Magna Powertrain - Roadmap into future driveline solutions

Drivetrain Forum 2016, Untergruppenbach
Magna Powertrain, Walter Sackl, Director Product Management, Global – Driveline Systems
Requirements Future Drivetrain Systems
- Market Driver
- Market Critical Attributes
- Module Specification

The Powertrain Revolution
- Change
- Complexity
- Roadmap

Examples of efficient drivetrain products
- Flex4 Disconnect Driveline System
- Mild Hybrid System 48V

Conclusion
Requirements Future Drivetrain Systems
Market Driver
Market Critical Attributes
Module Specification
### Market Drivers Create Growth Opportunities

#### Change in the automotive industry in the next 10 years will be greater than it has been in the last 100 years.

<table>
<thead>
<tr>
<th>Drivers of Change</th>
<th>Our Positioning</th>
</tr>
</thead>
</table>
| Government Legislation on Emissions / Fuel Economy | - Efficiency Improvements for Engines & Drivelines  
- On-Demand Products and Systems  
- Electrified Powertrain Systems (EV, HEV, P-HEV)  
- Lightweight Products |
| Global Platforms                               | - Global Products Sharing Common Modules  
- New DCT / Hybrid DCT Platform (GETRAG)  
- Core Technology Platform (Driveline)  
- Engineering and Manufacturing Capacity Globally |
| Active Safety                                  | - 4WD/AWD Leadership  
- Complete Systems Competence  
- Sophisticated Mechatronic Expertise |
| Increasing Focus on Cost, Value               | - Functional Integration (Merging Product Functions)  
- Vertical Integration (Increasing Value Added)  
- Horizontal Integration (Eliminating Components) |
• Challenging CO₂ emission targets drive new powertrain technologies
• In addition there are regional zero emission requirements
# Regulations driving alternative Powertrain Solutions

**Passenger cars US, EU, CHN 2020+**

### Regulations

<table>
<thead>
<tr>
<th>Federal / Union Law</th>
<th>Regulation</th>
<th>Subject to regulation</th>
<th>Regulation</th>
<th>Subject to Regulation</th>
<th>Regulation</th>
<th>Subject to Regulation</th>
</tr>
</thead>
<tbody>
<tr>
<td>EPA GHG</td>
<td>CO₂</td>
<td>EU GHG</td>
<td>CO₂</td>
<td>CAFC</td>
<td>I/100 km (CO₂)</td>
<td></td>
</tr>
<tr>
<td>NHTSA CAFE</td>
<td>MPG</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EPA Tier 3</td>
<td>NMOG+NOx, CO, PM</td>
<td>Euro 6c</td>
<td>NOx, HC, CO, PM</td>
<td>CN 5 (EU 5)</td>
<td>NOx, HC, CO, PM</td>
<td></td>
</tr>
</tbody>
</table>

### State Law

<table>
<thead>
<tr>
<th></th>
<th>Regulation</th>
<th>Subject to regulation</th>
</tr>
</thead>
<tbody>
<tr>
<td>CARB ZEV</td>
<td>BEV, PHEV, FCV</td>
<td>Diesel discouragement (FRA)</td>
</tr>
<tr>
<td>CARB LEV III</td>
<td>NMOG+NOx, CO, PM</td>
<td>City driving bans, tax diesel fuel</td>
</tr>
</tbody>
</table>

### City Law

<table>
<thead>
<tr>
<th></th>
<th>Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Congestion Charge (London)</td>
<td>Lower fees for EV's</td>
</tr>
<tr>
<td>Environmental Zone (50+ cities, GER)</td>
<td>Beijing 6 / Phase II</td>
</tr>
<tr>
<td>City center entry restrictions</td>
<td>Exemptions for ZEV's</td>
</tr>
<tr>
<td>&gt; Euro 5</td>
<td>Vehicle Quota (Shanghai, Beijing)</td>
</tr>
<tr>
<td>&gt;50% Quota share for ZEV's</td>
<td></td>
</tr>
</tbody>
</table>

### Key Points

- **Challenging CO₂ emission targets drive new powertrain technologies**
- **In addition there are regional zero emission requirements**
Impact of WLTP vs. NEDC in 2021
Comparison of test methods: load points

- Load points tested within NEDC and WLTP
- RDE load points not tested on the chassis dyno but on the road

