

# Ride comfort testing



## Introduction

Ride Comfort is the general sensation of noise, vibration and motion inside a driving vehicle, experienced by both the driver as well as the passengers. Ride comfort optimization goes beyond the pure ISO2631 Whole body vibration certification testing as it affects the comfort, safety and health of the passengers subjected to it:

- **Comfort:** the first impression during a test drive is an important criterion when buying a new car, and therefore represents the first appreciation of the brand image
- **Safety:** reduced concentration for the driver of a noisy vehicle after several hours on the road involves high risks of accidents
- **Health:** long term exposure to vibrations can cause lower back pain problems for the driver of trucks, buses or heavy off-road vehicles

The assessment of ride comfort can be seen consists the following domains:

- **Seat vibration:** ISO whole body vibration and general troubleshooting of seat vibrations
- **Steering wheel vibration or “shimmy”,** for example due to tire unbalance
- **Interior noise:** averaged overall A-weighted sound pressure level, sound metrics ...
- **General handling and motion of the vehicle:** yaw and roll rate, braking force ...

Measuring and quantifying ride comfort can help development teams in meeting the necessary standards and regulations, but moreover gives the required insight to troubleshoot, understand and improve the noise and vibration comfort of the vehicle.

## Industries and applications concerned

Following industries are concerned with ride comfort optimization:

- Automotive OEMs
- Automotive suppliers (manufacturers of seats, suspensions, tires, acoustic isolation, ...)
- Truck and bus manufacturers
- Train and railroad manufacturers
- Manufacturers of off-road, earthmoving and construction vehicles
- Manufacturers agricultural vehicles
- Manufacturers mining vehicles
- Manufacturers of forklifts, cranes, wheel loaders

## Measurement approach

Ride comfort is the measurement of seat and steering wheel vibration, interior noise and extra CAN-bus channels.

The basic setup consists of:

- a seat pad accelerometer that measures the acceleration in 3 directions on the seat cushion (seat vibrations)
- 2 accelerometers mounted at the left and the right side of the steering wheel (steering wheel vibrations)
- 2 microphones mounted at the driver and passengers ear positions (interior noise)
- CAN bus (vehicle motion parameters)

The basic setup can be easily extended as described below.



Ride comfort testing in all kinds of industries as there are e.g. automotive and agricultural vehicles

The LMS Test.Xpress software records the time signals of all channels and calculates in real-time the different parameters for ride comfort:

- Seat vibration:
  - Time domain weighting of the incoming acceleration signals according to the ISO2631 standard
  - Online weighted vector sum according to ISO2631 standard with clear color indication when exceeding the exposure limit and action values
  - This can be extended with e.g.
    - extra triax accelerometers on floor and back of the seat (see ISO2631)
    - transmissibility between floor and seat
- Steering wheel vibration:
  - Online double integration of both accelerations into displacement
  - Online calculation of vertical displacement of the steering wheel
  - Online calculation of rotation of the steering wheel
  - This can be extended with e.g.
    - Analysis of the vibrations first order as a function of the tire rotation speed in case of an unbalance on the tire
    - Hand-arm vibration analysis on the steering wheel according to ISO5349 standard
- Interior noise:
  - online acoustical A-weighting
  - sound pressure level
  - octave maps
  - L(A)eq values
  - support of artificial head
  - This can be extended with e.g.
    - Averaging over different microphones
    - Sound metrics like articulation index, Zwicker loudness, ...
- Vehicle condition parameters
  - Pitch and yaw rate of the vehicle
  - Forward tilt of the vehicle
  - vehicle speed and engine RPM
  - wheel rotation speed differences
  - braking pressure
  - fuel consumption
  - lateral vehicle acceleration
  - steering wheel torque
  - ...



(top) Seat pad sensor to measure seat acceleration in 3 directions  
(bottom) Mounting of steering wheel accelerometers

## The LMS Test.Xpress solution for ride comfort testing

The LMS Test.Xpress system consists of a measurement front-end (Scadas Mobile SCM01 or SCM05) and the LMS Test.Xpress analyzer software with parallel time recording.

The LMS Test.Xpress Human Body Vibration Filters apply the ISO2631 time domain filters to the incoming vibration signals and can be used for the seat and steering wheel vibrations.

