

BorgWarner Drivetrain Systems

eGearDrive 高效电动车驱动桥



8 Dec, 2011

Our Beliefs
Respect
Collaboration
Excellence
Integrity
Community





BorgWarner Overview

BorgWarner = Powertrain Innovation

Engine 72% / SALES

Turbo Systems

- Wastegate
- Variable Turbine Geometry (VTG)
- Regulated 2-stage (R2S™)

Thermal Systems

- Thermal Management Components and Systems
- Visctronic® Systems
- Fans/Fan Drives

Emissions Systems

- Exhaust Gas Recirculation (EGR) Valves
- EGR Coolers & EGR tubes
- Integrated EGR Modules
- Secondary Air Systems
- Actuators

Morse TEC

- Engine Valve Timing Systems
- Timing Chain
- Variable Cam Timing
- HY-VO® Transmission Chain

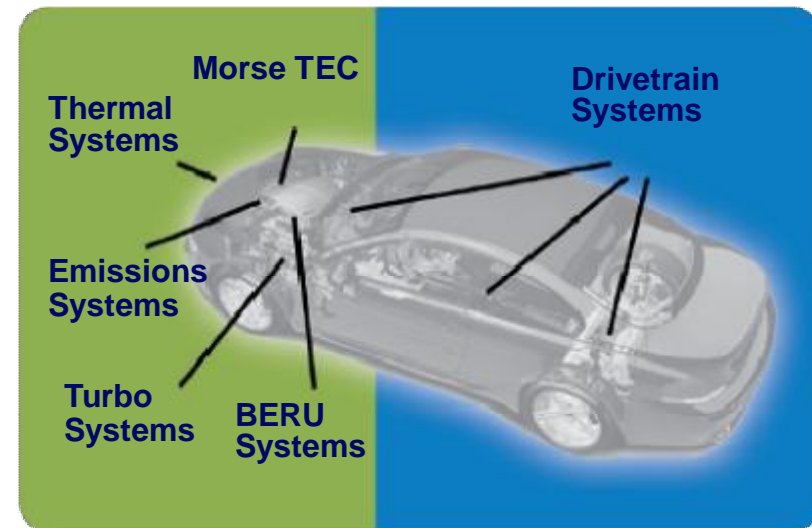
BERU Systems

- Glow Plugs
- Instant Start System
- Pressure Sensor Glow Plugs
- Spark Plugs
- Ignition leads, Ignition Cables
- Ignition Coils
- Sensor Technology
- PTC Cabin Heaters
- Tire Pressure Monitoring System

Drivetrain 28% / SALES

Drivetrain Systems

- DualTronic® Systems for Dual Clutch Transmissions
- Transmission Control Modules and Solenoids
- High Pressure Transmission Control and Actuation Systems
- One-way Clutches
- Friction Plates
- AWD Couplings
- Transfer Cases
- eGearDrive® Electric Drive Transmissions
- eAWD Torque Vectoring
- AWD Electronic Controls and Systems Integration



