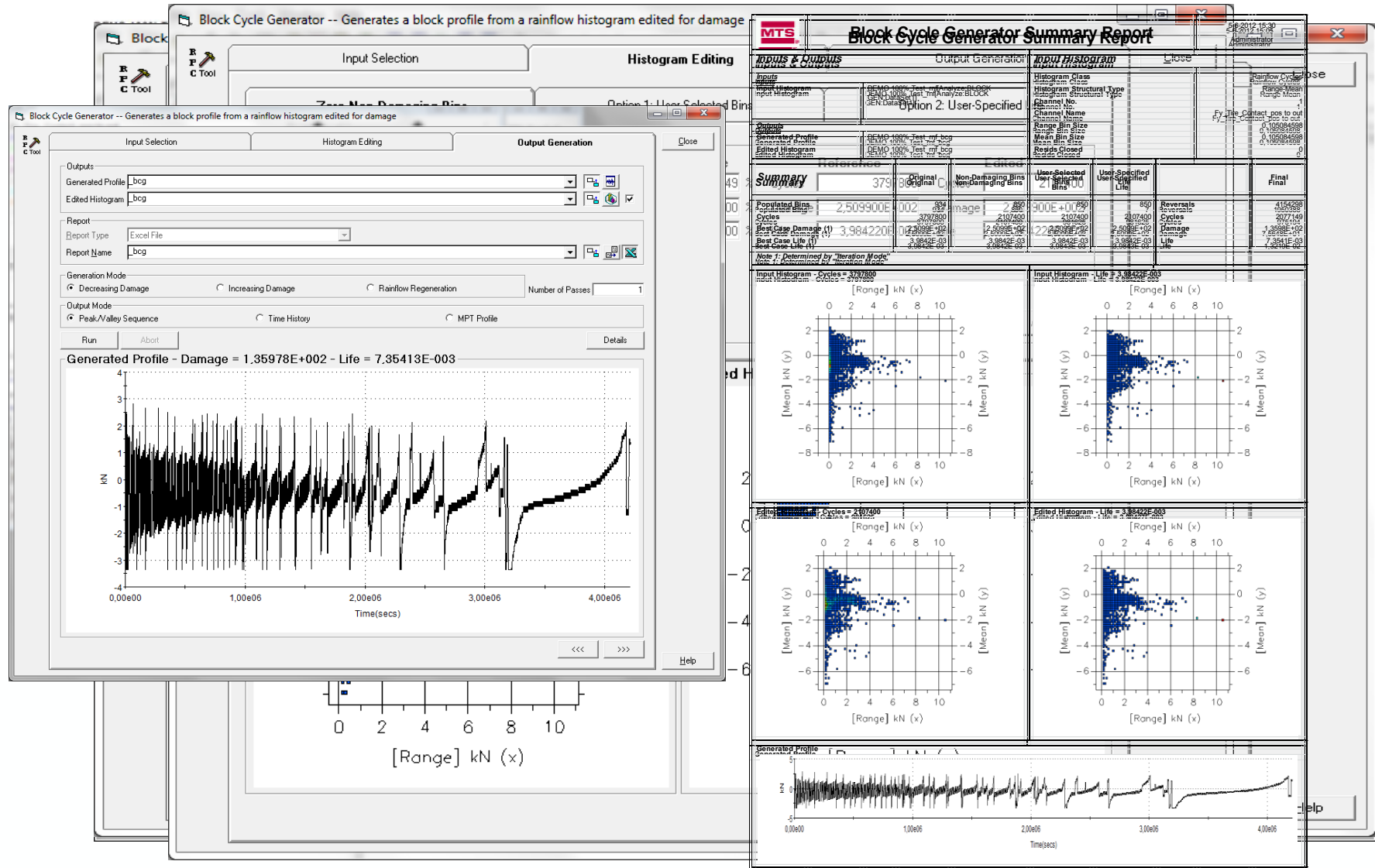
Report
Report Type: Excel File
Report Name: _dmc

Options
Analysis Method: Generic Stress Life / Load Life
Stress Units Mode: SI (MPa)
Histogram Mode: None
Histogram Parameters Mode: None
Histogram Boundaries Mode: None
Noise Band Mode: Absolute Value
☐ Clip GSL damage at 1 per half-cycle
☒ Is Microstrain
☒ Trim Histogram

Channel Table
☐ All Channels Same ☐ Append Channel ☐ Auto-Select Materials
☐ Remove Channel

