Drive away quality

Testing procedure for manual transmission based upon experimental analysis of customer driving

Authors:
Giovanni Palumbo
(giovanni.palumbo@crf.it)
Andrea Ugo
(andrea.ugo@crf.it)

Company:
Centro Ricerche Fiat (www.crf.it)
Turin - Italy

Fabrizio Amante
(fabrizio.amante@fiat.com)

Company:
Fiat Group automobiles s.p.a. (www.fiat.com)
Turin - Italy

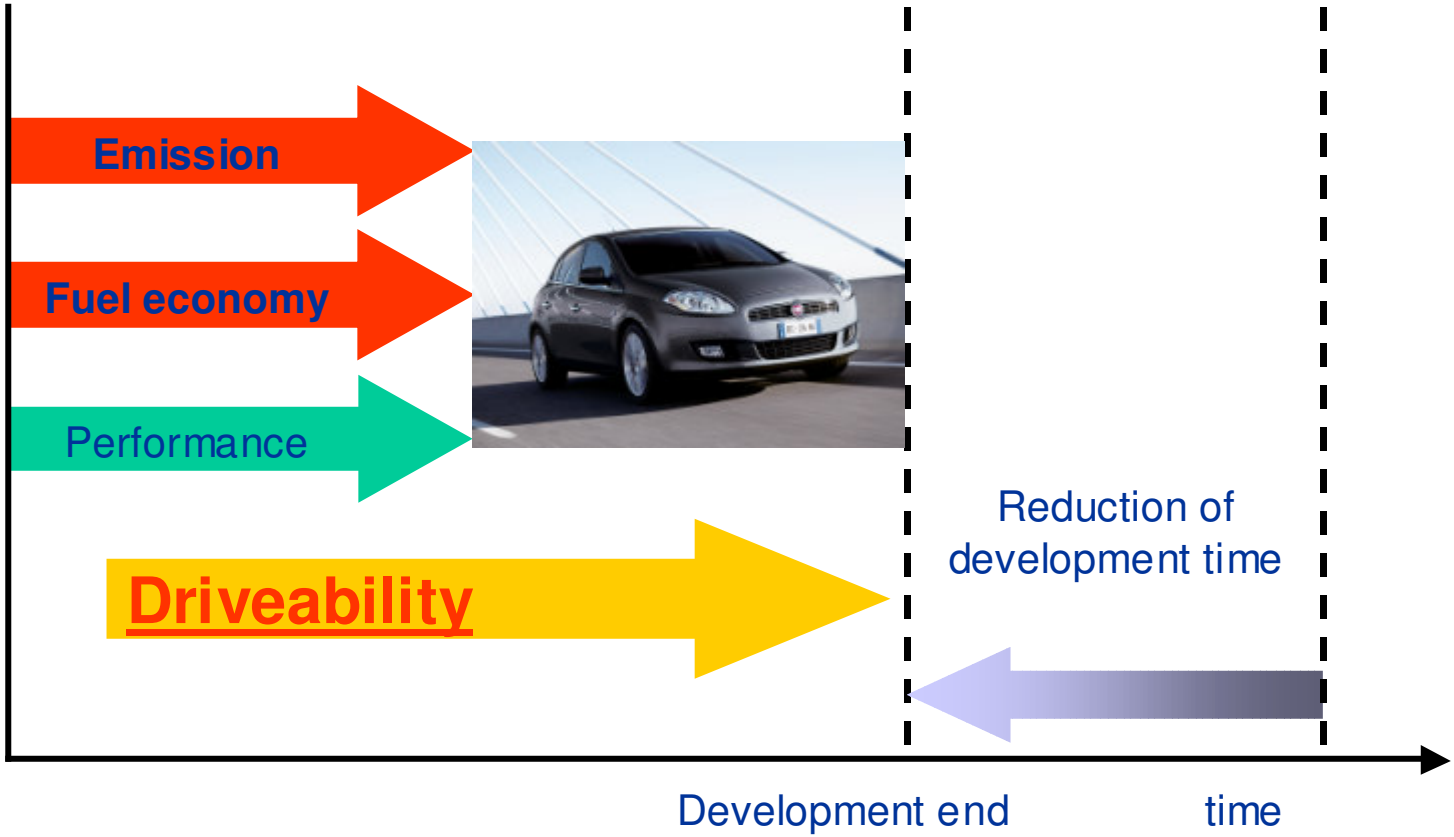
CENTRO RICERCHE FIAT

Index

FIAT GROUP

- General overview 
- Drive away procedure: Scope, Method & Technique 
- Test protocol application 
- Summary and next steps 