Customers expecting vehicles which deliver same performance and emissions in real life
Emission Summary

**ZEV - Global (tailpipe emissions):**
Low overall penetration rate of BEV/PHEV (10% in 2025) but many models in the market (all segments)
- Carb ZEV (50% of US market) & local requirements

**RDE (tailpipe) introd. in EU in 2017:**
drives cost for exhaust after treatment (CI) – influence on technology competition SI/CI/Hybrid for CO₂ reduction

**WLTP (CO₂ & tailpipe) - intro in EU 2017/18:**
- Impact of on 4WD /2WD needs to be addressed

Upcoming legislation changes:
2017: EU - Euro 6C
2018: China - China V

- ZEV requirements drive BEV, PHEV globally - technologies in all segments required.
- CO2 regulation drives OEM’s fleet improvements
  --> segment specific penetration of new technologies ex. 48V
Process to define Market Critical Attributes

Historical Key Performance Indicators (KPI) and Transfer to 2025

Vehicle Level KPI’s

Historical KPI and Transfer to 2025

2002 – 2015 -> Extrapolation to 2025

Powertrain KPI’s - System Level

ICE incl. Stop / Start
- 80% market share in 2025 *

Mild Hybrids
- 9% market share in 2025 *

HEV / PHEV
- 8% market share in 2025 *

BEV
- >> 3% market share in 2025 *

* Source IHS
## Process to define Market Critical Attributes

### Historical Key Performance Indicators (KPI) and Transfer to 2025

### Driving Performance/Economy

<table>
<thead>
<tr>
<th>Changes</th>
<th>Absolute</th>
<th>Relative</th>
<th>2025</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engine: Torque ICE [Nm]**</td>
<td>60</td>
<td>18.2%</td>
<td>21%</td>
</tr>
<tr>
<td>Engine: Power [kW]**</td>
<td>15</td>
<td>12.0%</td>
<td>18%</td>
</tr>
<tr>
<td>max. speed [km/h]*</td>
<td>3</td>
<td>1.3%</td>
<td>3.9%</td>
</tr>
<tr>
<td>Acceleration 0-100 km/h [s]*</td>
<td>-1.3</td>
<td>-14.1%</td>
<td>-14%</td>
</tr>
<tr>
<td>Elasticity 60-100 km/h 5th gear [s]*</td>
<td>-2.3</td>
<td>-17.2%</td>
<td>-5.5%</td>
</tr>
<tr>
<td>CO2 [g/km] – NEDC*</td>
<td>-61</td>
<td>-30.5%</td>
<td>-40%</td>
</tr>
</tbody>
</table>

### Safety

<table>
<thead>
<tr>
<th>Changes</th>
<th>Absolute</th>
<th>Relative</th>
<th>2025</th>
</tr>
</thead>
<tbody>
<tr>
<td>ISO/TR 3888 severe lane-change maneuver at GVWR [km/h]</td>
<td>9</td>
<td>7.9%</td>
<td>4%</td>
</tr>
<tr>
<td>ISO/TR 3888 severe lane-change maneuver at curb weight [km/h]*</td>
<td>9</td>
<td>7.3%</td>
<td>4%</td>
</tr>
<tr>
<td>VDA lane change (moose) test entering speed [km/h]</td>
<td>3.0</td>
<td>4.4%</td>
<td>1%</td>
</tr>
<tr>
<td>Slalom 18 m at curb weight [km/h]*</td>
<td>2.6</td>
<td>3.8%</td>
<td>3%</td>
</tr>
<tr>
<td>brake distance 100 km/h cold at curb weight [m]**</td>
<td>-1.9</td>
<td>-5.0%</td>
<td>-3%</td>
</tr>
<tr>
<td>brake distance 100 km/h cold at curb weight µ-split [m]**</td>
<td>-20</td>
<td>-17.2%</td>
<td>-8%</td>
</tr>
</tbody>
</table>

### Weight & Cost

<p>| | | | |</p>
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<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>Base Price</td>
<td>9,260</td>
<td>29.5%**</td>
<td>-1.1%</td>
</tr>
<tr>
<td>Vehicle: pay load [kg]</td>
<td>48</td>
<td>10.6%</td>
<td>9%</td>
</tr>
<tr>
<td>Curb weight [kg]</td>
<td>104</td>
<td>6.4%</td>
<td>4.6%</td>
</tr>
</tbody>
</table>

