Ride quality objective evaluation of heavy commercial vehicles

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Main goals

- **Definition of a Ride Perceived Quality Index**
- **Definition of Vehicle Technical Specifications for Target Setting**

and then …..

- **Objective Ride Methodology definition**
- **Subjective Ride Methodology tuning (Customer Perceived)**

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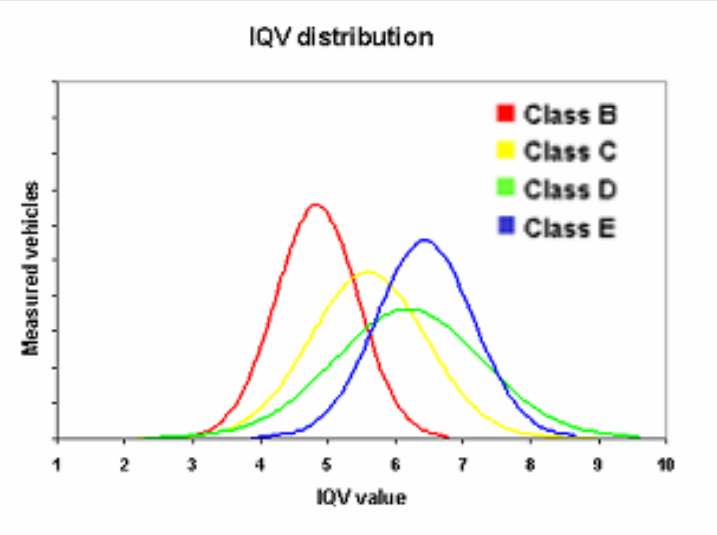
Background and Project Plan

Ride Objective Evaluation in Fiat Group

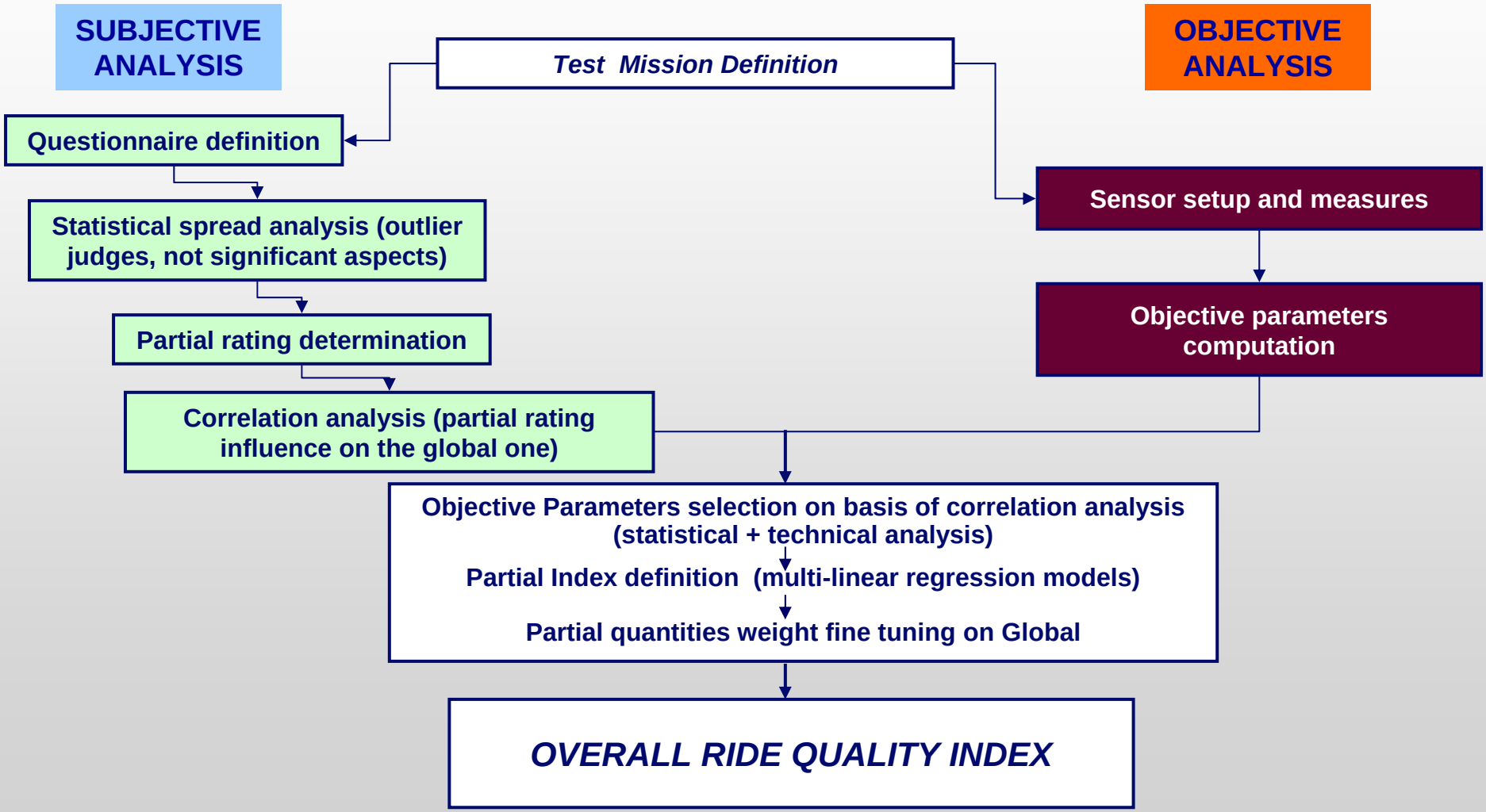
From the beginning of the ’90s a Vibration Perceived Quality Index has been established in Fiat Group Automobiles