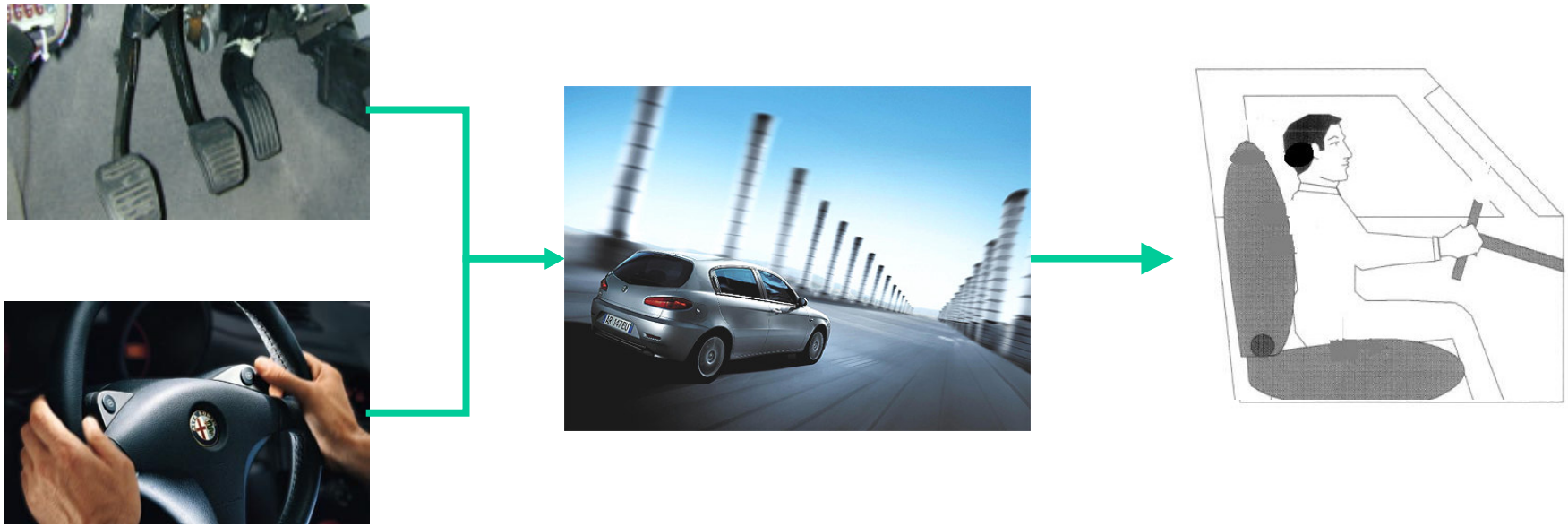
General overview



General overview: What Driveability means ?

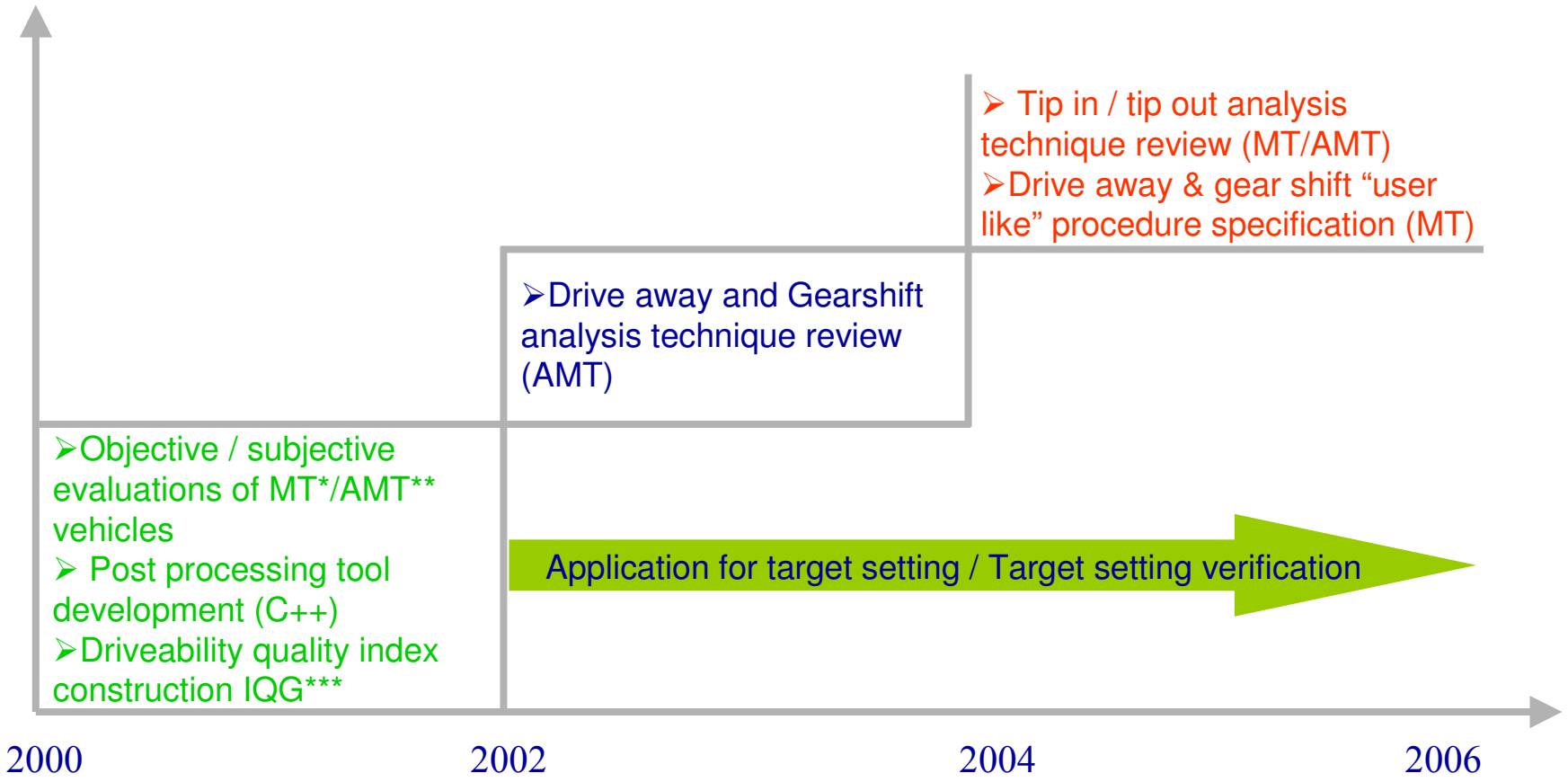
<< The analysis of vehicle longitudinal transient states perceived by customer due to driver gearshift request and/or accelerator pedal inputs>>.