	Channel Name	Process	Noise Band (Absolute)	Scale Factor	Material Name	Notch Factor
1	011_Fx_Hl	<input checked="" type="checkbox"/>	0.00000	1.000	k5_2.51E1_kN	1.000
2	007_Fy_Hl	<input checked="" type="checkbox"/>	0.00000	1.000	k5_2.51E1_kN	1.000
3	003_Fz_Hl	<input checked="" type="checkbox"/>	0.00000	1.000	k5_2.51E1_kN	1.000
4	575_Mx_korr_Hl_mR	<input checked="" type="checkbox"/>	0.00000	0.001	k5_2.51E1_kN	1.000
5	035_Mbr_Hl	<input checked="" type="checkbox"/>	0.00000	0.001	k5_2.51E1_kN	1.000
6	679_Mz_korr_Hl_mR	<input checked="" type="checkbox"/>	0.00000	0.001	k5_2.51E1_kN	1.000
7	intn_Fx_Hl	<input checked="" type="checkbox"/>	0.00000	1.000	k5_2.51E1_kN	1.000

Block test/ Sinus test damage calculation



Hydraulic facilities @ Benteler

Hydraulic actuators

- 2 100kN / 150mm stroke
- 10 50kN / 1x 50, 2x150, 4x250, 1x300, 2x280mm stroke
- 4 30kN / 150mm stroke
- 20 25kN / 1x50mm, 1x150mm, 18x250mm stroke
- 4 15kN / 200mm stroke
- 3 10kN / 1x50mm, 2x150mm stroke
- 1 5kN / 75mm stroke

Servo controllers

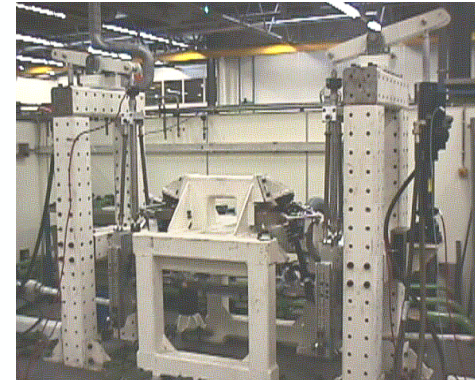
- 3 MTS Flextest GT (8ch/6ch/5ch systems)
- 3 MTS Flextest60 (8ch/6ch systems)
- 2 MTS Flextest IIIm (8ch systems)
- 1 MTS SE (2ch system)
- 1 MTS Flextest IIIm for 329 6DOF (14ch system)
- On all systems MTS Flextest software