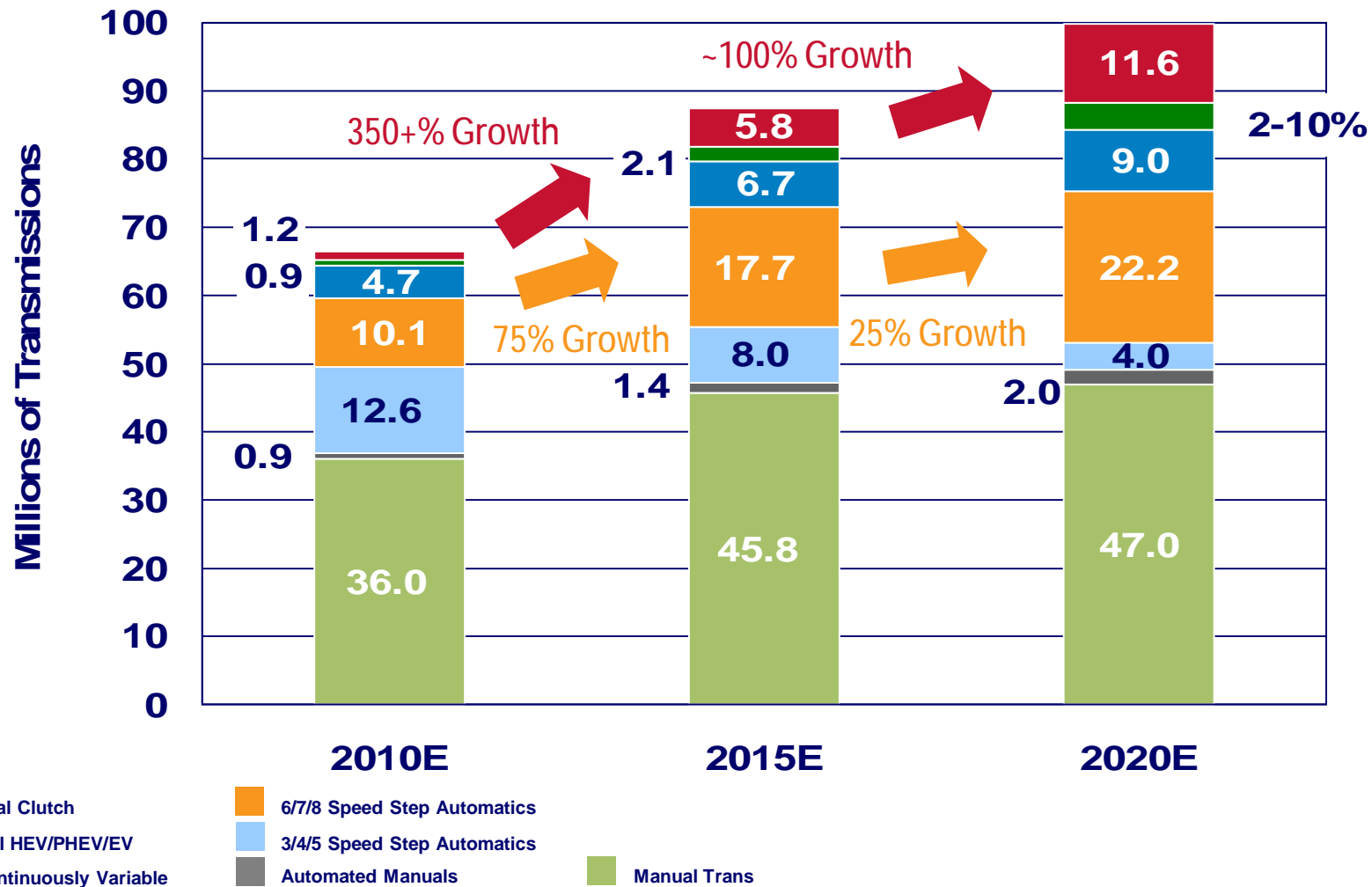
Drivetrain Systems Global Footprint



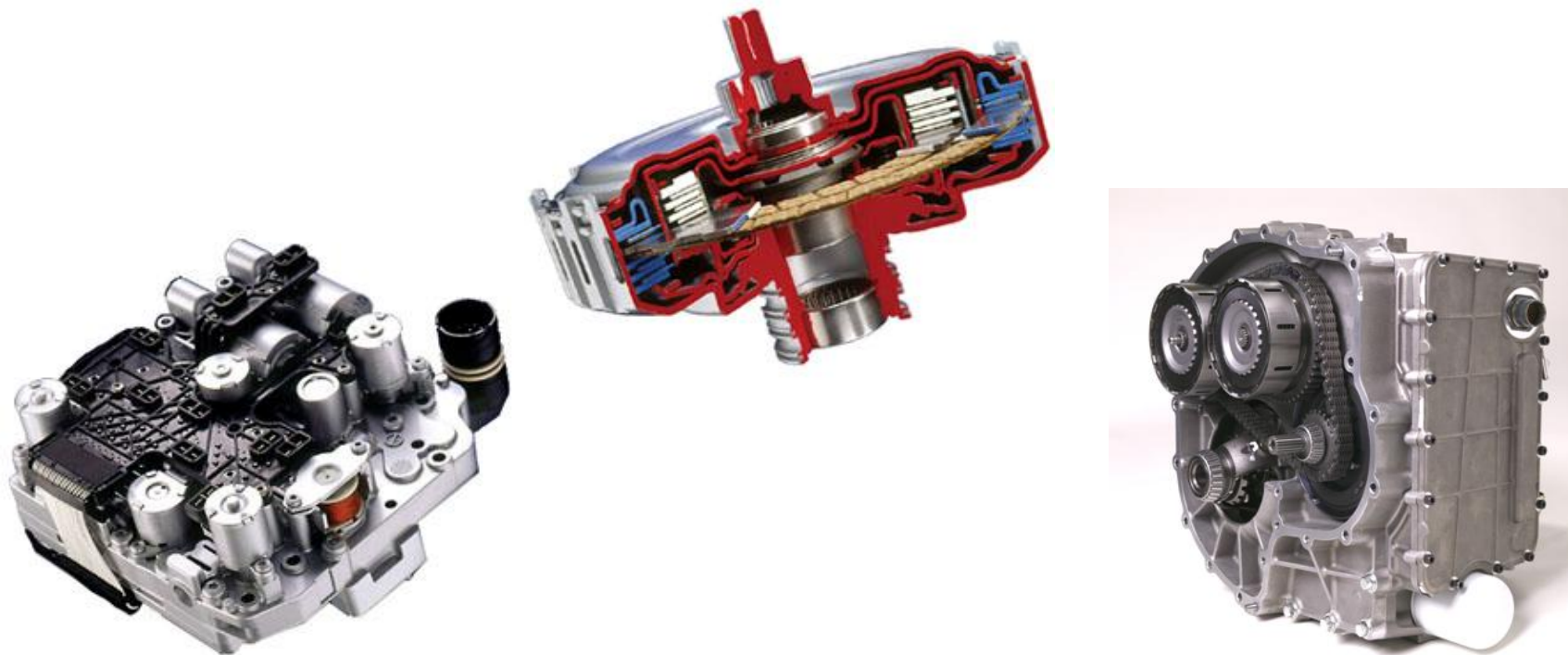


BorgWarner Transmission Applications

Automatic Transmissions Advance

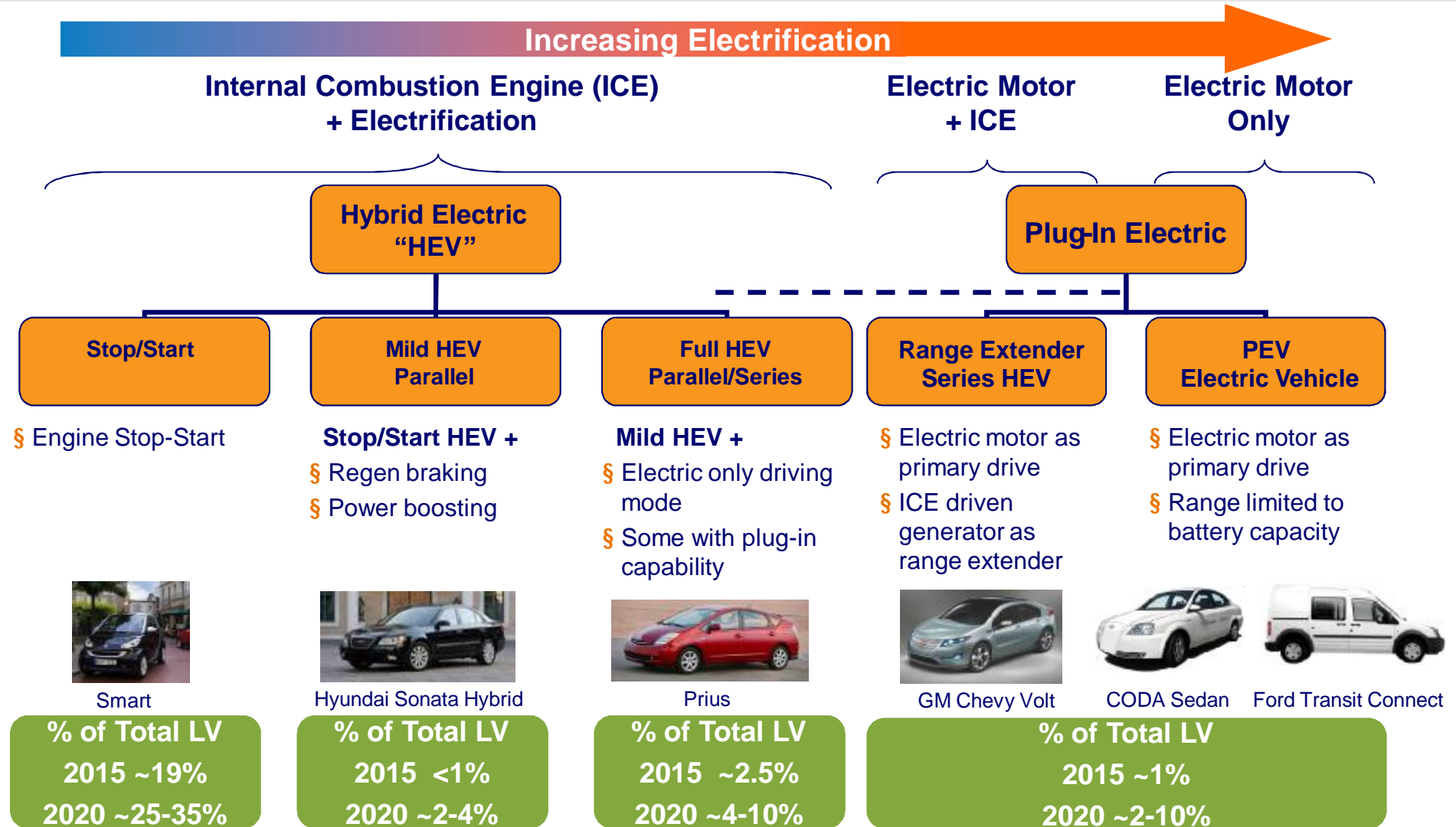


BorgWarner = Dual Clutch Technology



- § Global DCT volume of nearly 6 million units by 2015
- § BW DualTronic™ content in > 80% of global market by volume
- § Programs with VW/Audi, Ford/Getrag, BMW/Getrag, SAIC, FAW, Nissan, and other Chinese and Japanese customers

Hybrid and Electric Vehicle Segments



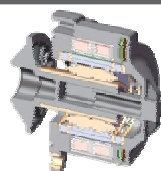
BorgWarner = Hybrid & Electric Vehicles

BorgWarner is developing advanced powertrain products for HEVs vehicles driving efficient use of electrical energy

Driving the Engine



Turbochargers

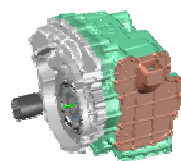


Electronic Coolant Valve



HY-VO[®] Chain Driven Alternator/Starter Module

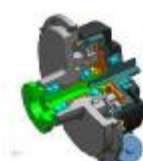
Driving the Wheels



DualTronic[™] DCT



eAssist



Disconnect Clutch



eGearDrive[®] Transmissions*

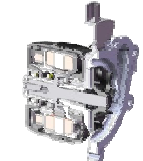
Driving the Accessories



Air Heater



Water Heater



Hybrid Coolant Pump






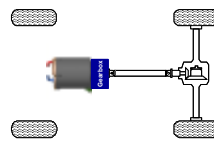
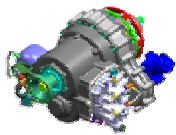
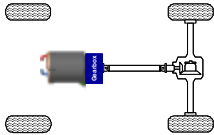
Hybrid Fan Drive