Driveability is a trade off between comfort e performance.



General overview: CRF Methodology development

Main breakpoints In CRF Driveability objectification methodology:



MT*: Manual transmission
AMT**: Automated manual transmission.
IQG***: acronyms for driveability quality index

Drive away “user like” procedure specification: Scope

Activity Scope :

➢ Definition of a new test track procedure for manual transmission vehicles close to common driver style

Method :

➢ Evaluation of physical parameters of driver inputs, accelerator and clutch pedal, and of vehicle response, such as driver seat acceleration/jerk.

➢ Research of a statistical correlation between input and vehicle response parameters to identify the more important phenomena to control the manoeuvre implementation.

Technique :

➢ Road drive away tests with a panel of customers and expert drivers which have driven three B-L0 class cars.

➢ Data logging of physical channels by analogue-digital transducers.

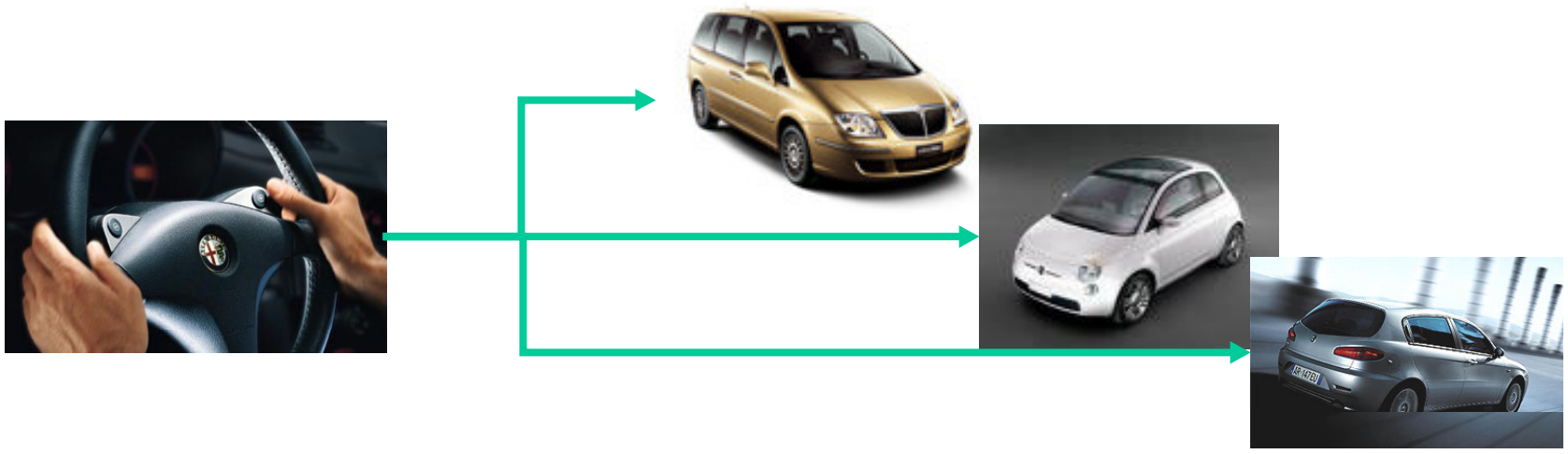
Drive away “user like” procedure specification:Technique

A panel of 12 people, 9 common drivers and 3 expert drivers, was built up.

