Customer Usage Based Validation of Transmission Systems using CarMaker
Agenda

- Transmission Systems & Components
- Transmission Requirements
- Customer Profile and Method Validation
- Analysis of Customer Diagnostic Readout Data
- New Concept and Utilization
- Software Functions and Control
- Going from Test Code Based Req. to Customer Usage
- TP7
- Future Rigs
- Conclusion
Transmission Systems & Components

- Manual Gearbox
- Automatic Gearbox
- AWD system:
  - PTU/RDU
  - Propeller Shaft/Joints
  - AOC (Active On-Demand Clutch)
- Drive Shafts/Joints
- Transmission for Electric Drive:
  - EFAD/ERAD (Electric Front Axle Drive/Electric Rear Axle Drive)
  - Hybrid Transmissions
  - Transmission Systems for 48V
- Differential
- P-lock System
Transmission Requirements

"Population Density"

Stress – Customer Load

Component Strength

No failures

"Damage Load"
Transmission Requirements

"Population Density"

Stress – Customer Load

Component Strength

"Damage Load"

Failures will Occur!

“Population Density”

Stress – Customer Load

Component Strength

"Damage Load"
Transmission Requirements - Validation Pyramid

- **Vehicle test**
  - Final vehicle verification, no failures should appear
  - Multipurpose test

- **System sign off test x-SKLT**
  - Suitable for customer usage correlation
  - Should exhibit relevant correlation with customer usage of the tested powertrain for the most important design factors i.e. transmitted torque
  - Requires adaptive test code

- **Component tests**
  - Components should be tested at highest damage level to cover all customers and applications and the system requirement
  - System suppliers responsible for component testing
  - Block testing suitable
Transmission Requirements

At VCC the Transmission System Requirement is based on the customer usage
Customer Profile and Method Validation

- City - (inner city driving – mostly up to 50 km/h)
- Rural - (outside city and country road driving)
- Mountain - (mix of hilly driving)
- Gravel - (mix of gravel roads up to 80 km/h)
- Highway - (mix of driving 90-130 km/h)
- Autobahn - (high speed driving)
- Start Event - (start on plain ground and in slope)
- Trailer - (mix of trailer driving situations)

Road Condition Distribution

<table>
<thead>
<tr>
<th>Condition</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>Dry</td>
<td>60%</td>
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<tr>
<td>Wet</td>
<td>30%</td>
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<tr>
<td>Snow/Ice</td>
<td>10%</td>
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Driving Style

- Sportage
- Average
- Mild

1st gear tooth-flank duty values

- trailer 2400kg
- trailer 2000kg

- Road to Rig driver
- Mix driver
- Plain city driver
- Plain autobahn driver
- Plain rural road driver
- Plain mountainous road driver
- City driver
- City-trailer driver
- Rural driver
- Rural-trailer driver
- Mount.driver
- Mount-trailer driver
- Gravel driver
- Gravel-trailer driver
- Highway driver
- Highway-trailer driver
- Autobahn driver
- Autobahn-trailer driver
- Trailer driver
- Average driver

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Analysis of customer diagnostic readout data

By comparing results from Vehicle ReadOut Data and Simulation Results the method has been Validated
Market Differences, Vehicle Speed

Vehicle Speed Distribution, Average Customer

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Customer Profile and Vehicle Validation

Speed profile for predefined customer profiles

- Plain city
- Plain autobahn
- Rural
- Road to rig
- Hway w much trailer

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Simulated 90 percentile vs Customer

Comparison Duty Value per Gear

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<tr>
<th>Gear</th>
<th>DV</th>
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<td>1</td>
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<tr>
<td>8</td>
<td>$1 \times 10^{23}$</td>
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Max 90%ile DV per Gear for each market
Required DV based on simulations
New Concepts & New Utilization

- Car Pooling
- AD Vehicles
- Hybrid Vehicles
- Electric Vehicles
- Dedicated Vehicle Usage
Software functions and control

• Torque Limit Functions
• Safety Functions for Special Situations
• Boosting and Regeneration
• Driveability Control
Going from Test Code based Req to Customer Usage

- Constant Torque Testing (Wöhler testing)
- Block Test
- Speed Profile Test
- Driving Situation Test (CarMaker)
TP7

- CarMaker for vehicle, tyre, road and driver simulation
- AWD rig (incl. wheel slip)
- 4 dynos
  - 3500 Nm / 150 kW
  - 2400 rpm / 270 km/h
  - Low moment of inertia (0.93 kgm²)
- Complete driveline incl. engine
TP7

- **DSKLT**
  - Driveline System Key Life Test
  - Focus on rear wheel loads (PTU/RDU)
  - Haldex clutch (AOC clutch)

- **ATSKLT**
  - Aut. Transm. System Key Life Test
  - Focus on transmission loads for all gears

- **MTSKLT**
  - Man. Transm. System Key Life Test
  - Focus on transmission loads for all gears
TP7

TP7 rig measurement

Vehicle measurement at Hällered Proving Ground
Future rigs

• TEM1 - Electric vehicle rig
  – CarMaker for vehicle, tyre, road and driver simulation
  – 3 dynos
  – In: 200 kW dyno, 20000 rpm, 400 Nm
  – Out: 2x200 kW dynos, 2500 rpm, 4000 Nm
  – Low inertia (out) dynos ±15000 rpm/s
  – Overload power/torque 20% 1 min/10 min
  – Climate box (-40°C to +120°C)
  – Battery simulation, 300 kW, 600A, 900V
TEM1

3-dyno configuration
TEM1

2-dyno and E-machine configuration
Conclusion

• Volvo methodology covers customer usage well
• In order to work with customer based requirements dynamic rig simulations are needed
• The trend is to do less work in vehicles and more in test rigs and simulation environments
Thank you!