Iteration software

- All MTS RPCpro v4.9 / v4.2 software

Rig build system

Standard rig build system available including adapters etc

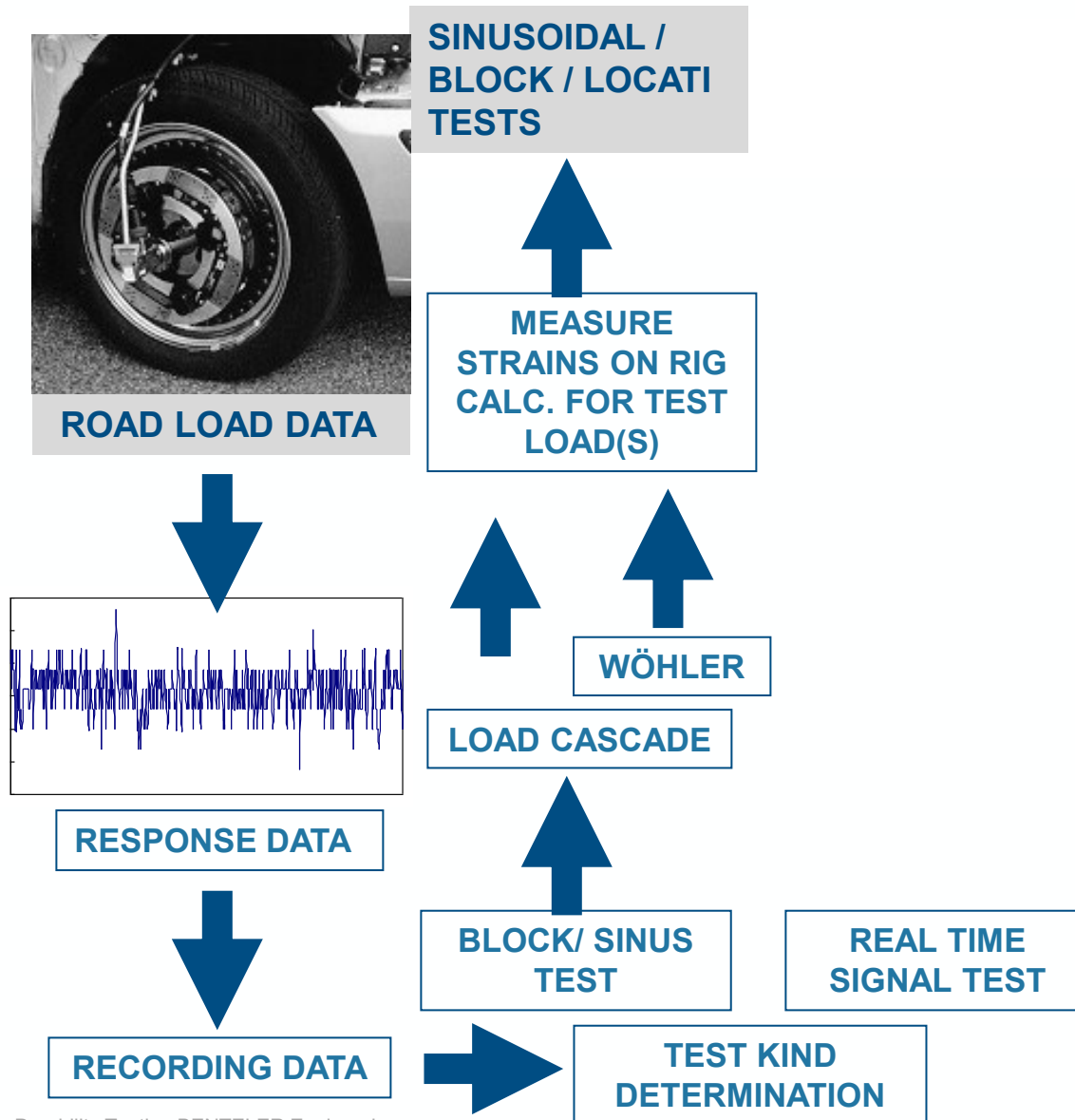


Standard rig build system



MTS Digital controllers

Work flow (Sinusoidal or real time tests)