Drivers were asked to drive by three different styles such as:

- **Low** : less speedy than everyday
- **Normal** : everyday like
- **High** : more speedy than everyday, very sporty

three different cars on test track in totally free driving.

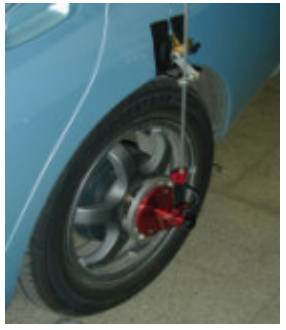


Drive away “user like” procedure specification: Experimental set up

Experimental set up consists of:

- analogue-digital multi-meter

- Driver seat accelerometer
- Vehicle speed
- Engine speed
- Gas pedal travel
- Clutch pedal travel



Sampling frequencies = 500 Hz, anti - aliasing filtering at 120 Hz.

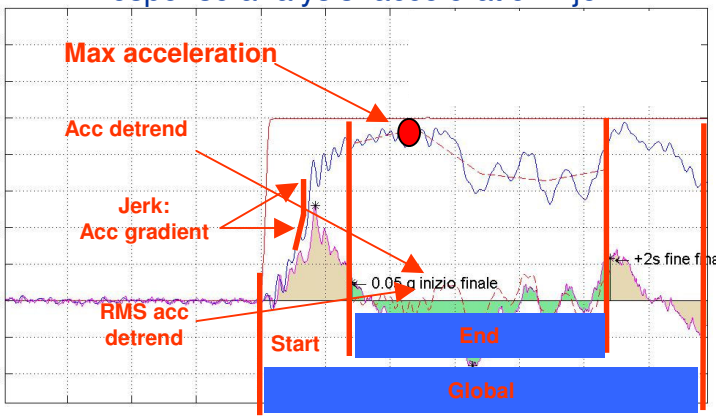
Drive away “user like” procedure specification: Method

Objective evaluations were post processed with drive away procedure, in Matlab © environment, used to analyse these manoeuvres for manual and automatic transmission cars, both robotized and power shift ones.

Input analysis	Response analysis: acceleration - jerk and engine/primary speed	
Accelerator and clutch pedal: ➢Max travel ➢Gradients	Acceleration and Jerk: ➢Max value ➢Min value ➢Gradients	Engine and primary axle speed: ➢Max value ➢Min value ➢Overshoot ➢Gradients ➢Synchronization speed ➢Clutch slipping time