### Interior Noise

<p>| | | | |</p>
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<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>at 80 km/h [dB(A)]</td>
<td>2.0</td>
<td>3.3%</td>
<td>-1 dB(A)</td>
</tr>
<tr>
<td>at 100 km/h [dB(A)]</td>
<td>1.0</td>
<td>1.6%</td>
<td>-1 dB(A)</td>
</tr>
<tr>
<td>at 130 km/h [dB(A)]</td>
<td>1.0</td>
<td>1.5%</td>
<td>-1 dB(A)</td>
</tr>
</tbody>
</table>

Roll out of piloted driving functions: Higher targets expected!

*Delta % = Delta (2002-2015)/2015 **(inflation 22%) german price base
Future Vehicle Requirements (2025)
Function Spider Diagram – Technology Matrix

• Zero Emission and CO2-requirements drive electrification.
• Higher longitudinal and lateral vehicle dynamic request (fleet average) to provide end user value. AWD/4WD and lightweight will support driving dynamics.

Function Spider Diagram – Technology Matrix

-40%
-15%
+75%

Zero emission
ICE optimization
Aerodynamic
Lightweight
Driving dynamics

e-Drive

Premium D,E, F segments)
Rational for increasing AWD/4WD penetration
Power-Density vs. Acceleration @ μ high

- AWD/4WD enables higher longitudinal dynamics already on μ –high (Premium)
- Significant end-user benefit for lower μ, ex. rain, …
- Higher power density will increase the need for 2nd axle torque esp in FWD
## CO₂ emission EU-27 fleet target: 75g

From Function Requirement to Module Specification

<table>
<thead>
<tr>
<th>Functional Requirement</th>
<th>System Approach</th>
<th>Module Specification / MAGNA MCA (market critical attribute)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduce CO₂ Emissions – 75g EU-27 fleet</td>
<td>AWD / 4WD with 2WD spin losses</td>
<td>• On demand lubrication systems (adjusting active oil amount)</td>
</tr>
<tr>
<td></td>
<td>AWD / 4WD with 2WD efficiency</td>
<td>• Ecomax Transfer Case with FAD Disconnect (4WD)</td>
</tr>
<tr>
<td></td>
<td>48V BiSG / CiSG / Gearbox Hybrid</td>
<td>• AWD/4WD: Flex4 Disconnect System</td>
</tr>
<tr>
<td></td>
<td>48V Driveline Hybrid</td>
<td>• 4WD: Ecomax Transfercase</td>
</tr>
<tr>
<td></td>
<td>48V Axle Drive- enhanced 2WD</td>
<td>• AWD / 4WD: Powersplit solution</td>
</tr>
<tr>
<td></td>
<td>Intelligent driveline</td>
<td>• AWD: 48V e-Axle: traction assist</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• enhanced use of ADAS sensors and derived decisions /chassis controller</td>
</tr>
</tbody>
</table>
# Premium Drivability
## From Function Requirement to Module Specification

<table>
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<th>Functional Requirement</th>
<th>System Approach</th>
<th>Module Specification / MAGNA MCA (market critical attribute)</th>
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</thead>
</table>
| **Power Density**      | Light Weight Solution System Level | • Plastic housings, Friction Stir Weld housings, magnesium  
                        |                  | • Multimaterial components & housings, load bone  
                        |                  | • Module integration on diff. levels (system, module…) |
|                        | AWD/4WD-Driveline Hybrid boosting | • AWD / 4WD: Powersplit solution  
                        |                  | • AWD: 48V e-Axle: traction assist  
                        |                  | • AWD: High Voltage e-RAD (80kW – 150kW) |
| **Longitudinal dynamics** | FA/RA delta speed management | • AWD / 4WD: Powersplit solution |
| **Lateral dynamics**   | Torque vectoring | • AWD & 4WD:  
                        |                   | • 48V traction motor with torque vectoring capability  
                        |                   | • eLSD solutions |
| **Smart**              | Smart driveline | • Predictive Systems for Disconnect/AWD/4WD functionality  
                        |                   | • Compensation of kinematic slip for maneuvering at ideal torque distribution FA/RA |
The Powertrain Revolution
Change
Complexity
Roadmap
ICE Optimization remains a key focus in the industry (on-demand systems, light-weighting, efficiency)

Highly efficient transmissions are an enabler to ICE-based vehicles meeting CO2 legislation

Mild and Full Hybrid Systems expand significantly: 48V implementation mainstream.