Key Factors for Electric Drive Transmissions

- § Highest efficiencies will be critical to maximizing driving range (impacts battery range and cost)
- § Higher input speeds
- § High sensitivity to Noise, Vibration, and Harshness (NVH)
- § Less gear ratios
- § High duty cycle of forward and reverse torques (regenerative braking)
- § Light weight and compact designs



eGearDrive® Product Range

Model Family	Driveline Architecture	Vehicle Segment Focus	Speeds / Reduction Ratio Range	Center Distance	Max Input Speed	Input Torque Rating	Available Park or Disconnect
31-03  SOP 2010	Transverse Drive (primary & secondary) 	B/C+ Segment	Single 6.5 to 9	210 mm	14,000 Rpm	200 Nm Continuous (300 Nm peak)	Mechanical or electric park lock Electric driveline disconnect
32-01  Prototype	Longitudinal Drive 	Light Duty Commercial Fleet Truck/Van	Single 2 to 3	95 mm	10,000 Rpm	200 Nm Continuous (300 Nm peak)	Mechanical or electric park lock
34-01  In Development	Longitudinal Drive 	Medium Duty Commercial Fleet Truck/Van	Multi-speed 3-speeds	110 mm	10,000 Rpm	400 Nm Continuous (650 Nm peak)	Mechanical or electric park lock



BorgWarner
31-03 Single Speed eGearDrive

31-03 eGearDrive®










Electric Drive Transaxle Technical Features

- Mass: 28Kg*
- Speeds: Single
- Available reduction ratios: 6.54, 7.17, 8.00, 8.28, 8.76, 9.07
- Efficiency: >97%
- Rated input torque: ~200 Nm continuous** (300 Nm peak**)
- Max input speed: ~14,000 rpm
- Center distance: 210 mm
- Lubrication: Splash
- Park lock system
 - § Electronic shift-by-wire park lock system (ePark)
 - § ECU integral to actuator (CAN capable)
- E-machine interface: Adaptable flange
- Status: SOP Q3 2010 (CODA Sedan – lead program)



*Core unit without motor adapter and without ePark
**Nominal rating – dependent on reduction ratio

Announced eGearDrive® Programs

Application	Left View	Right View
<p>31-03 CODA Sedan (2010 SOP)</p> 		
<p>31-03 Ford Transit Connect (2011 SOP)</p> 		
<p>31-01 Tesla Roadster (In production since 2008)</p> 		

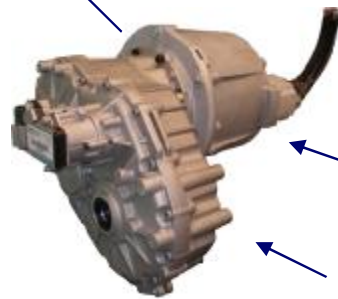
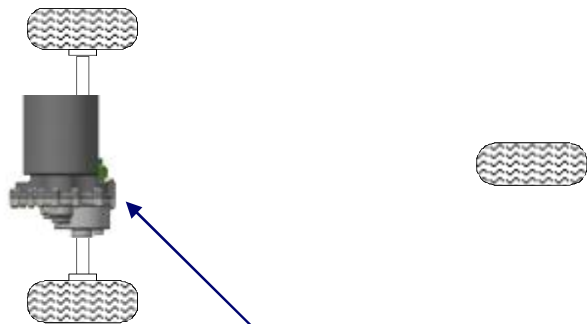
Automotive X-Prize Finalists: Aptera 2e and ZAP Alias



Aptera 2e (179 MPGe)

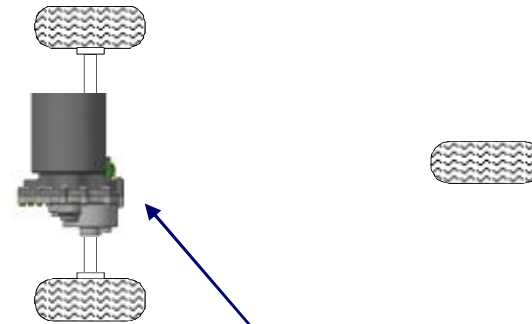


ZAP Jonway Alias (124 MPGe)



Remy Motor

BorgWarner 31-03 eGearDrive Transmission



UQM Motor

31-03 eGearDrive[®] Competitive Attributes

§ Adaptable Design

- § Adjustable to any electric motor interface
- § Accommodates different vehicle packaging (10 to 90 drop angle)
- § Wide range of reduction ratios (6.54, 7.17, 8.00, 8.28, 8.76, 9.07)



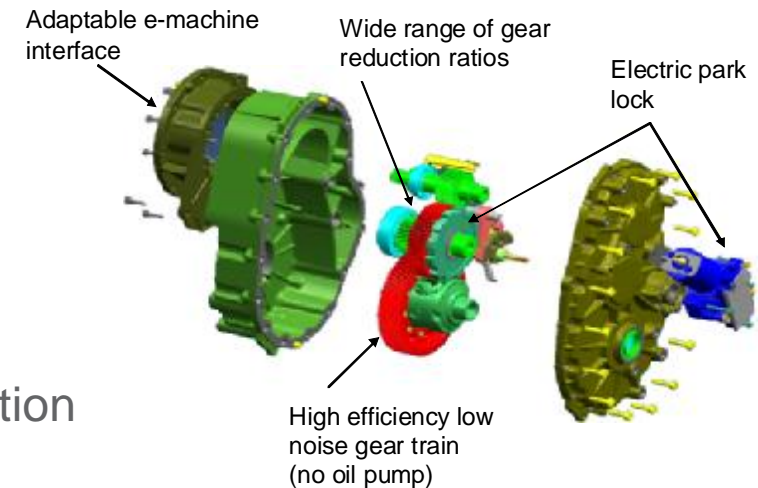
§ Efficiency and Noise

- § High efficiency helical geartrain – all ball-bearing construction
- § Pumpless lubrication (no oil pump)
- § World class noise levels



§ ePark System

- § Electronic shift-by-wire park lock
- § CAN enabled for ease of vehicle integration