The LMS Test.Xpress CANbus Support allows plugging in directly to the CAN bus of the vehicle, read out extra channels available on this bus and save them together with the data channels of the other sensors connected via the front-end.

The number of channels can go from 4 to 40, thus allowing:

- Measurement of extra triax sensors at the foot and back position of the seat (see ISO2631) or on multiple seats simultaneously
- Measurement of extra interior microphones or accelerometer positions
- Measurement of extra channels (strain gauges, speed, temperature, noise, ...)
- Later in-depth analysis of the measurement as all time signals are saved

The whole measurement, analysis and embedded MS Office reporting is controlled by use of a simple toolbar, and as all critical settings are blocked by a password there is no risk for errors or unwanted changes.

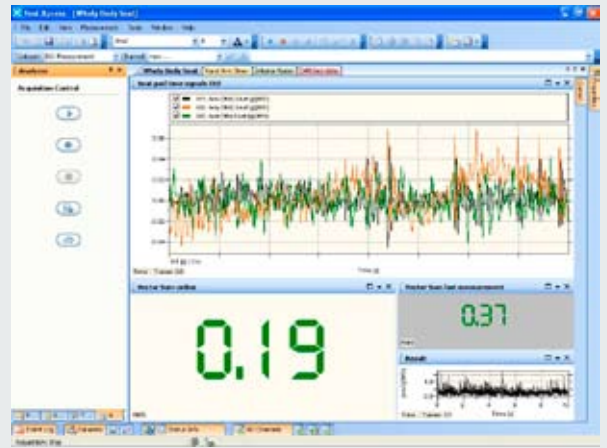
## Supported standards for ride comfort

The LMS Test.Xpress system supports the following Whole body vibration :

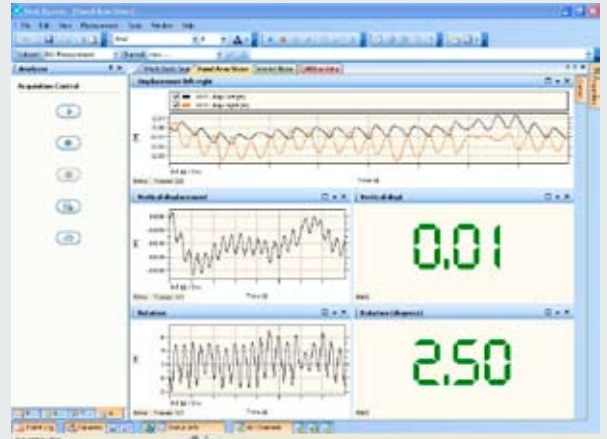
ISO 2631-1	General requirements
ISO 2631-2	Whole Body Vibration in Buildings
ISO 2631-3	Motion sickness
ISO 2631-4	Whole Body Vibration in Transport
ISO 2631-5	Response to multiple shocks

The LMS Test.Xpress system supports the following Hand-Arm vibration standards:

ISO 5349	Hand transmitted vibrations
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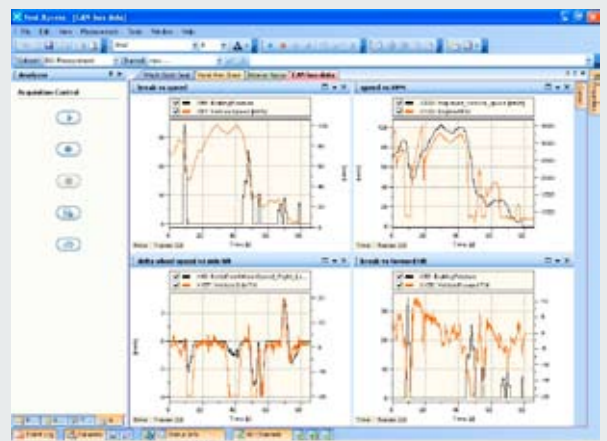
Seat pad time signals with real-time weighted vector sum and color indication of limits



Steering wheel signals with real-time integration to displacement and rotation



Interior microphone 1/1 and 3rd octaves, SPL, Leq, articulation index and loudness



CAN bus signals synchronized with other frontend channels



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