Now the same approach has been transferred towards Heavy Trucks

Background and Project Plan

QUALITY INDEX – APPLIED PROCEDURE



Background and Project Plan

REFERENCE VEHICLES

- **5 vehicles** (balance between significant statistic sample and test timing/resources)
- Test Configuration: **Full Load** since these vehicles are mainly used in this way
- Test vehicles remarkably different to assure best subjective perception distinction (among Worst and Best in Class). Therefore, test vehicles **NOT** defined with performance benchmarking criteria **BUT** to assure the best evaluation of Ride differences to define the quality index.

TEST TRACK:

Subjective	***La Mandria/Balocco***
Objective	***La Mandria/Balocco***

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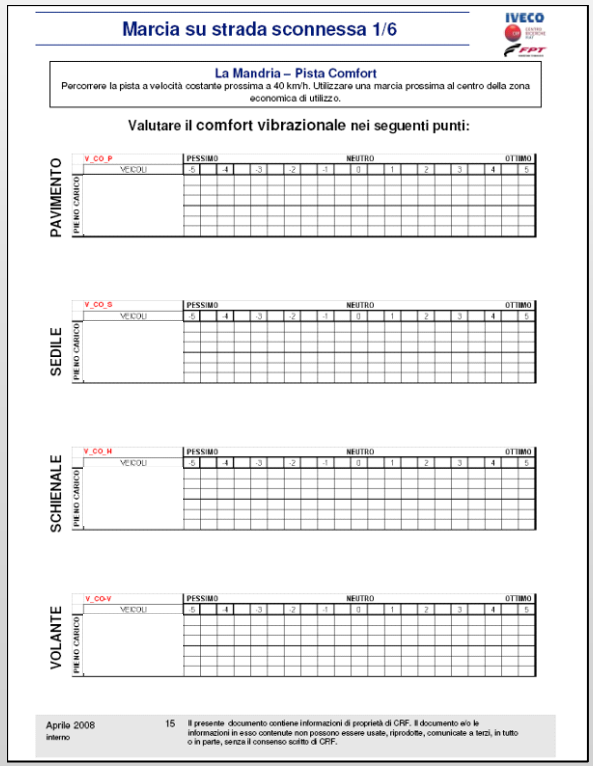
Subjective evaluation

Questionnaire definition and Jury Selection

Vibration Quality	Vibration at Idle	Floor
		Seat Cushion
		Seat back
		Steering Wheel
	Vibration on Highway	Floor
		Seat Cushion
		Seat back
		Steering Wheel
	Vibration on Rough Roads	Floor
		Seat Cushion
		Seat back
		Steering Wheel
		Cab motions
	Vibration on obstacle	Floor
		Seat Cushion
		Seat back
		Steering Wheel
		Cab motions