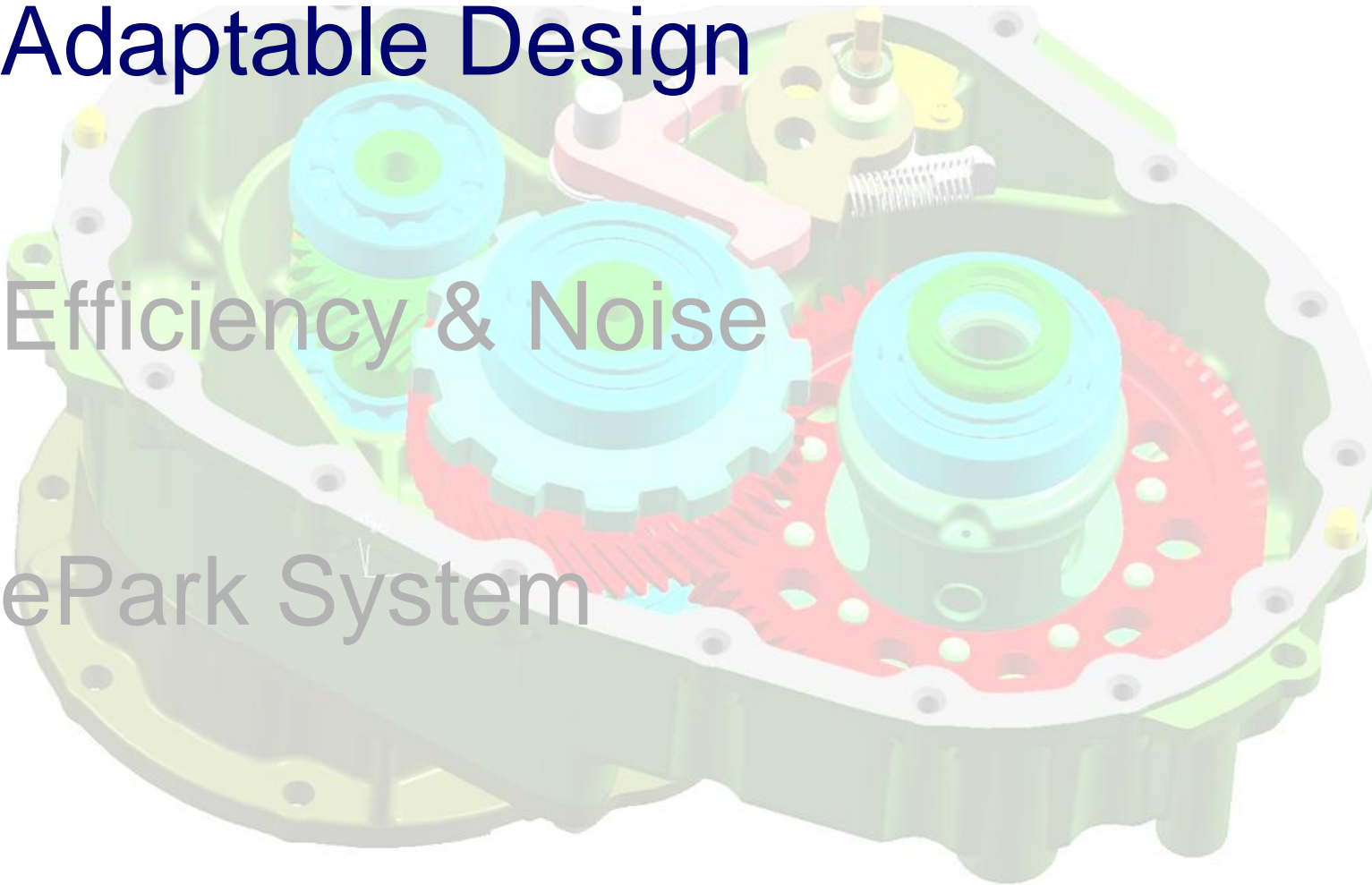


31-03 eGearDrive® Competitive Attributes

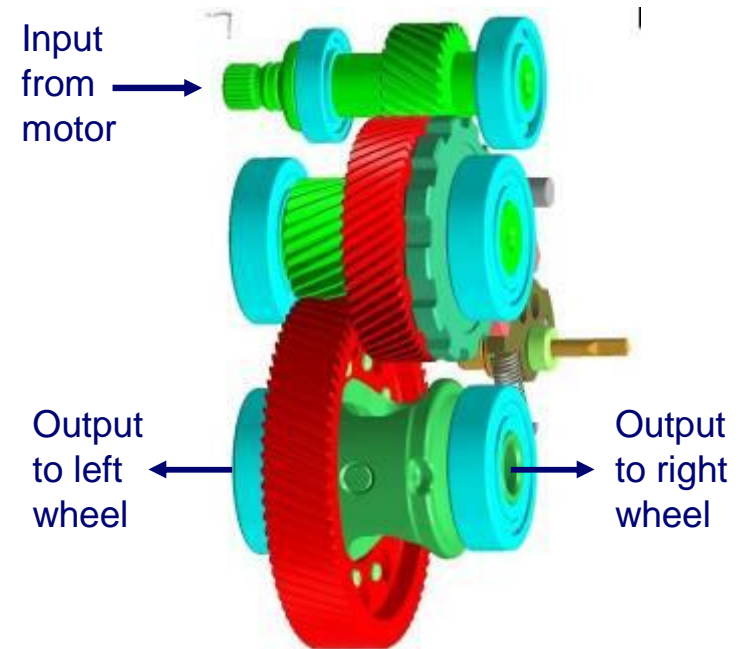
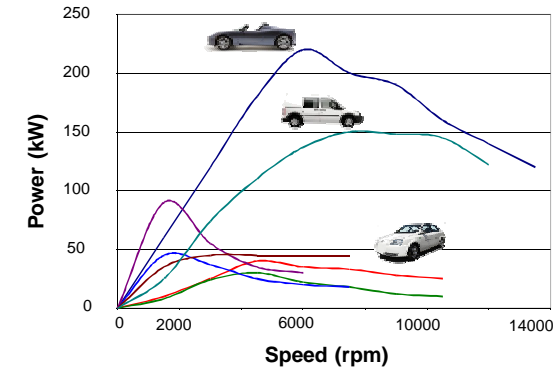
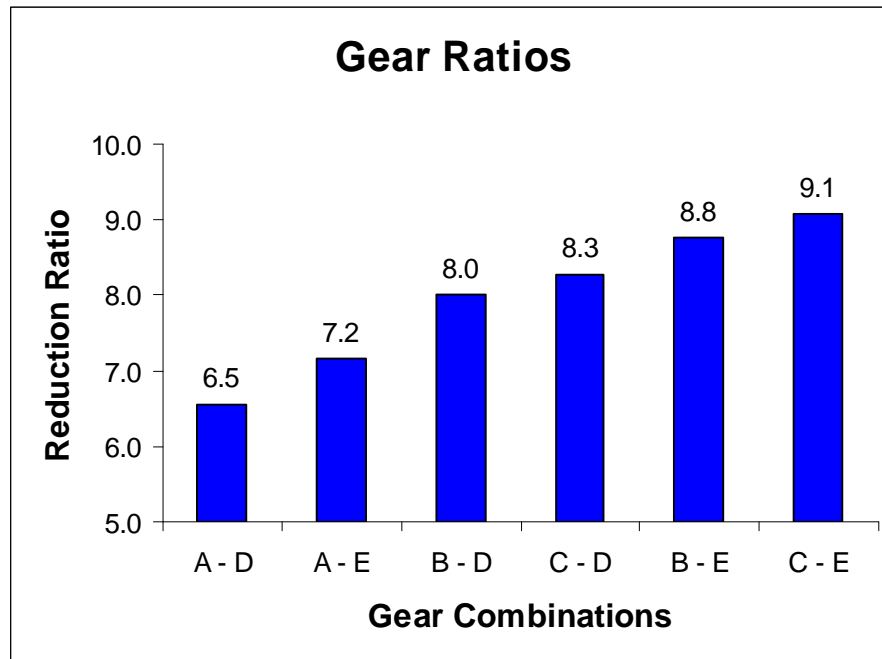
§ Adaptable Design

§ Efficiency & Noise

§ ePark System



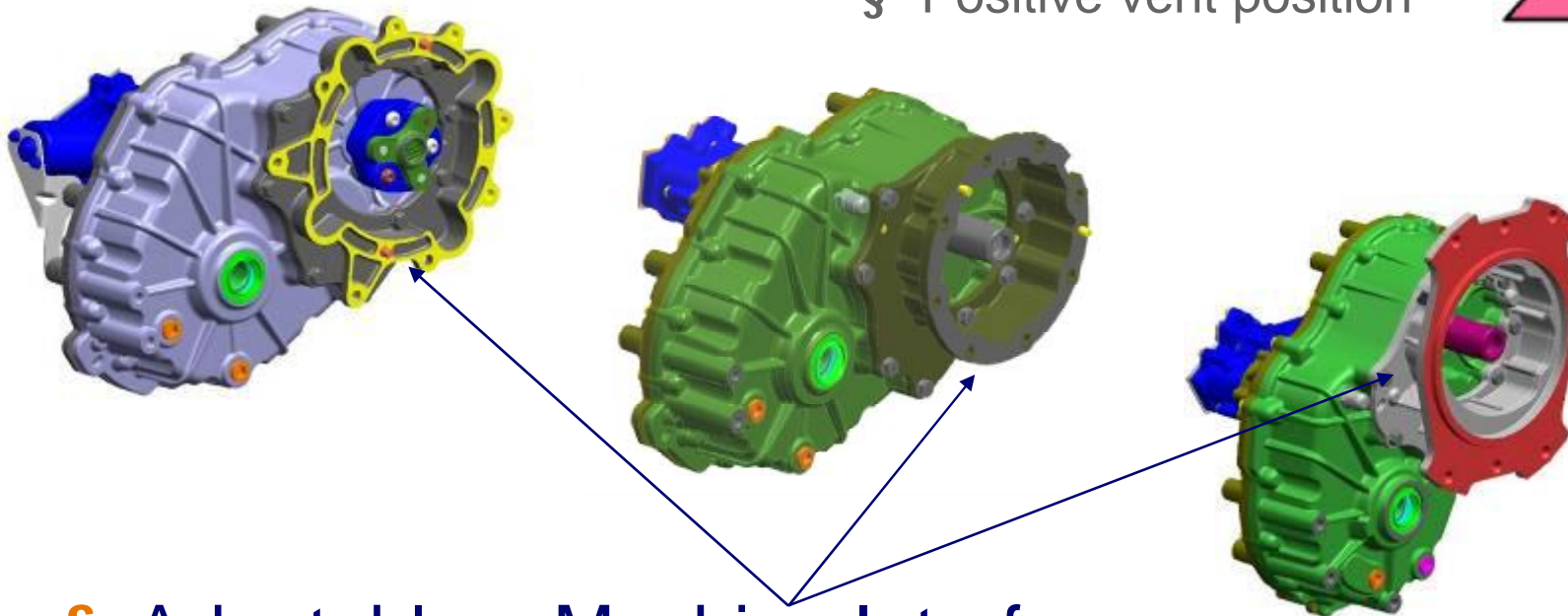
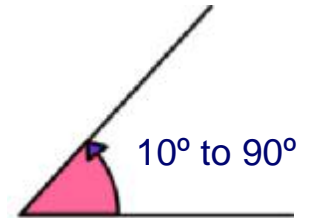
Adaptable Design – Gear Ratios



