Automated Tool Chain for Evaluation of Real World Tests
Developed and Applied in eCoMove and interactIVe

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Agenda

- interactlVe and eCoMove project
- Requirements on the design of an evaluation tool
- Process flow & General Data structure
- Minimum set of measures
- Calculation of derived measures and indicators
The interactIVe vision: Accident-free traffic and active safety systems in all vehicles

- Facts:
  - Duration: 48 months (January 2010 – November 2013)
  - 29 partners of 10 countries
  - Budget: 30 Million € (Founding by the European Commission: 17 Million €)

- interactIVe systems:
  - SECONDS (Safety enhancement through continuous driver support)
  - INCA (Integrated collision avoidance and vehicle path control)
  - EMIC (Cost-efficient emergency intervention for collision mitigation)
- Demonstrator vehicles

**SECONDS**
- Continuous Support
- Curve Speed Control
- Enhanced Dynamic Pass Predictor
- Safe Cruise

**INCA**
- Lane Change Collis. Avoid.
- Oncoming Vehicle Collis. Avoidance/Mitigation
- Rear End Collis. Avoidance
- Side Impact Avoidance
- Run-off Road Prevention

**EMIC**
- Emergency Steer Assist
- Collision Mitigation
Research Questions:
1. To what extent can eCoMove solutions decrease fuel consumption/CO₂ emissions of vehicle/fleet/network with cooperative technologies?
2. How can eCoMove sustainably change the behaviour of private and professional drivers into a more eco-friendly driving style?
3. What impact have eCoMove solutions in a cooperative environment for the traffic system of a city/region/network (smoother flows, congestion avoidance, shorter travel distances and times)?

General facts:
- Duration: 44 months (March 2010 to November 2013)
- 31 partners from 10 countries
- Budget: 30 Million € (Funding by the European Commission: 17 Million €)

Project aim:
To develop a combination of cooperative systems and tools using V2V and V2I communication to help:
- drivers sustainably eliminate unnecessary fuel consumption;
- fleet managers manage their vehicles more economically and promote eco-driving through feedback & incentives;
- road operators balance traffic flows in the most energy efficient way.
**ecoMove** - cooperative network

- **Transport Planning Office**
- **Logistics Centre**
- **Traffic Management Centre**
- **Traffic Situations**
- **eco FCD & Route Data**
- **Traffic Messages**
- **Post trip data collection**

**eco horizon**

- Maneuver & Traffic Data
- Request for Green Remaining Red/Green Time
Evaluation Methodology

- Although the scope of both projects and also the test design is different, the main steps for the evaluation of the test data are common.
- Following scientific approach of evaluation of test data, as for example proposed by the FESTA or PReVAL methodology.

- Step 0: System and function description
- Step 1: Expected impact and hypotheses
- Step 2: Test scenario definition
- Step 3: Evaluation method selection
- Step 4: Measurement plan
- Step 5: Test execution and analysis
Why is a tool needed?

- Test and evaluation amount in interactIVe
  - 11 different functions in 7 demonstrator vehicles
  - Over 900 test runs of 8 different conflict types (e.g. rear-end)
  - 30 general hypotheses (relevant for all functions) and 63 specific hypotheses

- Test and evaluation amount in eCoMove
  - Simulations to evaluate the impact of traffic management strategies
  - Driving simulator studies
  - Test runs in the cooperative network of the City of Helmond with 4 passenger cars and 2 trucks

Automated evaluation is necessary!
Requirements on the design of an evaluation tool

- Automated handling of test data puts several requirements on the tools to be developed.

- Especially the usage of the data structure within both projects must be defined carefully.