Jury Selection

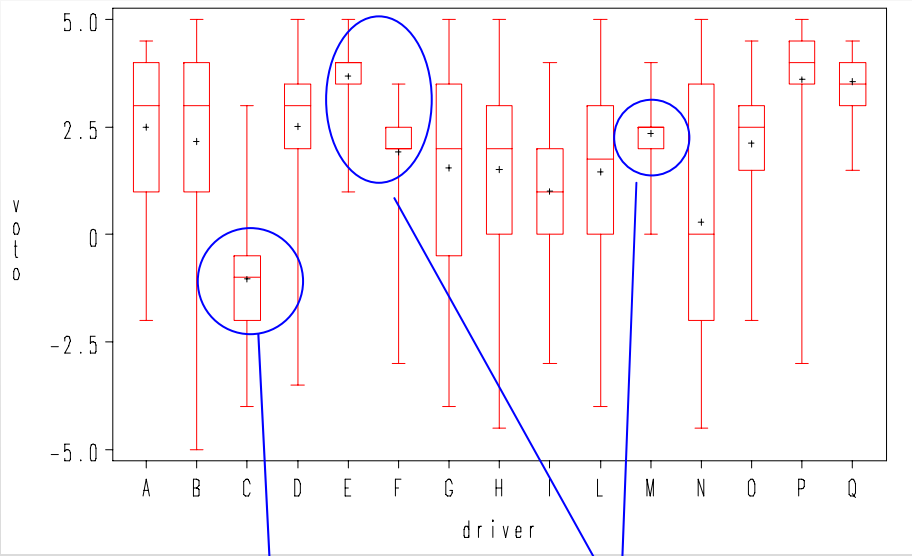
- ***15 Drivers***
- ***Professional drivers***
- ***Selected from IVECO and external companies***



