Future Propulsion Systems

BRP-POWERTRAIN

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Agenda

- BRP Bombardier Recreational Products
  - BRP Powertrain
- Challenges
  - Sustainability
- Future Propulsion Systems
  - Scenarios
  - Architecture
  - Enablers
- Summary
  - Key messages

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BRP

Market segmentation

BRP is no. 1 in following markets:
PWC
Sport Boat
Snowmobile
Roadster
Light Sport Aircraft

BRP Powertrain
A global company

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Megatrend
Sustainability

Enviroment
- Enviromental Management

Economy
- Justify Energy Demand

Society
- Different Generations

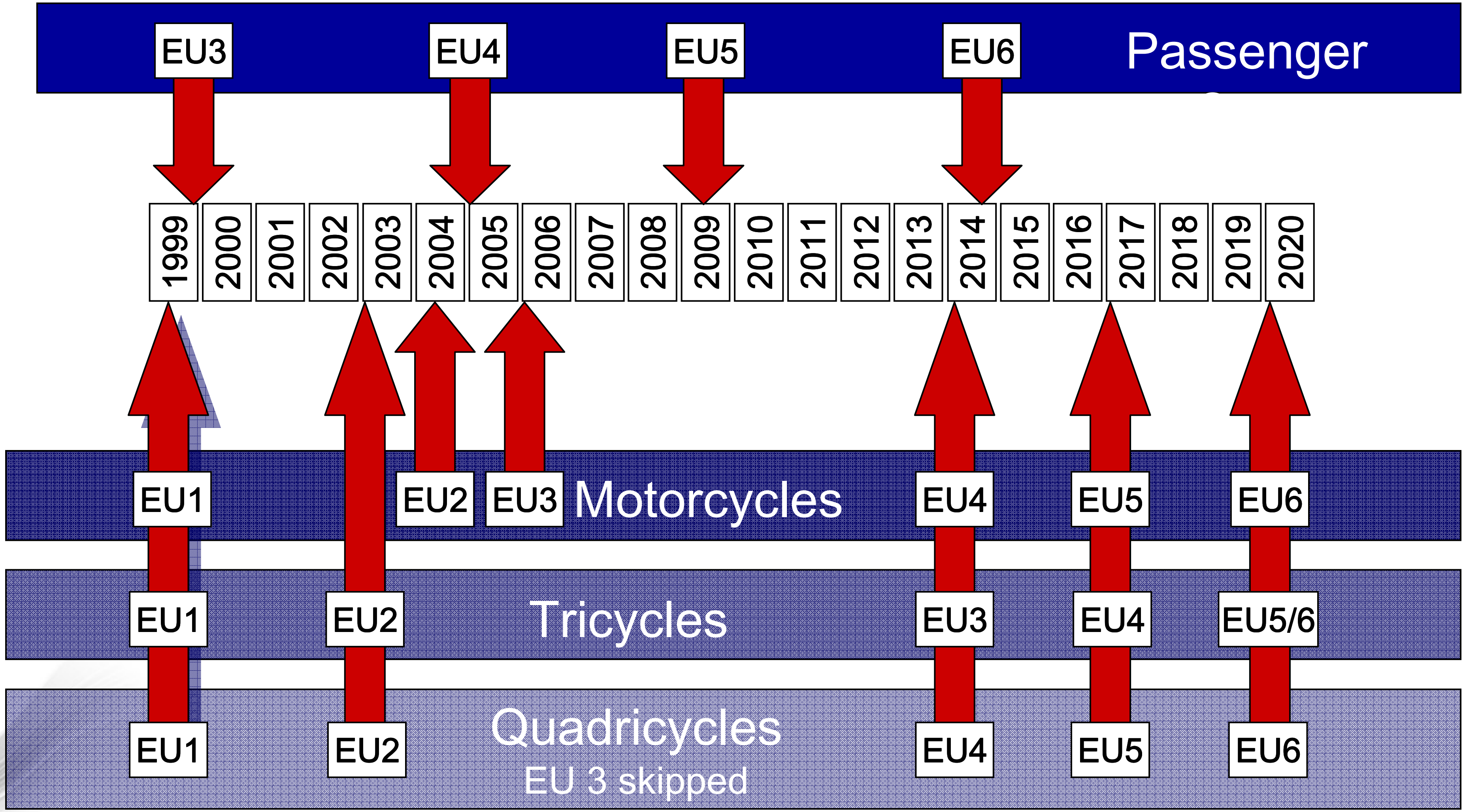
Society
Different expectations from different generations