- The following requirements result from various discussions with the validation experts of the two projects eCoMove and interactIVe:
  - Flexibility with respect to data format of logged data
  - Flexibility with respect to measures considered and indicators derived
  - High processing performance
  - Automated and fast processing of huge amounts of test data
  - Automatic plotting of relevant data and storage of statistical data
  - Storage of indicators without connection of confidential data
Process flow & General Data structure

- Evaluation tool is subdivided into different modules

- Evaluation tool is implemented in MATLAB

- The structure clusters logged data as well as derived data in four main categories, which are:
  - **General:** includes a description of the test case
  - **Signal:** includes all logged signals of the test run
  - **DerivedMeasures:** includes all base on the signals calculated derived measures
  - **Indicators:** includes all based on the signals and derived measures calculated indicators
Minimum set of measures

- For the evaluation a standard set of measures to be logged in the test runs has been agreed

<table>
<thead>
<tr>
<th>Measurement Name</th>
<th>Unit or data format</th>
<th>Logging frequency</th>
<th>eCoMove</th>
<th>interactive</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Vehicle movement related measures</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vehicle speed</td>
<td>km/h</td>
<td>10 Hz</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Longitudinal acceleration</td>
<td>m/s²</td>
<td>10 Hz</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Lateral acceleration</td>
<td>m/s²</td>
<td>10 Hz</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>GPS position (lat/long)</td>
<td>°</td>
<td>10 Hz</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Distance driven</td>
<td>m</td>
<td>10 Hz</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td><strong>Driver input related measures</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gas pedal position</td>
<td>% [0 (= not pressed) to 100 (=fully pressed)]</td>
<td>10 Hz</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Brake pedal position or status</td>
<td>% [0 (= not pressed) to 100 (=fully pressed)]</td>
<td>10 Hz</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Gear usage</td>
<td>Integer representing different stati</td>
<td>Event</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td><strong>Function related measures</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>System ON or OFF</td>
<td>Integer representing different stati</td>
<td>Event</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td><strong>Engine related measures</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Engine speed</td>
<td>1/min</td>
<td>10 Hz</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td><strong>Target object related measures</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Distance to vehicle in front</td>
<td>m</td>
<td>10 Hz</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Absolute velocity of vehicle in front</td>
<td>m/s</td>
<td>10 Hz</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td><strong>Examples of project specific measures</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vehicle air conditioning status: on / off</td>
<td>Byte representation</td>
<td>Event</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Windows status: open / close</td>
<td>Byte representation</td>
<td>Event</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Accumulated Fuel consumption per vehicle</td>
<td>litres</td>
<td>10 Hz</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Clutch position or status</td>
<td>% [0 (= not pressed) to 100 (=fully pressed)]</td>
<td>Event</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Engine torque</td>
<td>Nm</td>
<td>10 Hz</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Trip Active: to identify the duration of a trip (to exclude standstills and pauses)</td>
<td>Integer representing different stati</td>
<td>Event</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Status Brake Light</td>
<td>Byte representation</td>
<td>10 Hz</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Distance to lane marking</td>
<td>m</td>
<td>10 Hz</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Yaw Rate</td>
<td>Rad/s</td>
<td>10 Hz</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Steering wheel angle</td>
<td>10 Hz</td>
<td></td>
<td>x</td>
<td></td>
</tr>
</tbody>
</table>

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Calculation of derived measures and indicators

- Derived measures
  - Derived measures are signals, which cannot be directly obtained from the measurement files, because the signals are not available
  - Examples TTC, TLC

- Indicators
  - Indicators are quantitative or qualitative single values which characterise the test run
  - Indicators are required in order to test the hypothesis and must be chosen according to the analysed hypothesis
  - Examples: Minimum TTC, Average fuel consumption

- Calculation scripts for derived measures and indicators are available in a library and can be chosen according to the evaluation question
Implementation of tool

Hypotheses Testing Tool (interactIVe)

- Select test runs (with indicators)
- Divide test data in treatment and baseline
- Select relevant indicator
- Select values to be calculated
- Values for hypothesis testing
Conclusion

- Automated Tool Chain for Evaluation of Real World Tests
- Applied in two European projects interactIVe and eCoMove
- Common data structure for the evaluation in both project
- Tool implemented in MATLAB
- Library for indicator and derived measure calculation scripts
Contact

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