Electric Vehicle market begins to take off: aggressive customer strategies for CN, EU up to 20% in 2025!!
Complexity of Architectures

ICE incl. Stop / Start
Industry Standard today
# 6

Mild Hybrids
12% - 30% industry 2025
# 21

HEV / PHEV
11% up to 22% Industry 2025
# 17

BEV
>> 3% industry 2025
# 4

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## Roadmap

**Driveline Systems 2025**

<table>
<thead>
<tr>
<th>FR Architecture: 4WD</th>
<th>FF Architecture: AWD</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Standard Systems</strong></td>
<td><strong>Standard Systems</strong></td>
</tr>
<tr>
<td><strong>Electrified Systems</strong></td>
<td><strong>Electrified Systems</strong></td>
</tr>
</tbody>
</table>

**Scenario 2025: Product Mix**

<table>
<thead>
<tr>
<th>ICE &amp; Start / Stop</th>
<th>Mild Hybrid</th>
<th>Full / Plug In Hybrid</th>
<th>BEV</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ecomax</strong></td>
<td>Single speed active</td>
<td>A)</td>
<td></td>
</tr>
<tr>
<td><strong>E Drive</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Actimax</strong></td>
<td>Single speed active</td>
<td>A)</td>
<td></td>
</tr>
<tr>
<td><strong>Ultimax ATC2s</strong></td>
<td>Double speed active</td>
<td>A)</td>
<td></td>
</tr>
<tr>
<td><strong>Ultimax FT</strong></td>
<td>Double speed full time</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Trumax</strong></td>
<td>Single speed full time</td>
<td></td>
<td>PTU RDM</td>
</tr>
<tr>
<td><strong>Ultimax PT</strong></td>
<td>Double speed part time</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**E Drive**
- eAxle 48V
- ePowersplit4 48V
- E RAD (HV)
- E Drive

**Flex4**
- Flex4 RDM
- Flex4 Disconnect

**Dynamax**
- Dynamax Coupling

**PTU RDM**

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Examples of Efficient Driveline Products
Flex4 Disconnect System
48V Mild Hybrid Systems
Flex4 – Disconnect System

Flex4. The seamless connection.
Magna Powertrain’s FLEX4™ is a preemptive disconnect system which greatly increases the fuel efficiency of 4WD vehicles.

True 2WD to 4WD vehicles by disconnecting all unnecessary components from the drivetrain. Non-moving parts do not cause friction and churning losses. 4WD is engaged only when required, therefore improving fuel efficiency and reducing CO₂ emissions.
48V e-Axle

- Add-on solution for CO2 reduction
- Modular 48V driveline system for traction aid
- Partly substitution of established all wheel products driven by CO2 regulations
- High speed e-motor with high power density
- Integrated power electronics / platform approach
- Integrated thermal management
- Advanced sensor systems (e.g. torque measurement)
- Modular software
- Lightweight / plastic housing parts / adv. gear design
- 1,200 Nm @ axle in single speed version

Performance:
- Traction Aid on snow up to 20kph
- Step mu launch support up to 10% incline

Fuel saving potential WLTC: ~ 10% (5.3 vs. 4.8 liters/100km)
48V e-Powersplit

- CO2 reduction compared to standard AWD solutions
- Improved recuperation potential
- Full AWD performance
- Additional AWD functionality (over speeding on 2nd axle)
- 48V HDT Powershift Hybrid Transmission implemented
- Powersplit gearbox on rear axle with 48V E-Machine

Performance:
- Full & Extended AWD function
- Premium drivability
- Energy harvesting

Fuel saving potential WLTC: ~ 10% (5.3 vs. 4.8 liters/100km)
Conclusion
Driveline Systems Summary

- **Hybrid Axle**
  - Electric
    - Hybrid Axle Drive up to Full Electric
  - Mild Hybrid 48V
    - Mechanical Torque Distribution up to recovering Energy
  - 4WD/AWD
THANK YOU
FOR YOUR ATTENTION
DRIVETRAIN FORUM
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