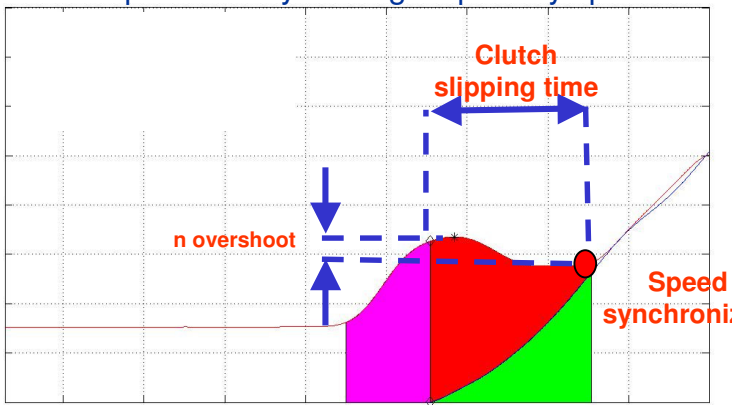
Method of analysis: Physical parameters

Response analysis: acceleration - jerk



Accelerator pedal Acceleration

Response analysis: engine/primary speed



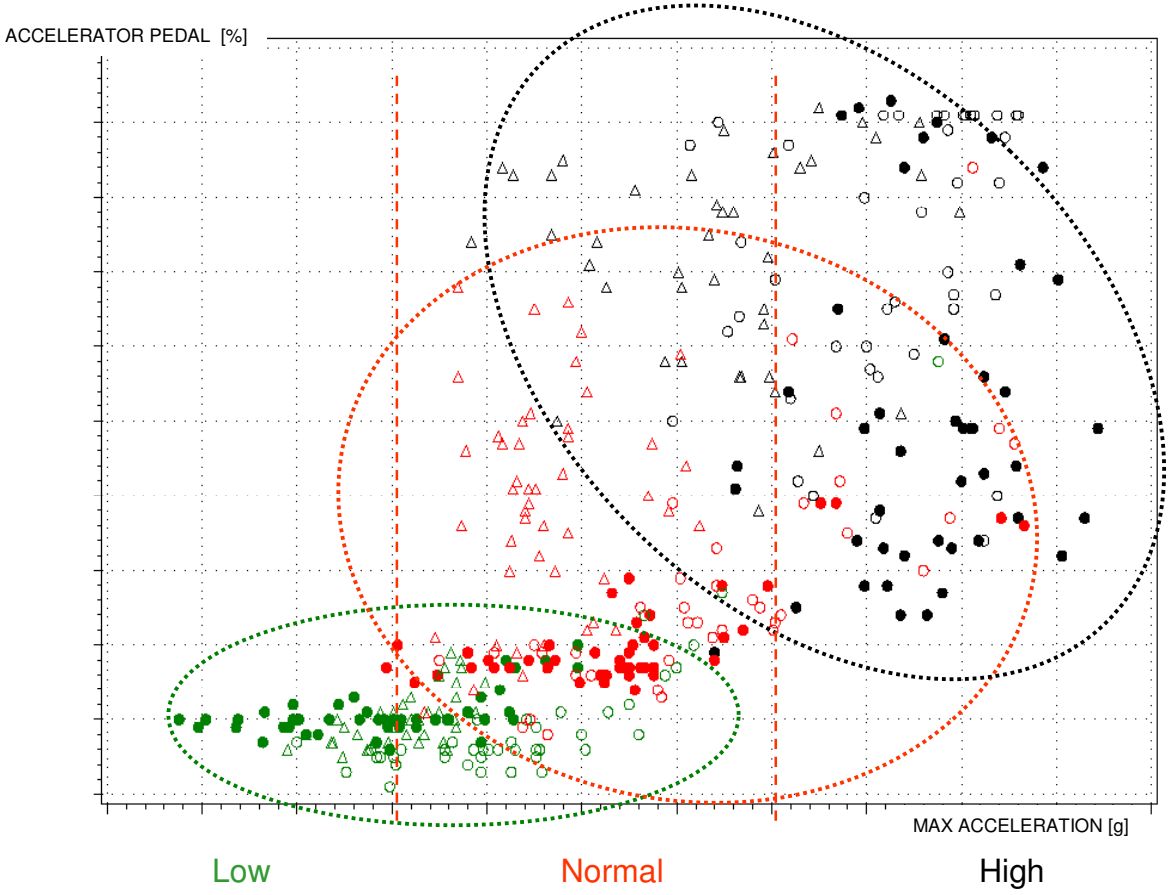
Engine speed Primary speed

The two graphs show the main channels used to analyse this manoeuvre.

- Graph on left side shows parameters relative to acceleration and jerk.
- "Start": sub event of the analysed manoeuvre is useful to evaluate the acceleration gradients and maximum acceleration.
- "End": other sub event describes the vehicle behaviour around engine and gearbox synchronization.
- Graph on right side shows parameters relative to engine and gearbox primary axle such as maximum engine speed, engine speed at synchronization and overshoot of engine speed.

Method of analysis: Acceleration vs Accelerator pedal

The analysis is developed to search and to define the relationships between input control parameters and vehicle response parameters.