	Values	Organizational Culture	Management Style	Working environment
Baby Boomers (1946 – 63) (45% of active pop.)	Work is serious	Hierarchy Respect authority and norms Take time to make the right decisions	Boomers are manageable and loyal Follow orders	Quality of life
Generation X (1964 – 78) (30% of active pop.)	Work must have a meaning	Careerism Politics Fast	Mentoring Loyalty redefined: commitment to their work/career, not employer	Flexibility for their "sandwich" situation
Generation Y (1979 – 83) (15% of active pop.)	Work is done in teams	Reputation (ethics) of the company Challenges and experimentation Very fast-paced	Guidance Autonomy – free agents Good relationship with supervisor Frequent feedback	Opportunities to socialize at work Work/life balance is a priority
Generation C (1984 – 96) (45% in 10 years)	Technology is key	Stimulation Creativity Instant	Managers who "walk the talk"	Lifestyle and friends above work

Source CORPORATE EXECUTIVE BOARD

Enviroment

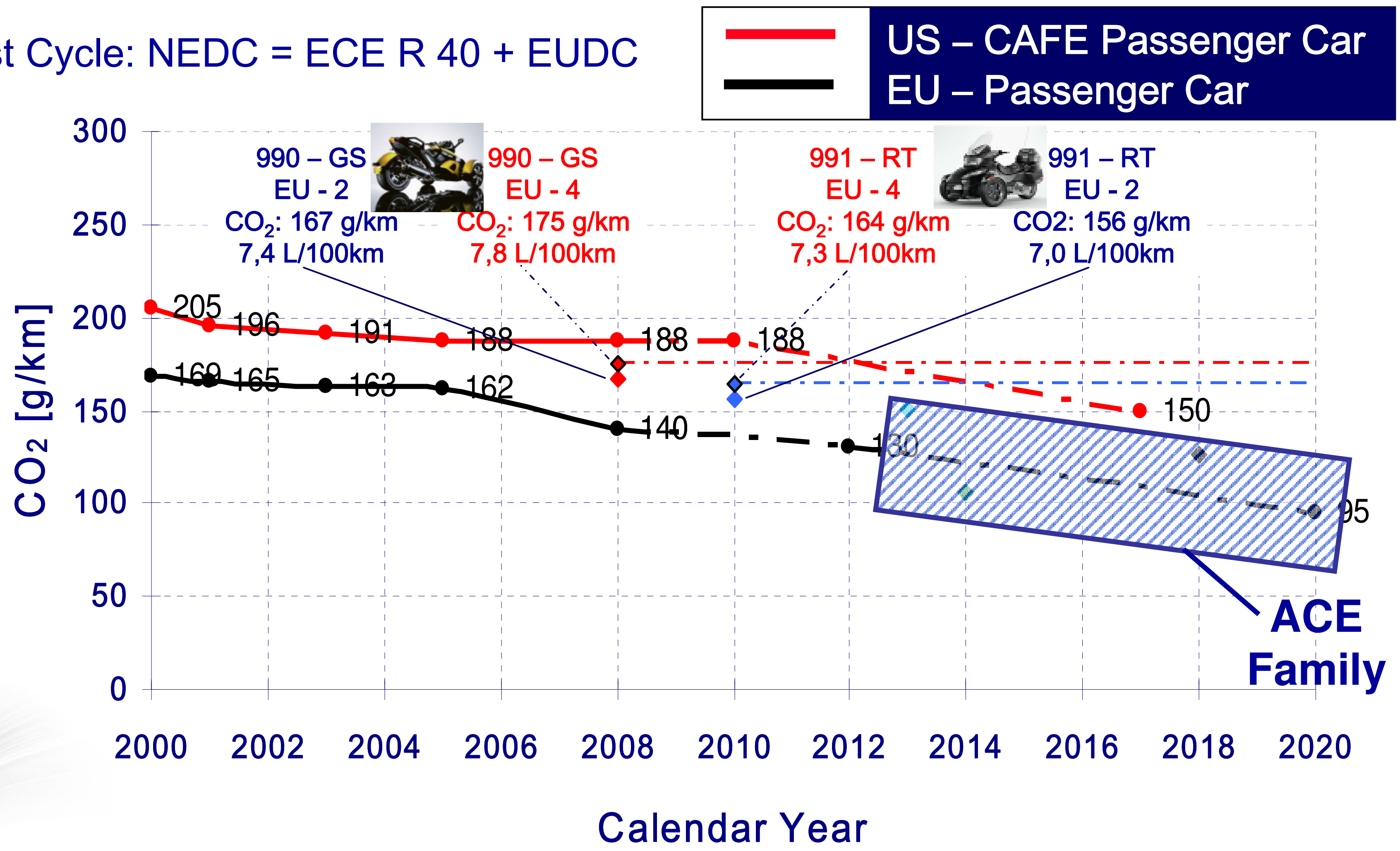
Emission Legislation Standard CO/HC/NOx



Enviroment

Emission Legislation Standards CO2

Test Cycle: NEDC = ECE R 40 + EUDC



Economy – Justify Energy Demand

iea - international energy agency scenarios

<u>Base line scenario</u>: no existing changes in policies with projected C02 emissions of 40.2 Gt in 2030

- 1,5% increase of energy demand per year,12 000 -> 16800 Mtoe
- Main driver of demand for coal and gas is power generation
- Non hydro renewable energy technologies show fastest rate of increase
- Capital required to meet projected energy demand -> 26 T$

<u>450 scenario:</u> global and radical coordinated policies worldwide with projected CO2 emissions of 26.4 Gt in 2030

- 0,8% growth rate of energy demand per year
- Increased energy efficiency in buildings and industry reduces the
- demand of electricity and to a lesser extent fossil fuels
- Average emission extensity of new cars is reduced by more than half