Adaptable Design – Motor Interface and Orientation

§ Flexible Drop Angle

- § Fill & drain options
- § Universal mount bosses
- § Positive vent position



§ Adaptable e-Machine Interface

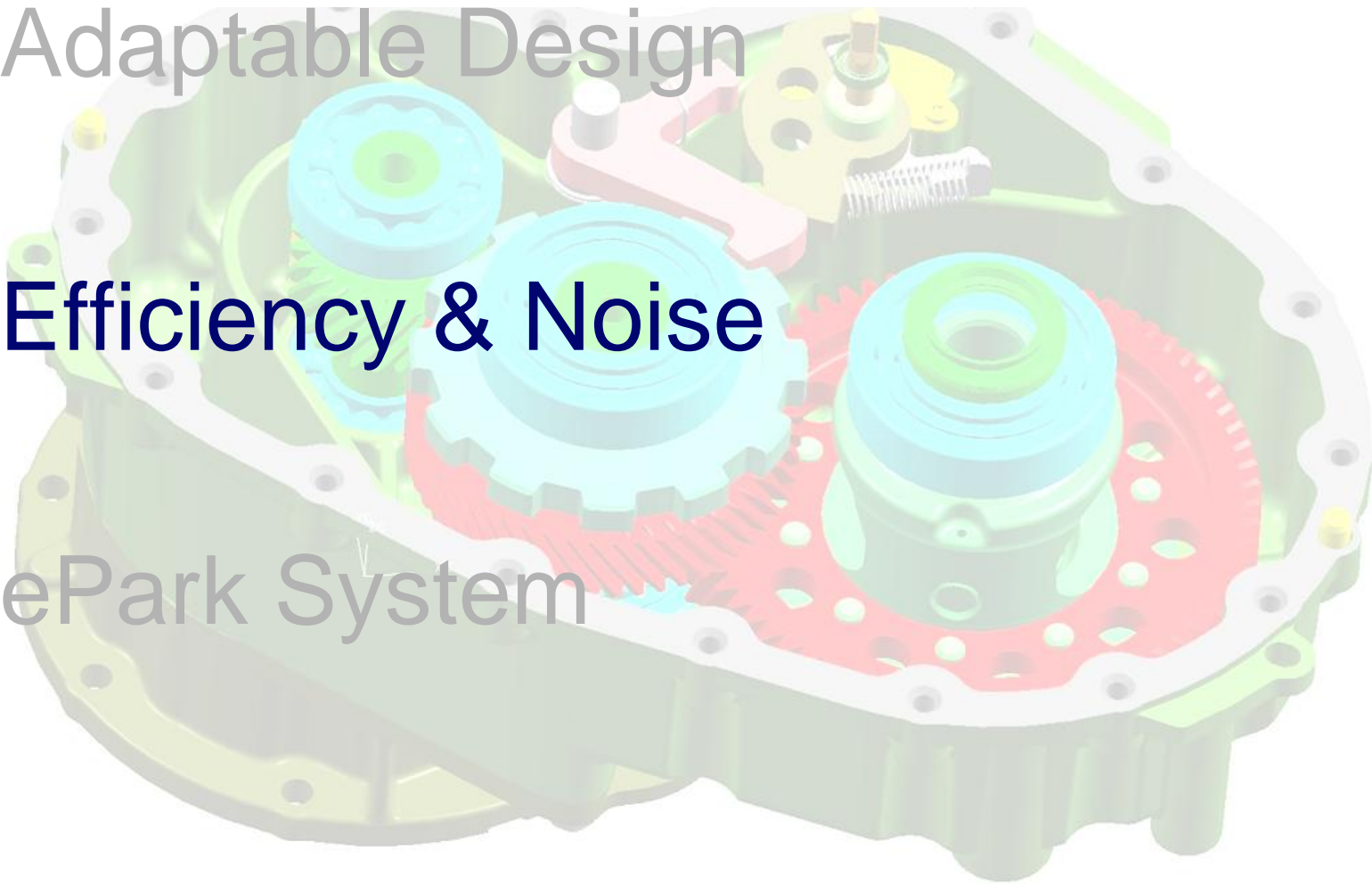
- § Unique motor flange adapter design
- § Various input shaft connection options

31-03 eGearDrive® Competitive Attributes

§ Adaptable Design

§ Efficiency & Noise

§ ePark System



Efficiency - Gear Design

§ Helical Gears

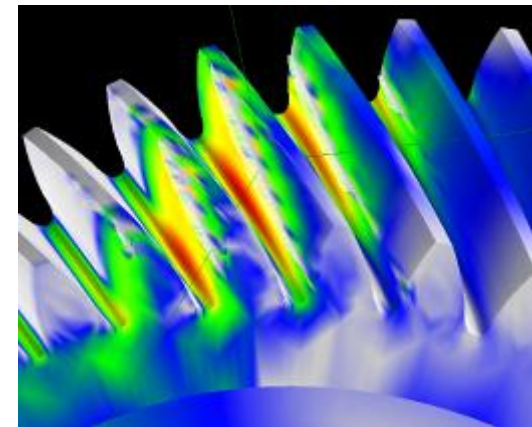
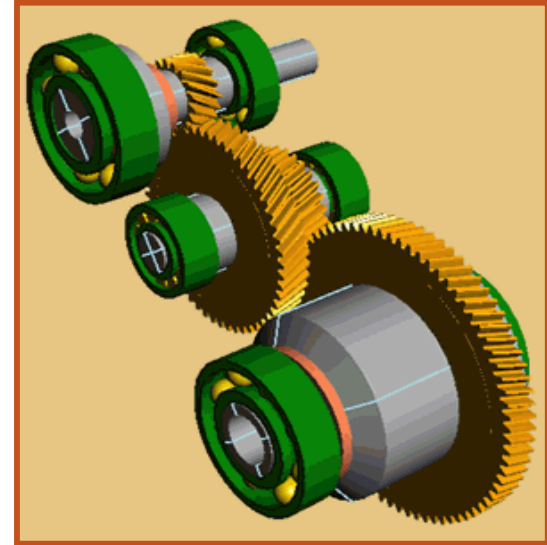
- § Low Noise Transmission
- § Total Contact Ratio >4 on first mesh for reduced high speed mesh whine
- § Modified Tooth forms