Subjective evaluation

Statistical spread analysis

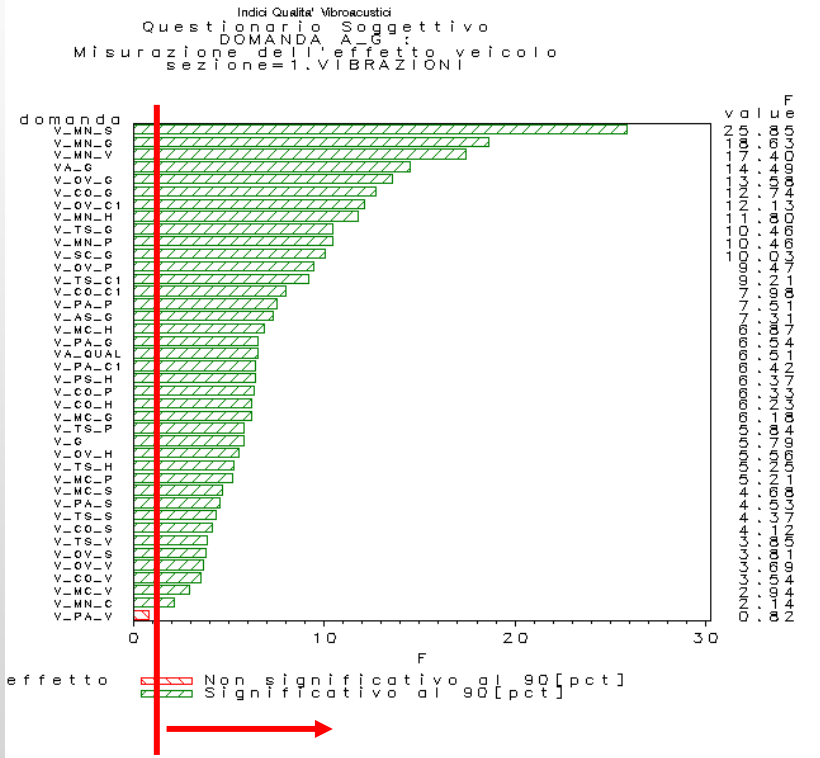
Search of outlier judges



Driver with different average votes

Drivers who do not use the full scale range

Search of more meaningful aspects



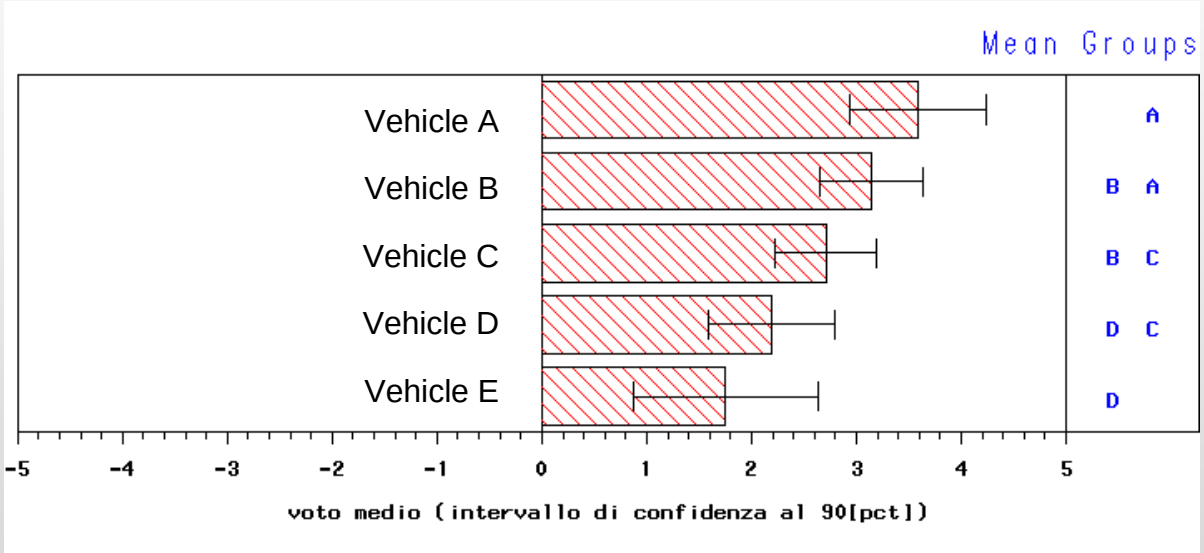
More meaningful aspects

Judges could not evaluate only 1 aspect: steering wheel vibration on pavè

Subjective evaluation

Partial rating example: Seat Cushion vibration on Rough Road

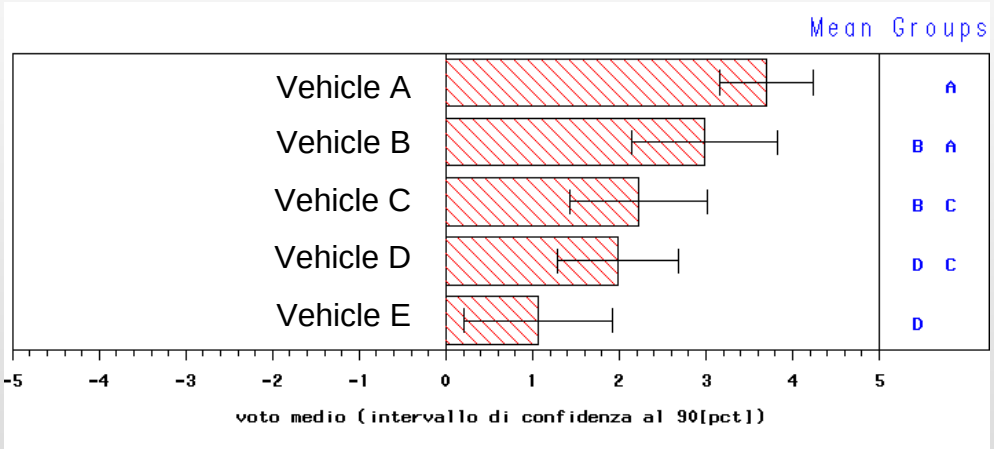
Evaluation of vibration perceived at the seat cushion on a rough road.
A certain overlapping between statistical groups is observed.



Subjective evaluation

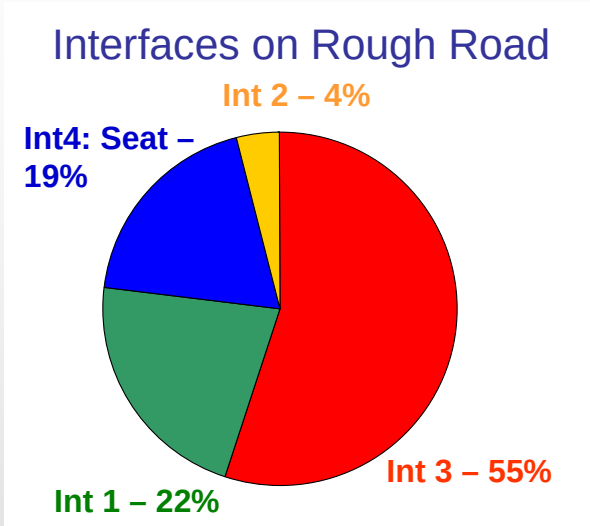
Ride Global Evaluation and influence of partial ratings

Global Rating



A principal component analysis has been applied for the identification of the main clusters in subjective perception.