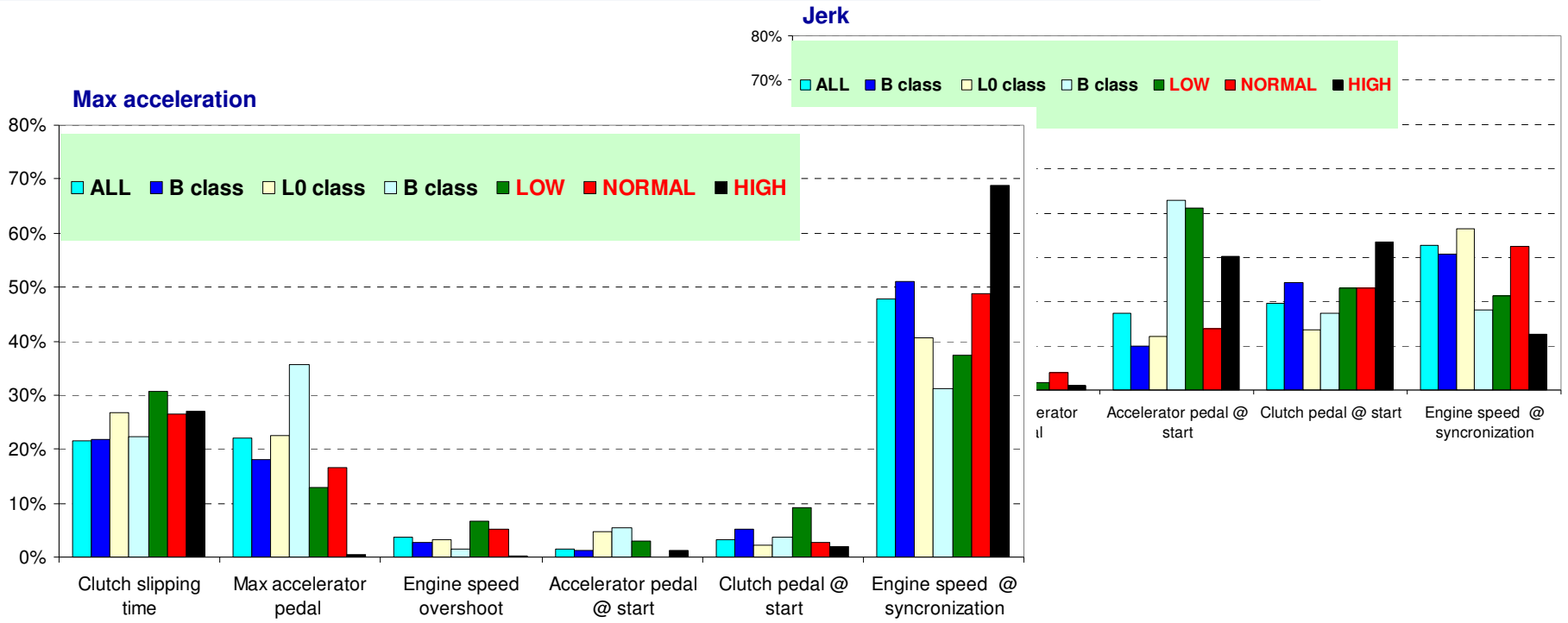


The graph shows the experimental points between max acceleration and max accelerator pedal and it can be seen:

- there were up to 300 single events analysed.
- three almost different regions exists.
- in "High" & "Normal" the measured points are more distributed than the "low".

From the analysis of all physical parameters, it appears that drivers are mainly oriented to comfort than to sport in every driving condition

Drive away “user like” procedure specification: Statistical models

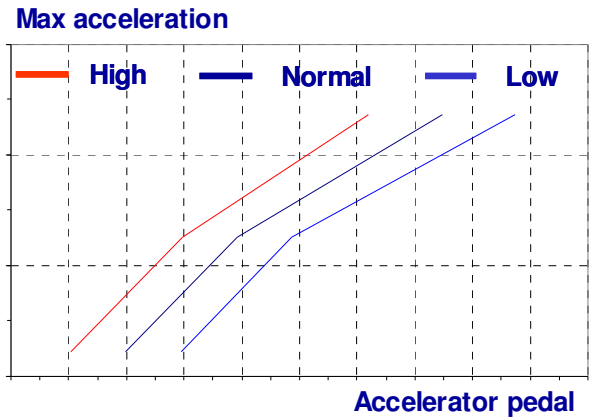


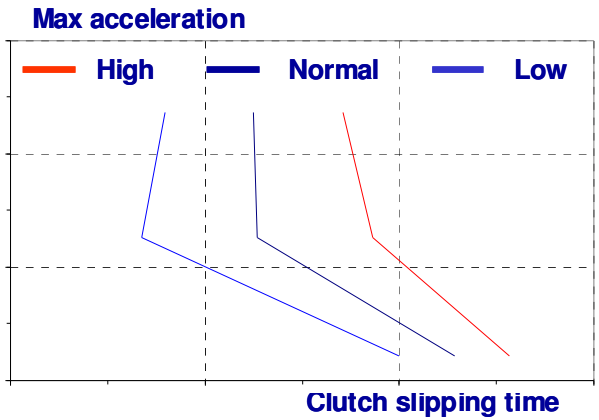
Statistical analysis is carried to search objective parameters of input execution influencing acceleration and jerk. It is found:

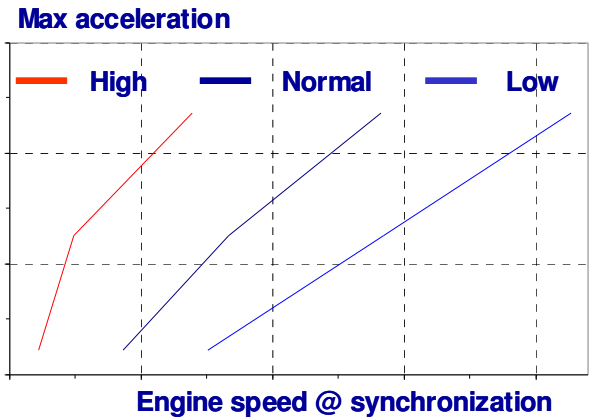
- In “high” driving condition the standard deviation of many parameters is high.
- Max gas pedal travel, engine speed @ synchronization and clutch slipping time are able to distinguish driver input execution due to theirs great influence on acceleration and jerk.

Drive away “user like” procedure specification: Test protocol (1/2)

Statistical models help us to focus attention on three main input control parameters.
Next step was to describe the “acceptance field” of the manoeuvre based upon the relations between acceleration and main influencing parameters.