§ Fatigue Performance

- § Ground AGMA class 10
- § Surface finish for high speed rolling

§ High Speed Performance

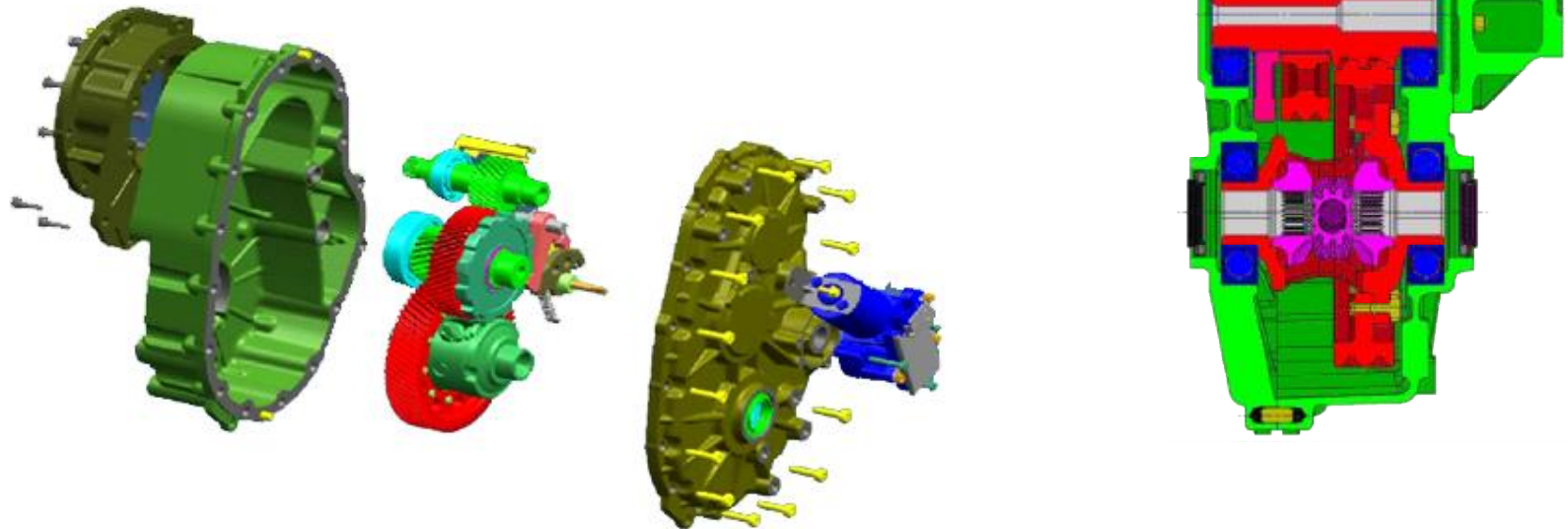
- § Surface finish for reduced flash temperature



Efficiency – Deep Groove Ball Bearings

§ Offset architecture to accommodate deep groove ball bearings

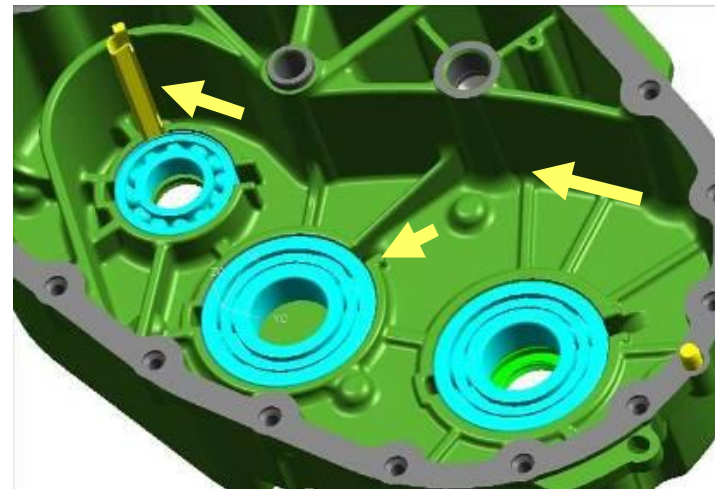
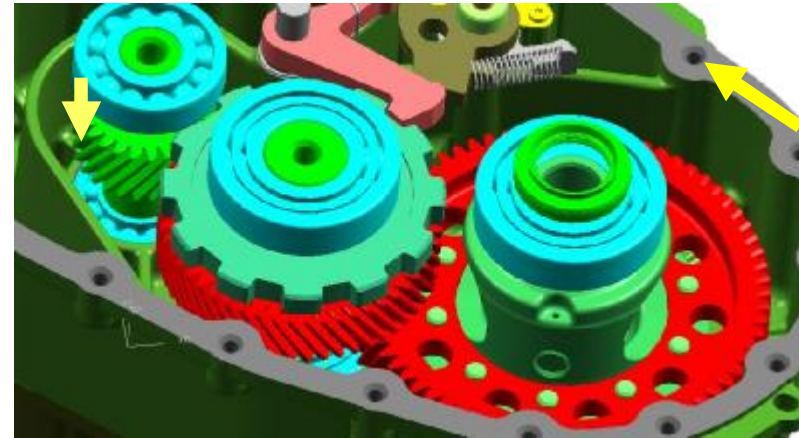
- § Ball bearings are larger but.....
 - § No system preload (as in tapered rollers)
 - § Lower parasitic losses
 - § Lower running temperature



Efficiency – Pumpless Lubrication

§ Pumpless Design

- § Utilizes the natural pumping action of gears to lubricate bearings and seals
- § Oil gallery and fluid level to accomplish distribution goals
- § Supports multiple drop angles