Weights of the partial aspects



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Objective evaluation

- **Vehicle setup**
- Test procedure
- Post-processing and Example of some results

Measured variables for quality index are:

- **TRIAXIAL ACCELERATION AT THE SEAT CUSHION**
- **TRIAXIAL ACCELERATION UNDER THE SEAT (CAB SIDE)**
- **VERTICAL ACCELERATION AT THE SEAT GUIDE**
- **VERTICAL ACCELERATION AT THE FLOOR**
- **TRIAXIAL ACCELERATION AT THE STEERING WHEEL**

TOTAL: 11 channels + vehicle speed

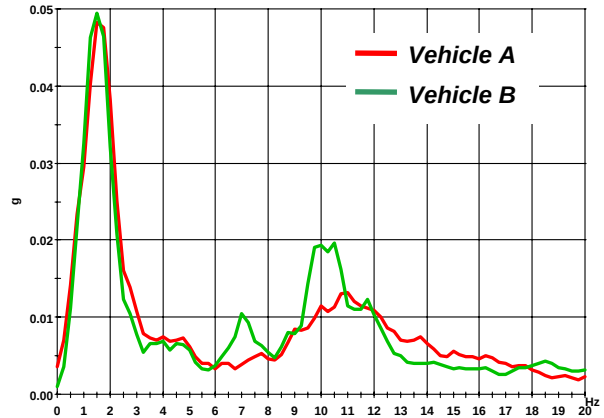
Objective evaluation

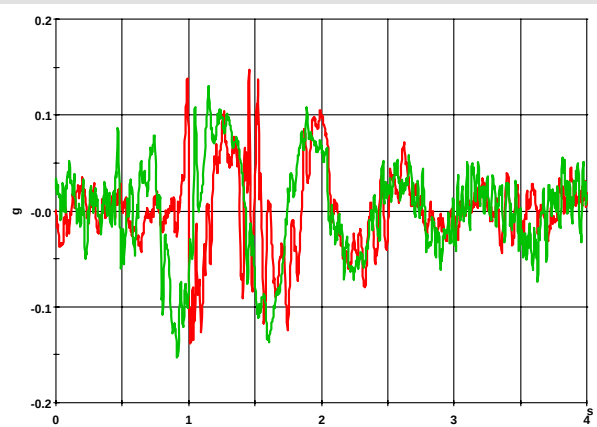
- Vehicle setup
- **Test procedure**
- Post-processing and Example of some results

Ride road tests:

- **Highway**
- **Rough Roads (both asphalt and paved)**
- **Rectangular obstacle**
- **Idle**