The first graph shows the relationship between maximum acceleration and gas pedal travel, the second shows the relationship between maximum acceleration and clutch slipping time while the last shows the relationship between maximum acceleration and engine speed at synchronization.
The customers use the area between the red line and blue once, so it can be seen as “acceptance field” of the manoeuvre in order to be considered as “user like”.

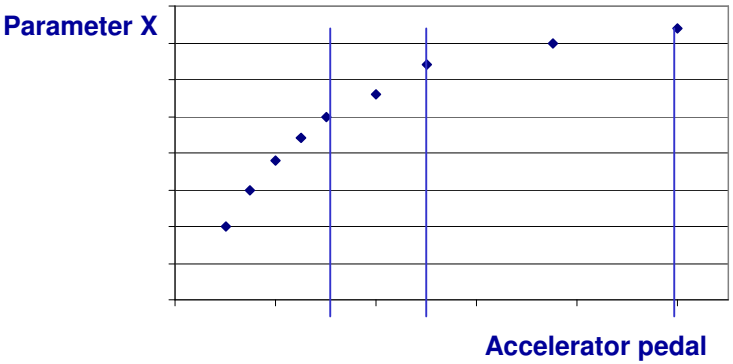
Drive away “user like” procedure specification: Test protocol (2/2)

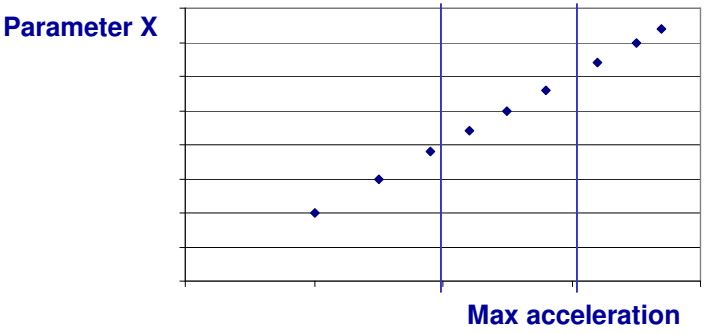
Main phases of test protocol consist of:

- To perform a series of drive away starting from the minimum available acceleration to max available acceleration.
- To repeat the single manoeuvres three times as far as possible similar between them.
- To post processing data logged evaluating the respect of boundary limits of “acceptance fields”.
- To throw away tests which are out of “acceptance fields”.

The physical parameters evaluated can be used to analyse a tested car in two different ways:

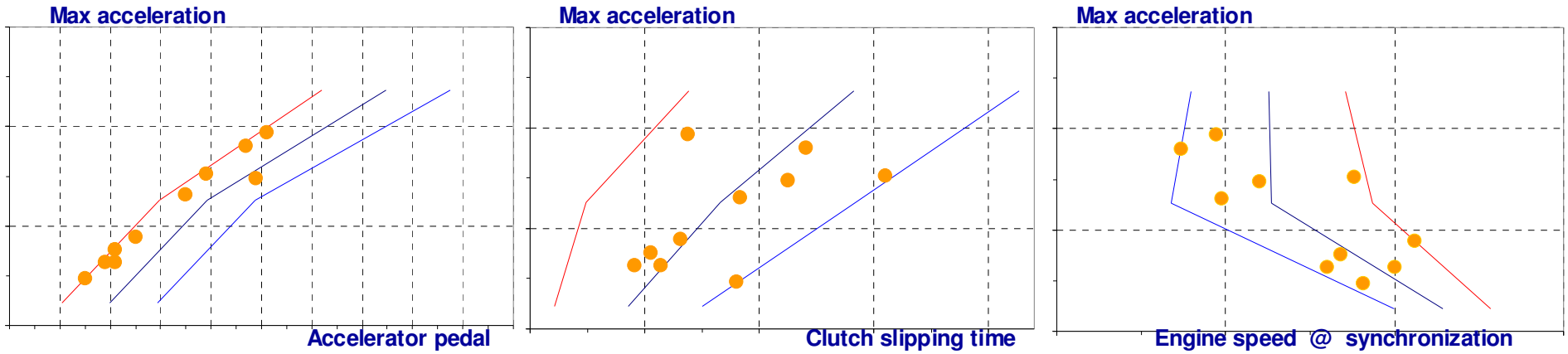
- physical parameters as function of accelerator gas pedal (as driver do)
- physical parameters as function of maximum acceleration (as driver feel).





Test protocol application (1/2)

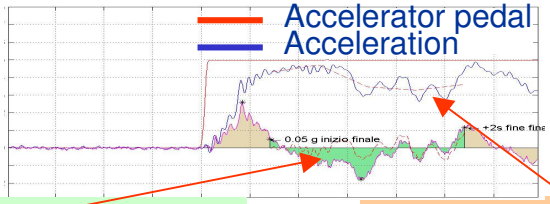
The first application of this protocol is done with one car and professional driver.