Efficiency – 31-03 eGearDrive®

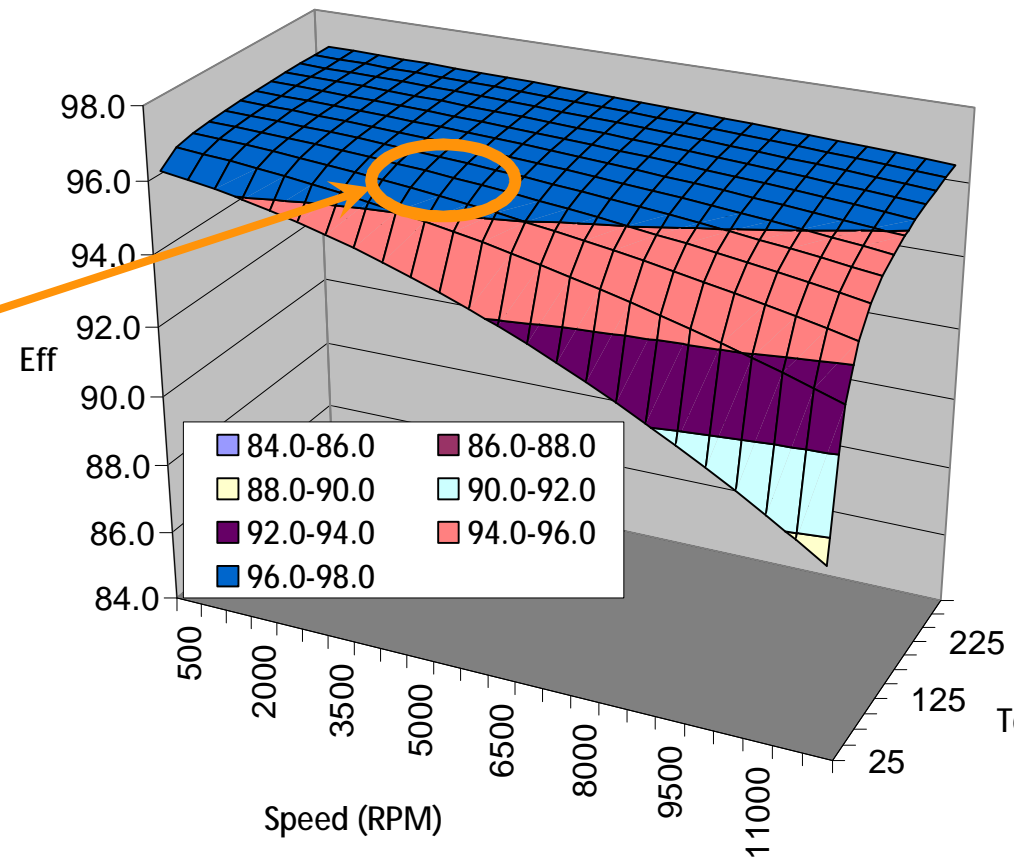
Efficiency = Driving Range

31-03 eGearDrive Efficiency

§ Efficiency

§ Peak ~ 97%

§ Normal Operating Condition ~ 96%

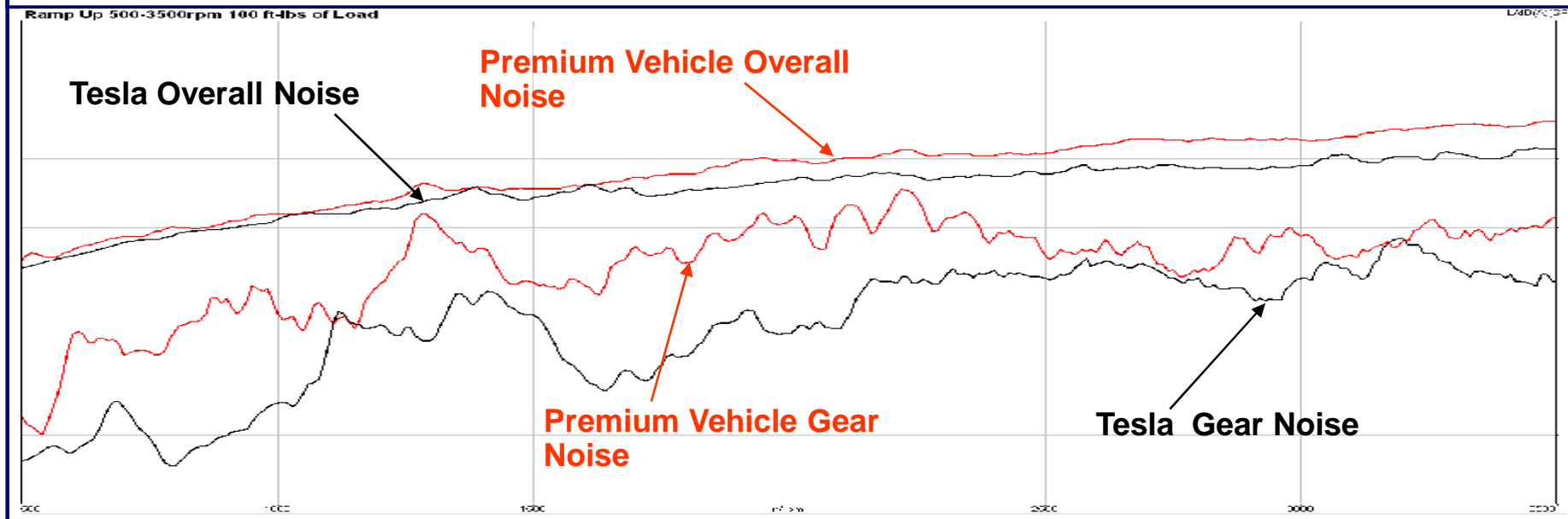


Noise Quality

Tesla 31-01 vs. Gear Drive Transfer Case System Acoustic Response

Tesla – BLACK

Premium Vehicle Powertrain - RED



§ Drivers have a noise expectation

§ Modern vehicles have very good noise quality

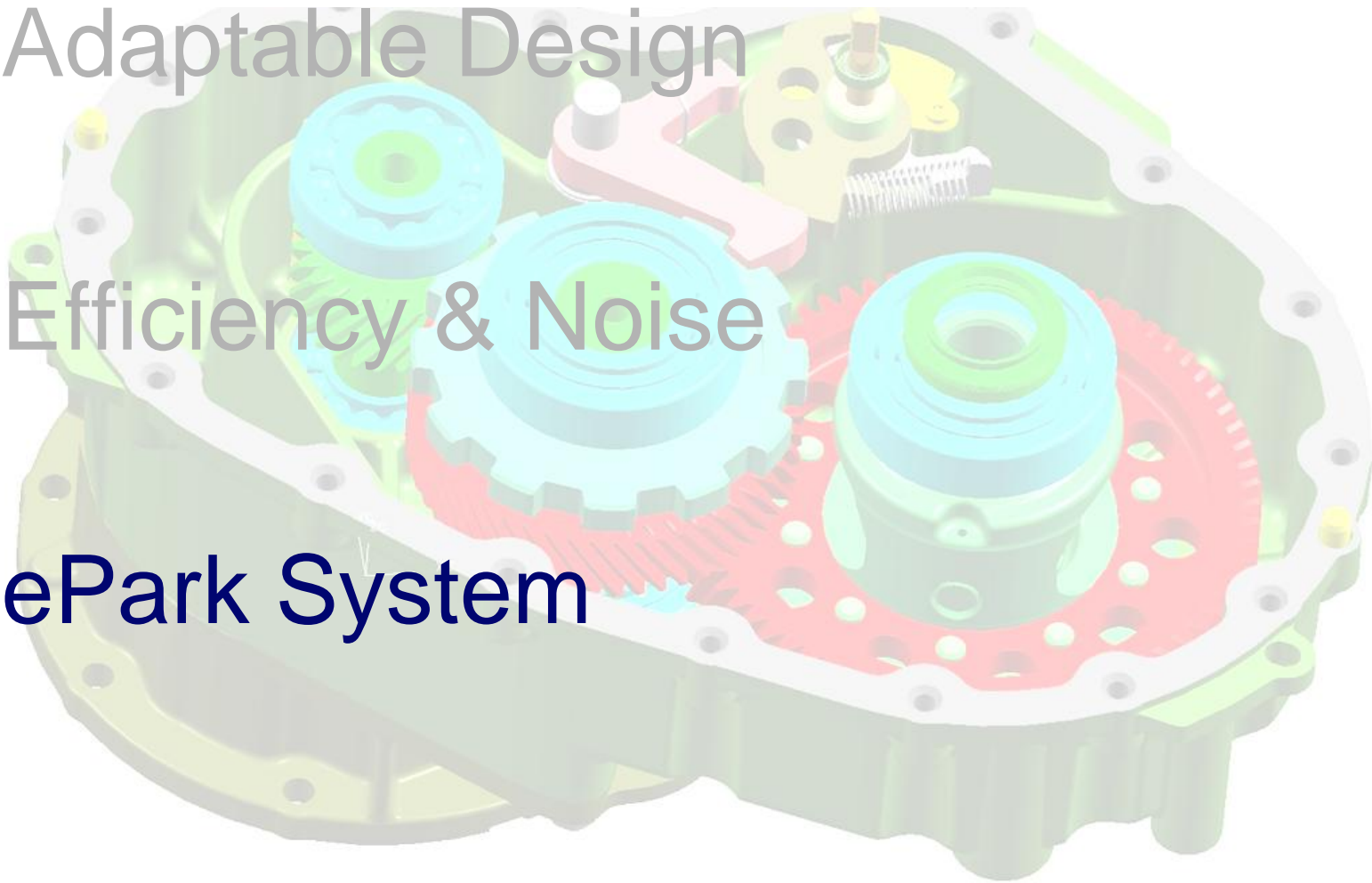
§ Electric vehicles need to have equivalent or better noise quality