Servo hydraulic applications

Frame testing

Axle test rig

Fuel Rail

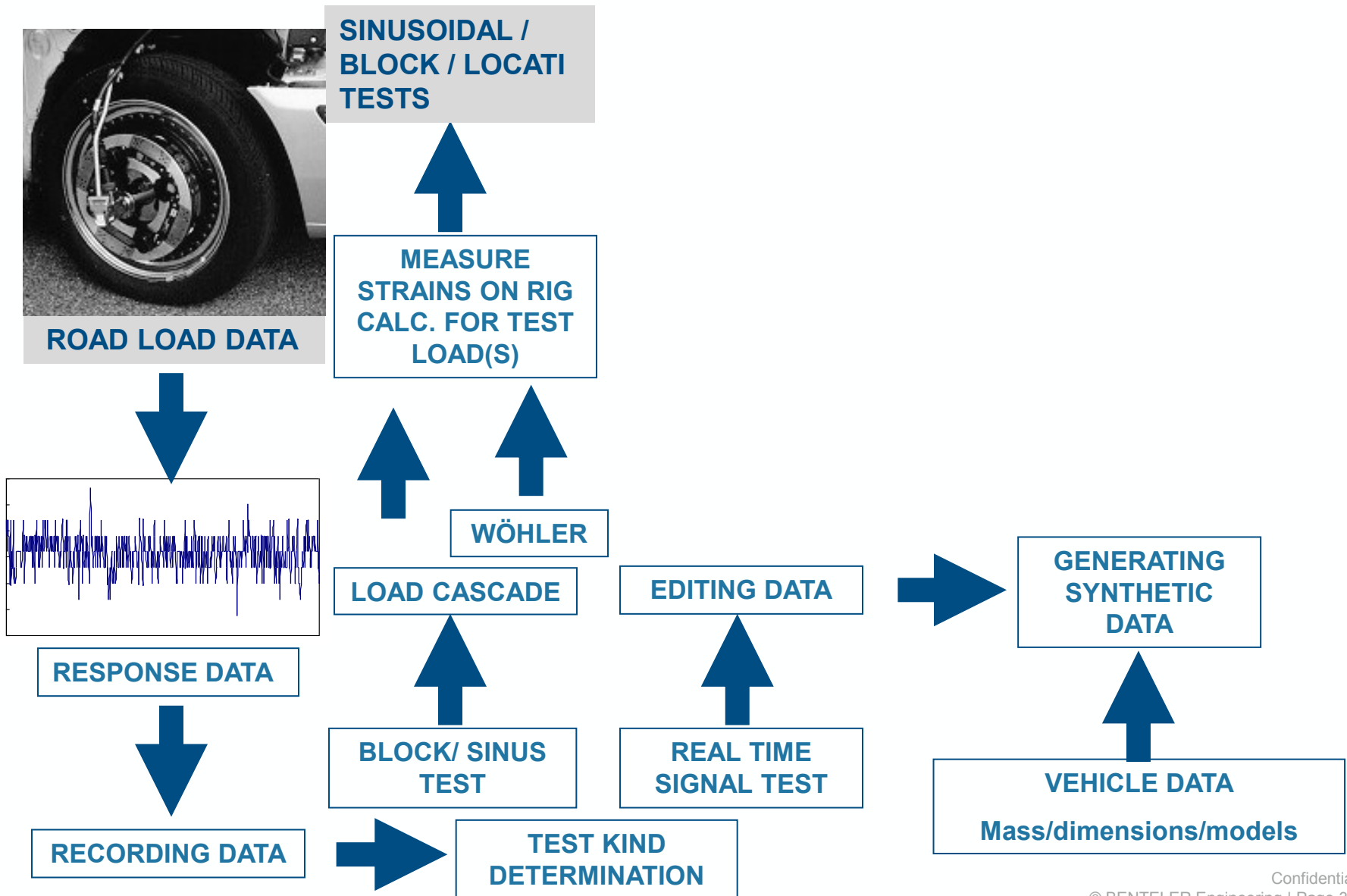
Towbar testrig

2-Ax vibration Test

Dedicated Tests



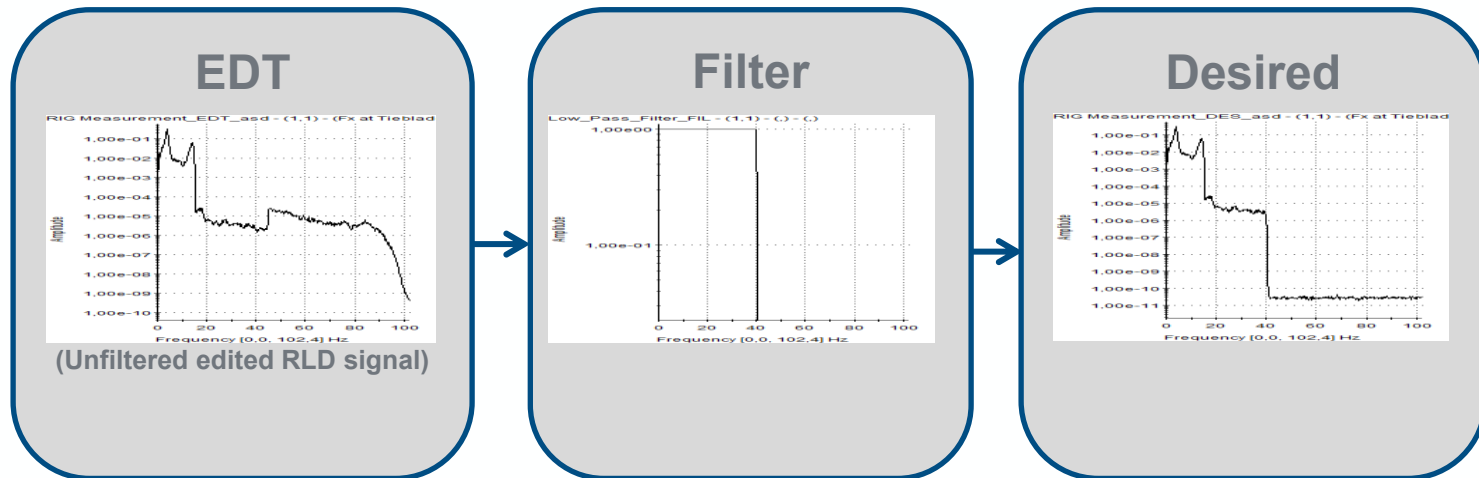
Work flow (Sinusoidal or real time tests)