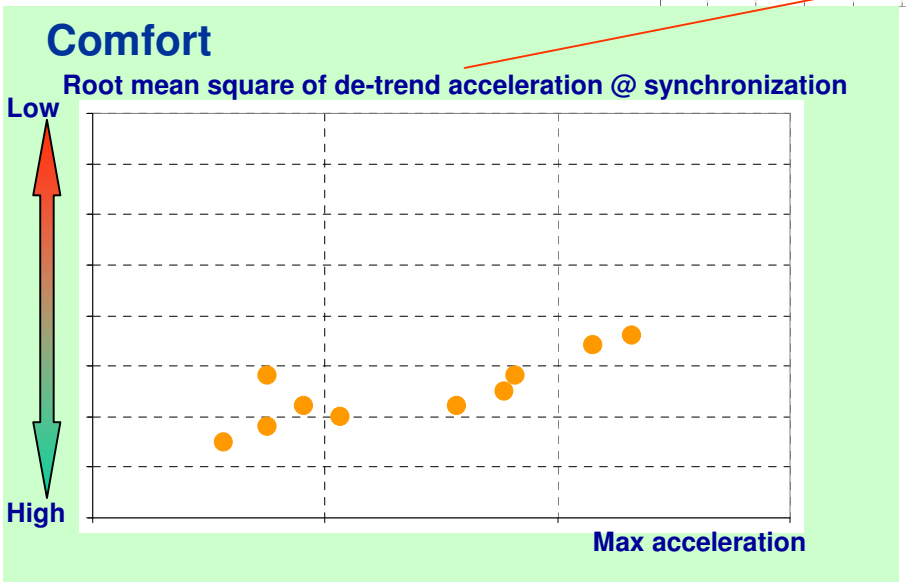


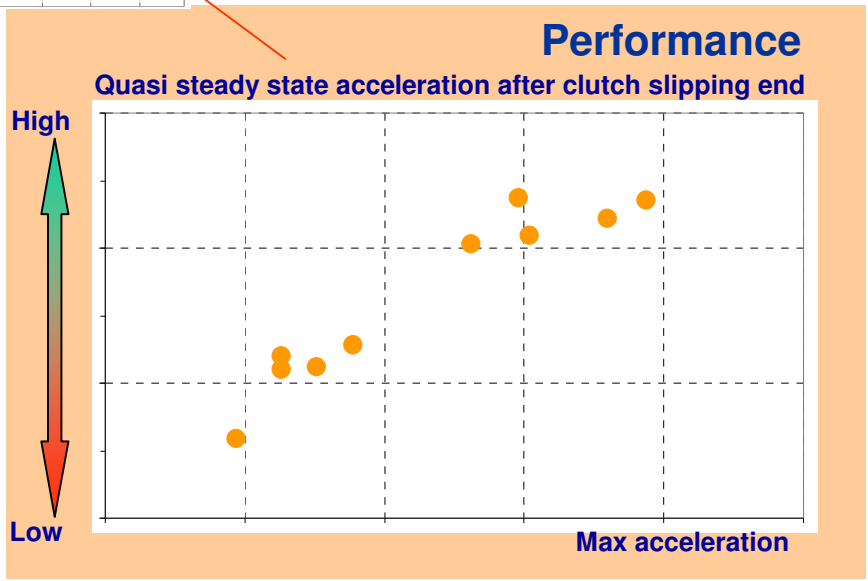
The coloured points into the graphs represent physical parameters evaluated during tests of the drive away procedure which are contained into the boundaries of the “acceptance field” of the manoeuvre.

In the next page the parameter X – max acceleration analysis is done to evaluate the trade off between performance, represented by quasi steady state acceleration after clutch slipping end, and comfort represented by root mean square of acceleration @ synchronization

Test protocol application (2/2)







These graphs show:

- Comfort: progressive growth of evaluated parameter, in particular at high acceleration maximum value is less then apex value, good comfort.
- Performance: it is noticeable a progressive growth of steady state acceleration. Maximum value isn't so far from apex value.

This car has a good trade off between performance and comfort.

CENTRO RICERCHE FIAT

Summary and next steps

FIAT GROUP

It was presented :

✓ Longitudinal acceleration and jerk are the most important signals for the subjective evaluation of drive away quality, but they are very dependent on driving style.

✓ A study with common drivers has been done in order to analyse their behaviour in different drive away situations.

✓ The more effective parameters on driver commands were identified using statistical techniques.

✓ A standard procedure for objective test with instrumented car was defined, fixing an “acceptance field” of the driver input in order to perform a user like manoeuvre.

✓ A test application result obtained with the new approach was presented.

An extension of this activity is running in order to define a “user like” gear change manoeuvre