Seat Guide vertical Acceleration





Objective evaluation

- Vehicle setup
- Test procedure
- **Post-processing and synthesis**

Main calculated parameters

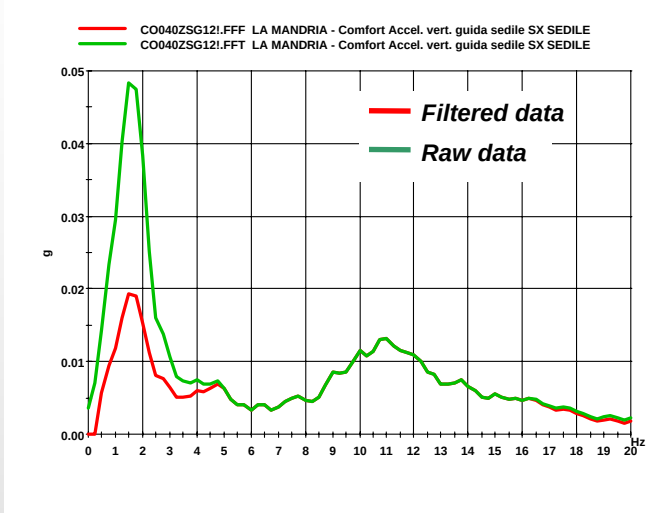
Random Roads & Idle

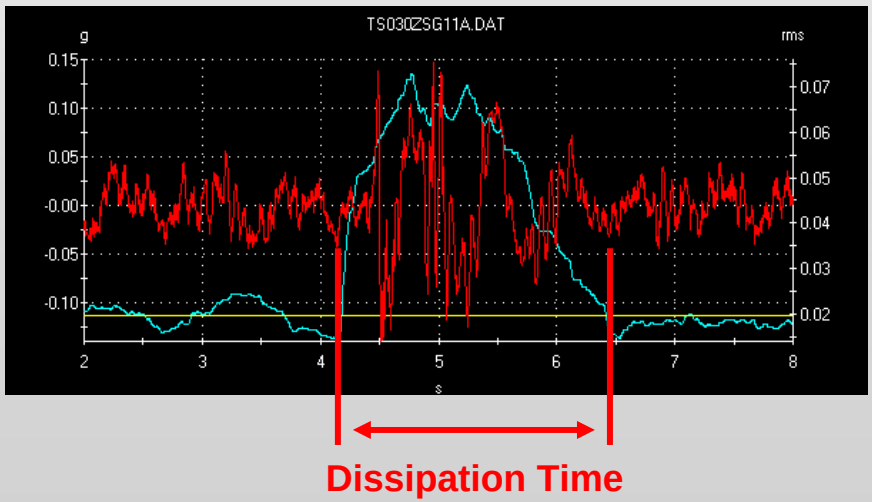
- **RMS in time domain**
- **RMS in a frequency band**
- **RMS from spectra filtered ISO 2631**

Obstacle:

- **Range**
- **RMS**
- **RMS difference (between impact and stationary)**
- **Dissipation Time**

Filtering ISO 2631





Dissipation Time

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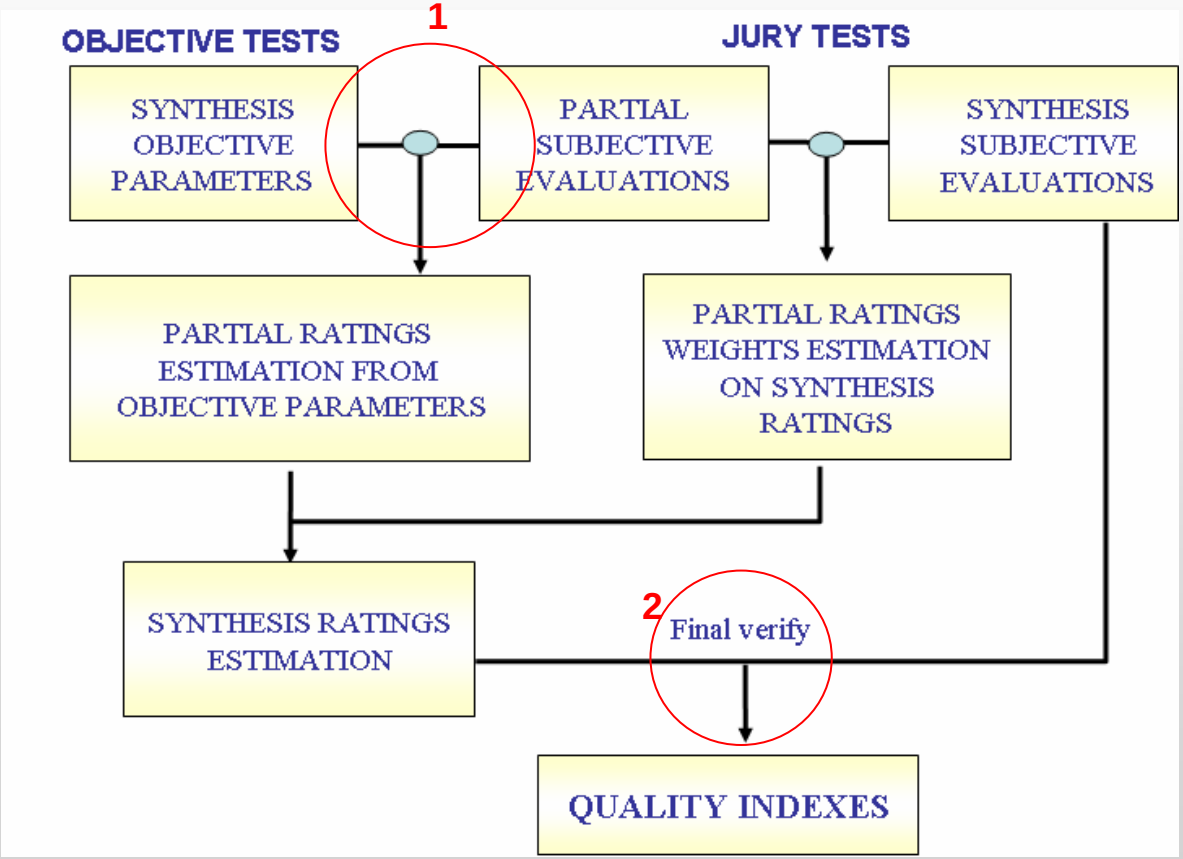
Ride Quality Index