31-03 eGearDrive® Competitive Attributes

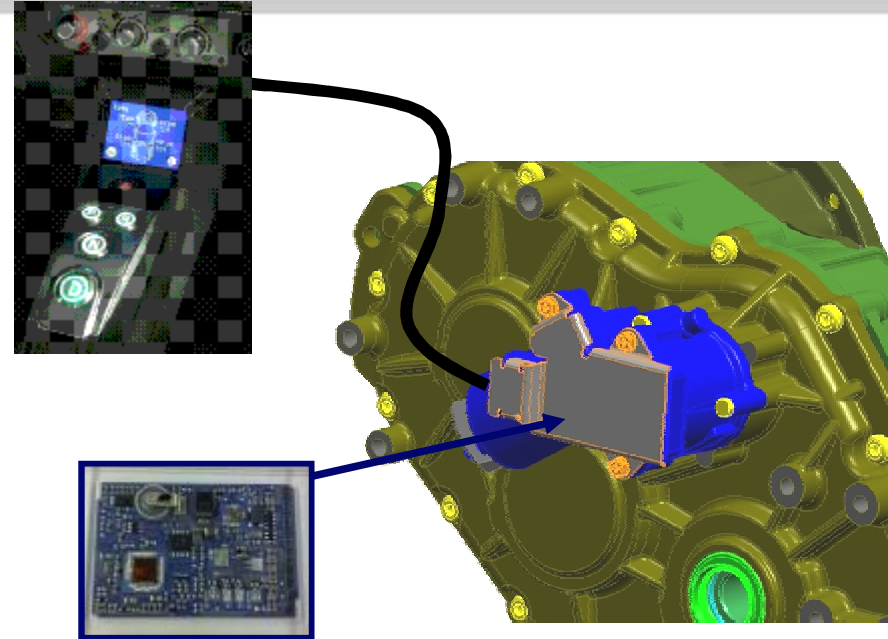
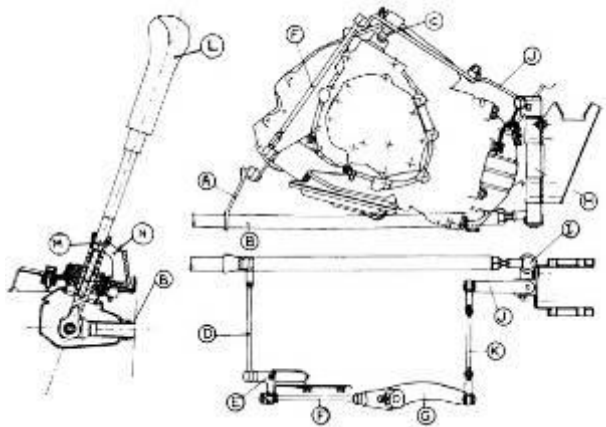
§ Adaptable Design

§ Efficiency & Noise

§ ePark System



ePark Advantage



Mechanical Systems

- § High mass
- § High build variation
- § High complexity






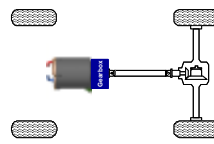
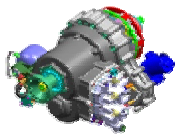
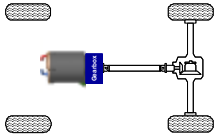
ePark

- § Shift-by-wire park lock
- § Integral ECU
- § CAN enabled
- § Easily adaptable



BorgWarner
34-01 Multi-Speed eGearDrive

eGearDrive® Core Product Range

Model Family	Driveline Architecture	Vehicle Segment Focus	Speeds / Reduction Ratio Range	Center Distance	Max Input Speed	Input Torque Rating	Available Park or Disconnect
31-03  SOP 2010	Transverse Drive (primary & secondary) 	B/C+ Segment	Single 6.5 to 9	210 mm	14,000 Rpm	200 Nm Continuous (300 Nm peak)	Mechanical or electric park lock Electric driveline disconnect
32-01  Prototype	Longitudinal Drive 	Light Duty Commercial Fleet Truck/Van	Single 2 to 3	95 mm	10,000 Rpm	200 Nm Continuous (300 Nm peak)	Mechanical or electric park lock
34-01  In Development	Longitudinal Drive 	Medium Duty Commercial Fleet Truck/Van	Multi-speed 3-speeds	110 mm	10,000 Rpm	400 Nm Continuous (650 Nm peak)	Mechanical or electric park lock

34-01 Features and Benefits

§ Three-speed geartrain

- § Improved vehicle gradeability while maintaining vehicle top speed target
- § Allows motor operation in most efficient speed range
- § Enhanced battery electric driving range
- § Reduced clutch shift energy requirements over two-speed

§ Efficient dual clutch power flow

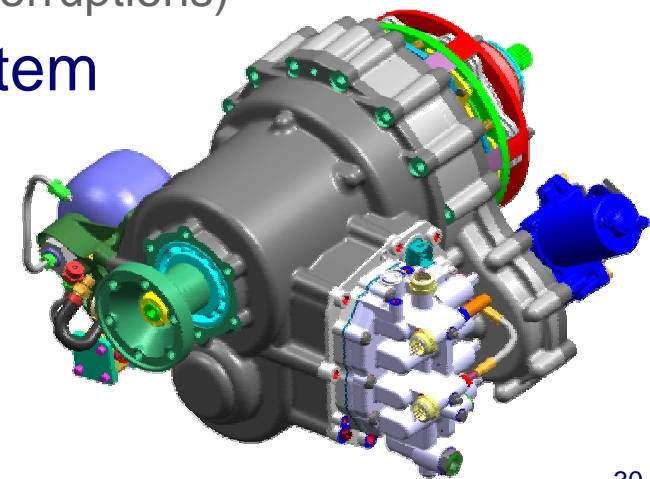
- § No power required to hold transmission in 1st or 3rd gear
- § Fully automatic power shifts (without torque interruptions)

§ High pressure hydraulic actuation system

- § High-efficiency pump-on-demand system

§ Electronic park lock

- § Electronic shift-by-wire park lock
- § CAN enabled for ease of vehicle integration

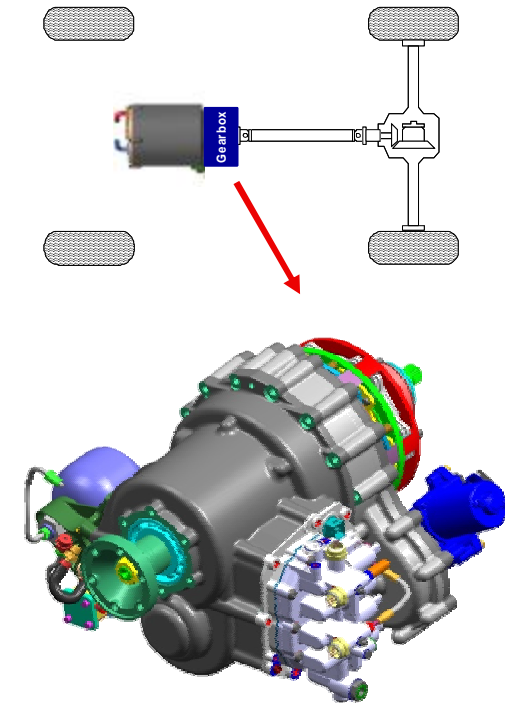


34-01 eGearDrive™

Electric Longitudinal Drive

Technical Features (Initial Concept)

- Mass: 68.5 Kg
- Speeds: Three
- Available ratios: 1st: 3.125; 2nd: 1.726; 3rd: 1.0
- Rated input torque: ~400 Nm continuous (650 Nm peak*)
- Max input speed: ~10,000 rpm
- Gear center distance: 110 mm
- Output/Input orientation: Inline
- Shift system: Dual clutch with on-demand high pressure hydraulics
- Lubrication: Splash
- Efficiency: TBA
- Park lock system
 - § Electronic shift-by-wire park lock system (ePark)
- E-machine interface: Adaptable flange
- Status: In development



*Torque capacity dependent on duty cycle and life requirements

What eGearDrive® Systems Provide

- § Over one hundred years of geartrain system design experience
 - § Industry first high-speed high-range electric sports car transaxle application (Tesla Roadster)
- § Proven single-speed electric drive technology for fast to market low-risk implementation now!
- § Adaptable designs for rapid vehicle integration
- § Highest efficiency for extended driving range
- § High reliability and best in class NVH
- § Mechanical and electronic park lock systems
- § Shift system technology for multi-speed requirements

Component and Systems Relationships



BOSCH



Enova



FEV



HITACHI



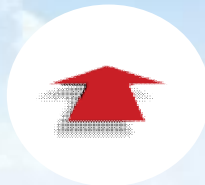
TESLA MOTORS



And growing.....

Thank You

*feel good
about driving*



*better fuel economy
reduced emissions
great performance*