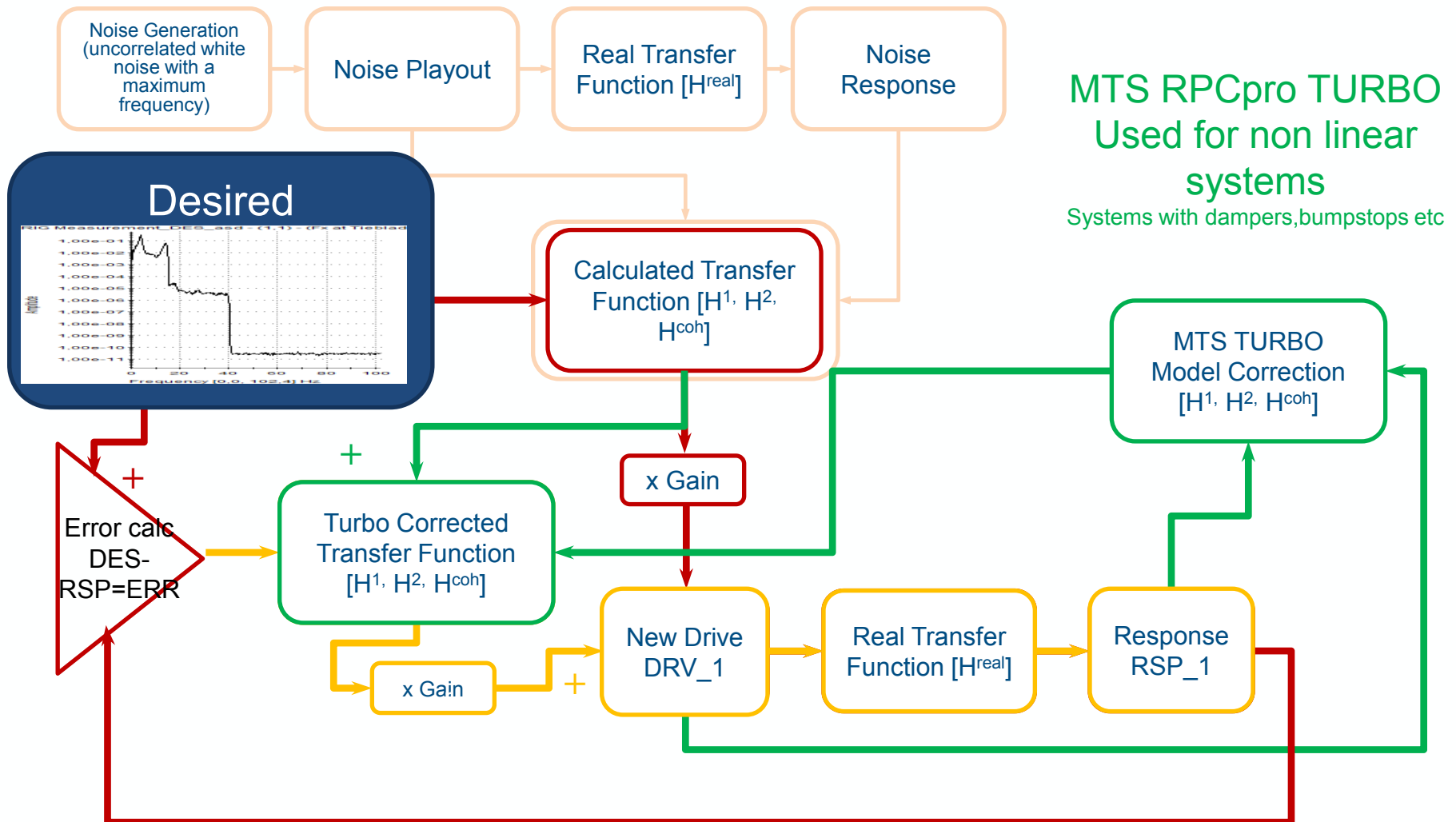
Iteration process for rig control

RPC Pro from MTS

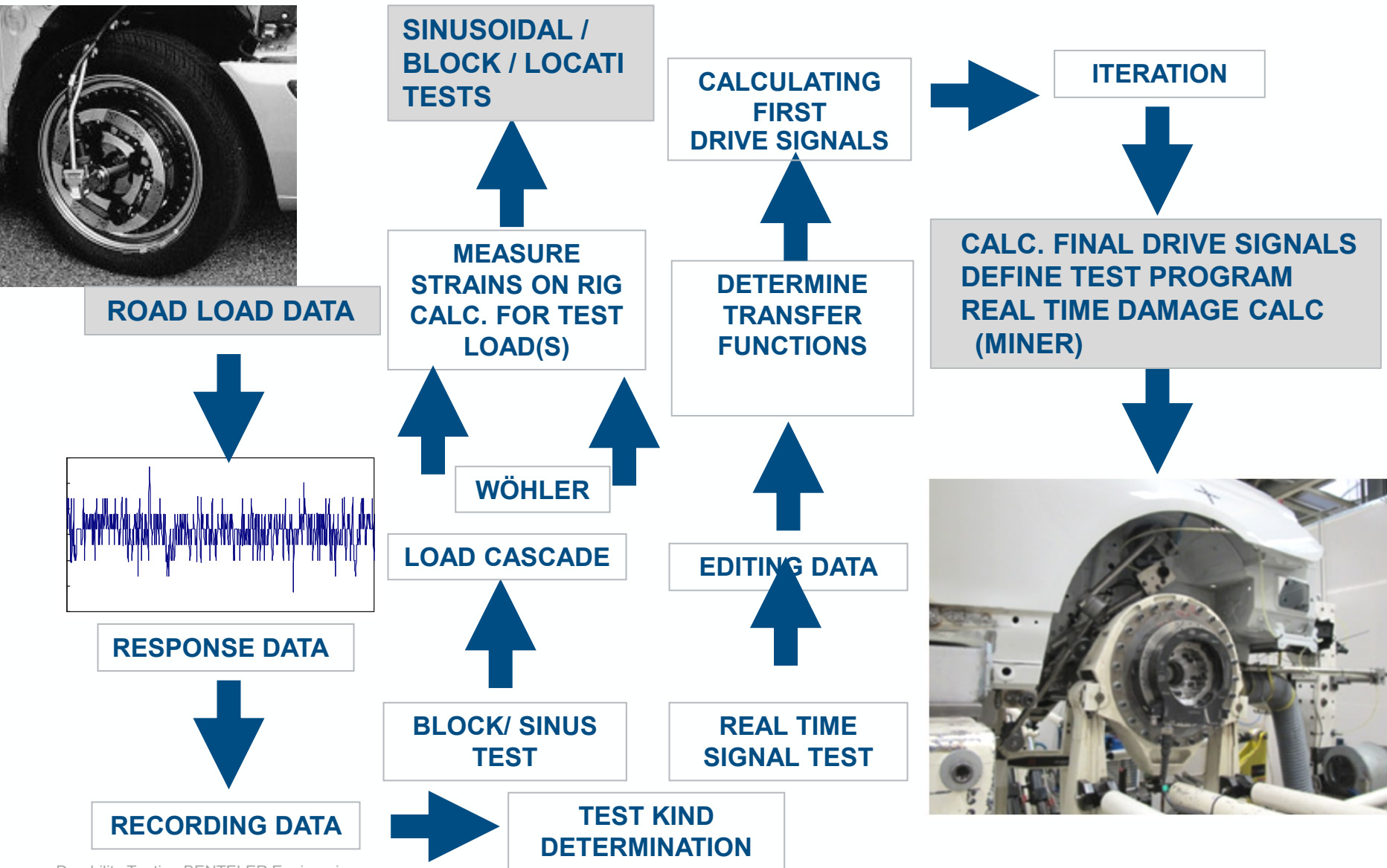
- Desired/ “soll” signal input
- Iterative process for Response (output control)
- Turbo option for Model correction



Iteration Flow chart



Flow (Sinusoidal or real time test Works)



12 Channel rig (6Dof)

Detailed specification:

Cylinder type	MTS244.21 (50 kN 2x) X MTS244.11 (15 kN 4x) Y/Mz MTS244.20 (31 kN 2x) Y/Mx MTS244.23 (156 kN 2x) Z MTS244.11 (13.3 kN 2x) My
Max. Load X	22 kN / 390mm / 2 m/s
Max. Load Y	26 kN / 260mm / 2 m/s
Max. Load Z	63 kN / 380mm / 7 m/s/ 39g(750/50kg)
Braking mom.	My4 kNm/ 35°/ 550°/s
Steer mom.	Mz.3.8 kNm/16°/ 400°/s
Camber mom.	Mx7 kNm / 16°/ 400°/s
Add control	for 13 th actuator
Test site control	FlextestIIIm V3.5 RPCpro V4.9
I/O	28 AI/ 8 AO/ 8 DI/ 8 DO
Res. Freq.	< 0.8Hz in Z; torsion+bend >50Hz (base plate of 90 Tons; 7.2x 5m)