The process for Index identification



1: Partial index

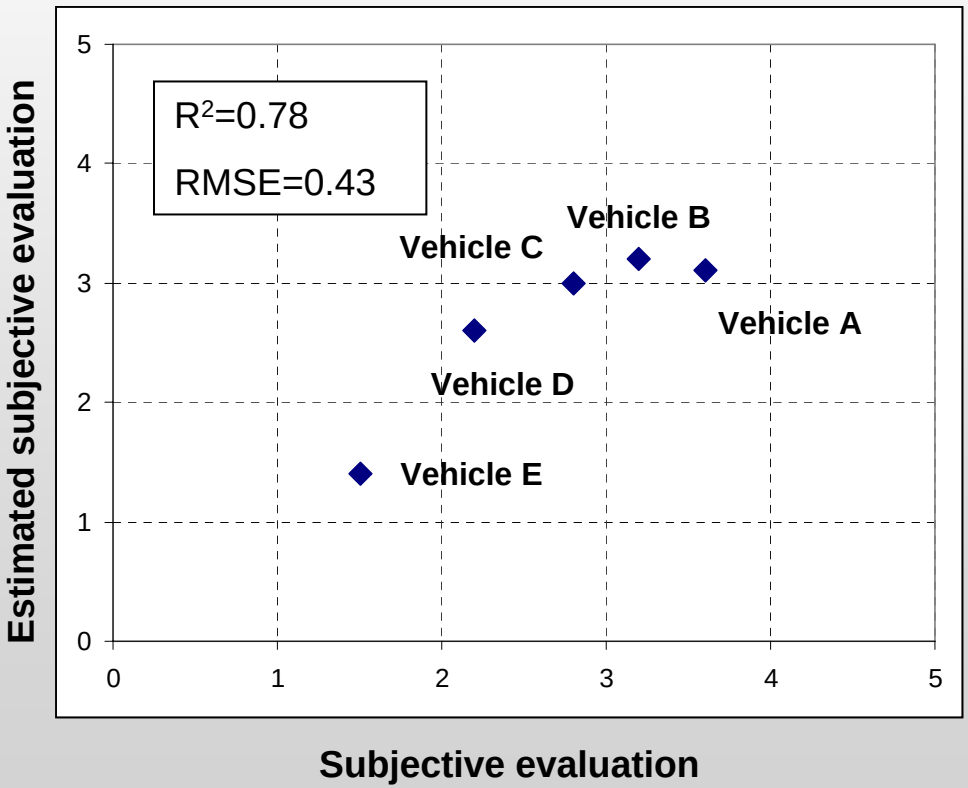
Subjective evaluations are correlated with measured parameters.

2: Global quality index

Starting from the weights of partial aspects on global determined from subjective evaluation, a refinement is done in order to compensate the aspect not yet covered by partial objective indexes.

Ride Quality Index

Partial ratings: Correlation with Subjective Evaluations



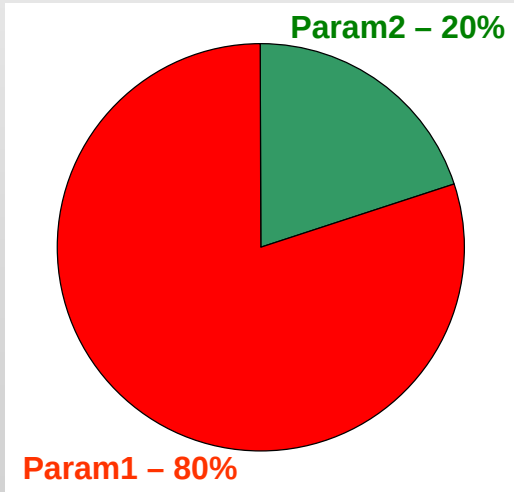
Seat vibration on rough road

Index = A + B * Param1 + C * Param2

Parameters:

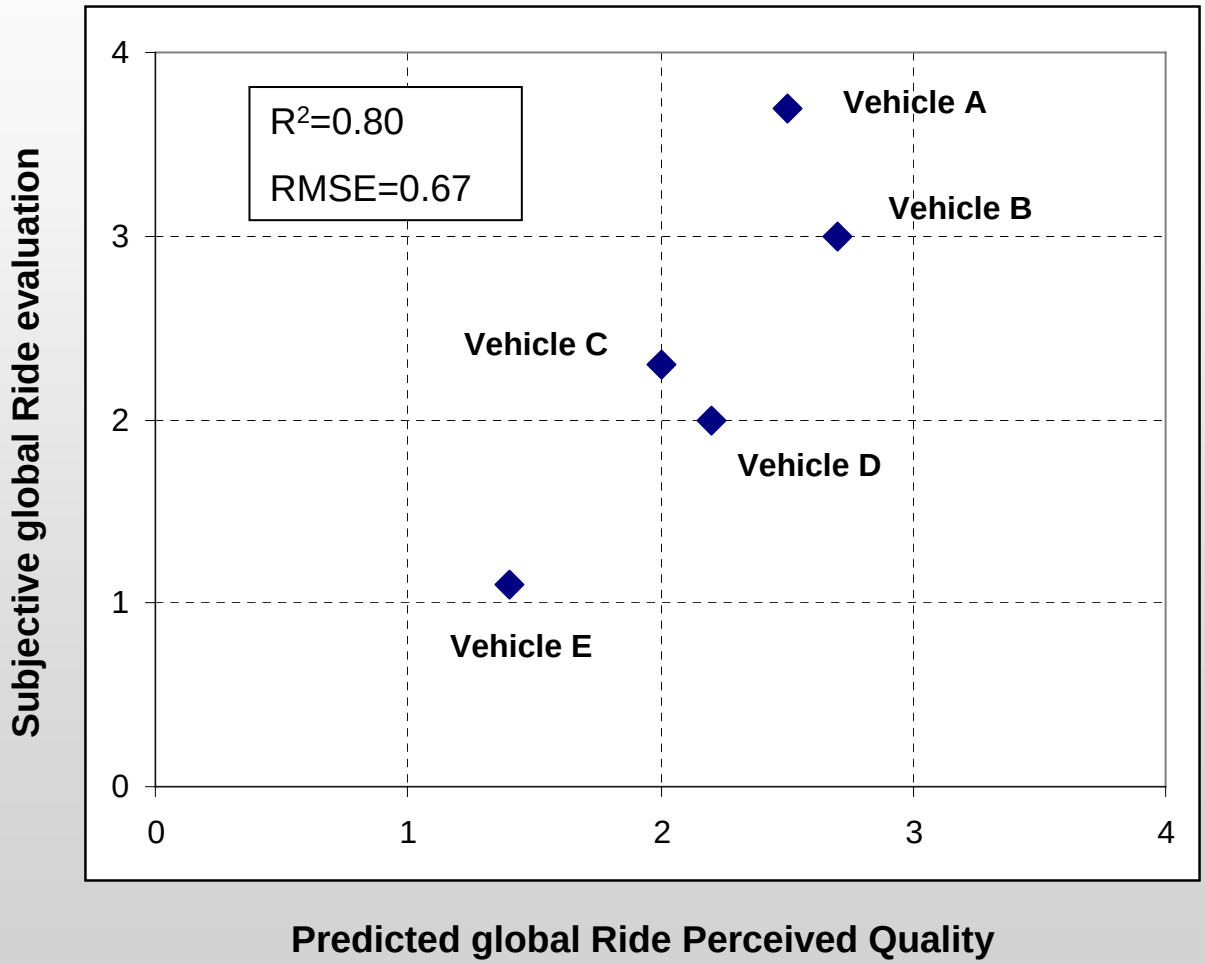
Param1: *RMS of vertical vibration at seat guide ISO 2631 filtered*

Param2: *RMS of longitudinal vibration at cushion*



Ride Quality Index

Global Ride rating: Correlation & Composition



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Conclusions and Next steps

A methodology for objective Ride assessment of HCV was developed

- TECHNICAL TARGET SETTING USING PERCEIVED QUALITY INDEX
- OBJECTIVE EVALUATION OF PROJECT SOLUTIONS/PROTOTYPES
- TARGET DEPLOYMENT REVIEW/IMPROVEMENT

Next steps: further methodology development

- DEPLOYMENT TO SUBSYSTEMS AND COMPONENTS - PROCEDURES & STANDARDS
- TARGET VIRTUAL VERIFICATION USING SIMULATION MODELS
- EXTENSION TO OTHER VEHICLE PERFORMANCES