Vehicle weight: max. 3500 kg
Corner weight: max. 750 kg
Wheel base: max. 3000 mm
Track width: max. 1700 mm
Dynamic wheel radius 250 -400 mm



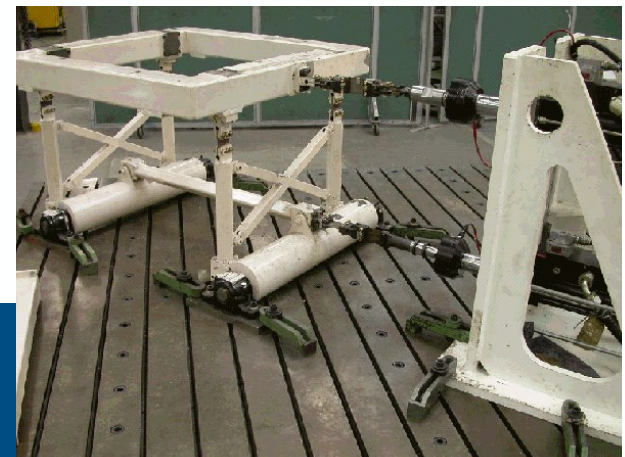
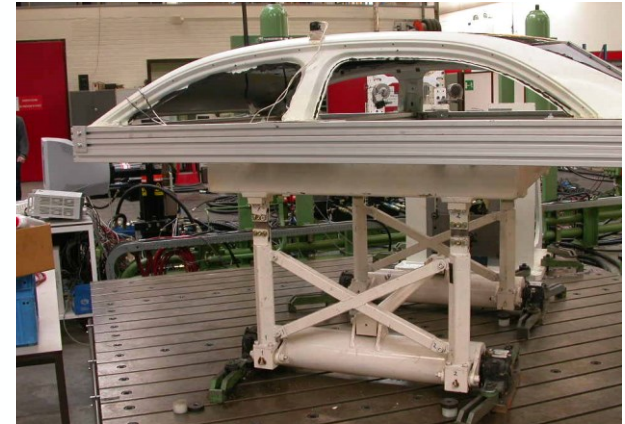
Dimension rig wheel-adapter 388 mm
Excitation Freq. 0-50 Hz
Make MTS 329 6DOF
Rig height middle 1866mm
Table height 1370mm - 450mm
Construction 2002/2009

2 Axial shaker rig

Detailed specification:

Max. Load	50kN&25kN / 50mm stroke
Cylinder type	MTS248.05 50mm 50kN MTS208.03F02 50mm 25kN
Accel.	5g in Z direction at 12Hz
Max.freq.	80 Hz
Servo controller	MTS Flextest GT 1
Iteration	RPCpro / RPCIII
Res. Freq	< 1Hz (base plate 25 tons; 3x3m)
Temperature	ambient
Construction	1990x
Last update	2008

Specimen weight max:	200kg
Mounting size:	1150x1150mm
Inside size:	920x920/600mm



Fuel rail test rig LP/HP

Detailed specification:

Max. Pressure	LP=>500 bar (760-1031A-HP8) HP=>700 bar (J634-013)
Test medium	Oil Shell Tellus S2MA 46
Test outputs	5/6
Oil flow spec	Direct: Max pressure < 190bar: 50l/min Booster: Max press < 500bar: 27l/min
Oil compression	Tellus DO46= 0,65%/100bar
Oil content rig	40cc \Rightarrow 0,3cc/100bar
Test frequency	from 0 and 50Hz depending from specimen content and max pressure
Test freq calc	$(27000/60) / (\text{max press}/100) / ((\text{spec content}+40)*0.01)$
Cooling system	Closed system to water 15°C
Leak detection	Oilbug RedEye
Servo controller	MOOG-MTC
Temperature	ambient upto 65 °C
Construction	2004
Last update	2015



Specimen weight max.: 20kg
Mounting size: 880x470x470mm

Crush rig / Static impact

Detailed specification

In house developed hydraulic test rig to perform crush tests and static impact tests

Actuator type:

Hydraudyne 200kN 750mm

Velocity controlled:

0- 120mm/min

Capacity:

loads up to 200 kN, displacement up to 750 mm

Barrier dimension:

1830 x 750mm

Suitable for e.g. test according to FMVSS214 and 216, body crush tests, steering wheel strength tests, bumper crush tests and static impact tests.



Durability Testing

High frequency

Range of services:

- Resonance determination
- Endurance testing
- Analysis of test results

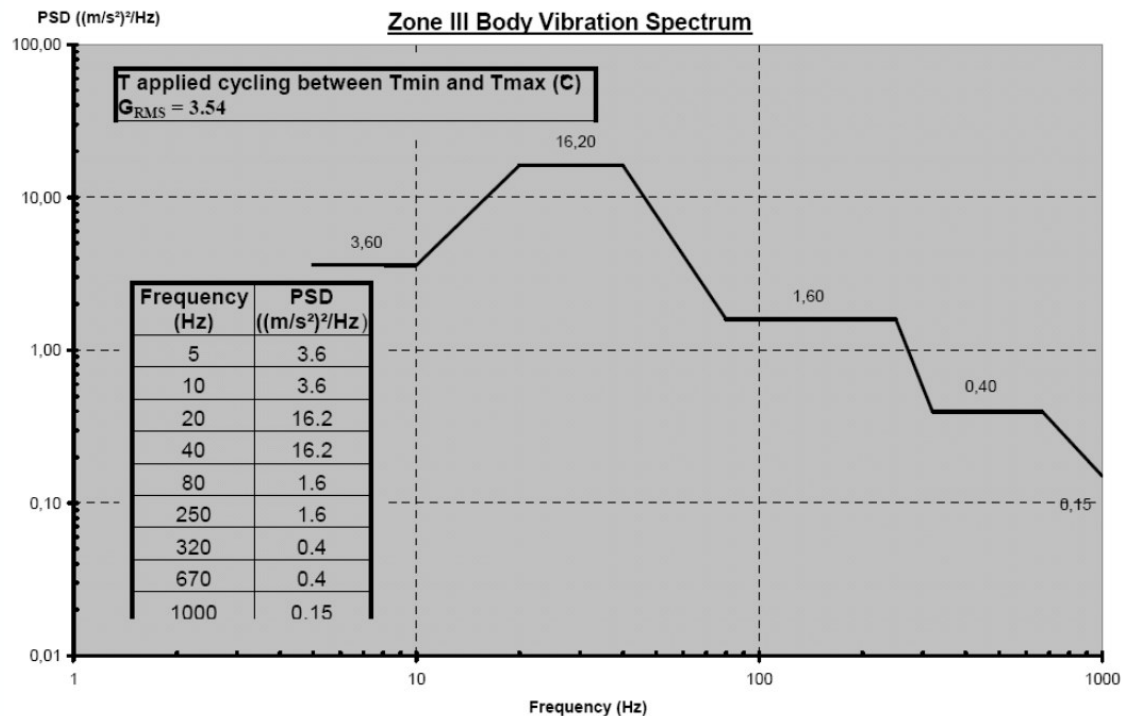
Equipment:

- 2x V455 Electro dynamic shakers
- 1x V721 Electro dynamic shaker
- 1x V830 Electro dynamic shaker
- 1x ETS MPA409 Electro dynamic shaker
- 1x ETS BT900 Slip table
- 3x M+P Vibpilot controller
- 1x Lms Test.Lab – Sine controller



Electro Dynamic Testing

- Functional testing for resonance frequencies in operating range
- Typical endurance testing with noise spectrum
- Testing in X, Y and Z direction; test time < 1 week



Durability test improvements:

- Shorten test time
- Improve correlation
- Improve reproducibility
- Minimize spread



Range of services:

- Functional testing at climatic circumstances
- Thermic lifecycles at a maximum variation speed of 1 °C/min
- Mechanical lifecycle tests at extreme temperatures, steady state or temperature cycles

Equipment climate testing:

- Climatic chamber:
 - -40° - + 80°C
 - 30 – 95% RH
- 3 Climatic cup boards:
 - -40° - +150°C
 - 25-95% RH
 - 10 m3



Conformity of production (cop)

Range of services:

- Airbag deployment tests from -40 to + 80°C incl. High speed video recording from 2 directions.
- COP EG 74/408 static seat tests / dynamic head impact test on seats and head restraints.
- COP on chassis modules/parts
- COP on industrial and marine engines

Equipment:

- Airbag deployment test chamber
- Emissions test laboratory
- Head restraint & seatback test rigs
- Hydraulic actuators



- Netherlands PLOT = Platform OmgevingsTechnologie
- Germany DVM = Deutscher Verband für Materialforschung und –prüfung
- England EIS = Engineering Integrity Society
- Expo Testing Expo Stuttgart



Durability Testing

Tour Test Center



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Thank you for your attention!