- Capital required to meet projected energy demand reduction -> 36.5 T$

Fossil fuels will remain the dominant sources of primary energy worldwide in both scenarios, end use efficiency is the largest contributor to CO2 emissions

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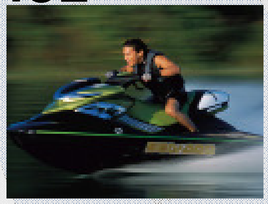
Future Propulsion

Szenarios

- **Ultimate** Power to weight
- **Ultimate** Ride to autonomy
- **Limited** Access to playground
- **Legal** Emission tank to wheel

Internal combustion engine ICE



Ultimate Power Vehicle

Technology

- Direct injection 2- & 4-stroke
- Charging SC & TC
- Emission control concepts
- Intelligent transmissions
- Variable auxiliaries
- Light weight materials

Key Issues

- Emissions reduction
- Efficency improvement
- Noise reduction
- Alternative fuels

- **Efficient** Power to weight
- **Efficient** Ride to autonomy
- **Extended** Access to playground
- **Reduced** Emission tank to wheel

Hybrid

Efficient Power Vehicle

Technology

- Micro hybrid (start/stop)
- Parallel hybrid
  - Emission control concepts ICE
  - Intelligent transmissions
  - Energy storage concepts (quick charge and discharge)

Key Issues

- Cost of Battery/Power electron.
- Weight / Size of Powertrain
- Packaging of Powertrain
- Emissions reduction of ICE
- System Complexity

- **Ultimate** Power to **emissions**
- **Limited** Ride to autonomy
- **Unlimited** Access to playground
- **Zero** Emission tank to wheel

Electric

Zero Emission Limited Ride Vehicle

Technology

- Full electric
- Series hybrid (Range extender)
  - Emission control concepts ICE
  - NVH concepts ICE
  - Battery technology concepts (continues charge and discharge)

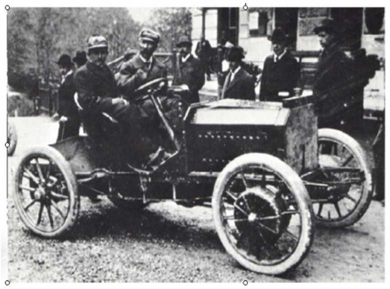
Key Issues

- Costs of Battery/Power electron.
- Weight / Size of Battery
- Packaging of ICE / generator
- NVH reduction of ICE
- Limited Autonomy

Future Powertrain
Architecture

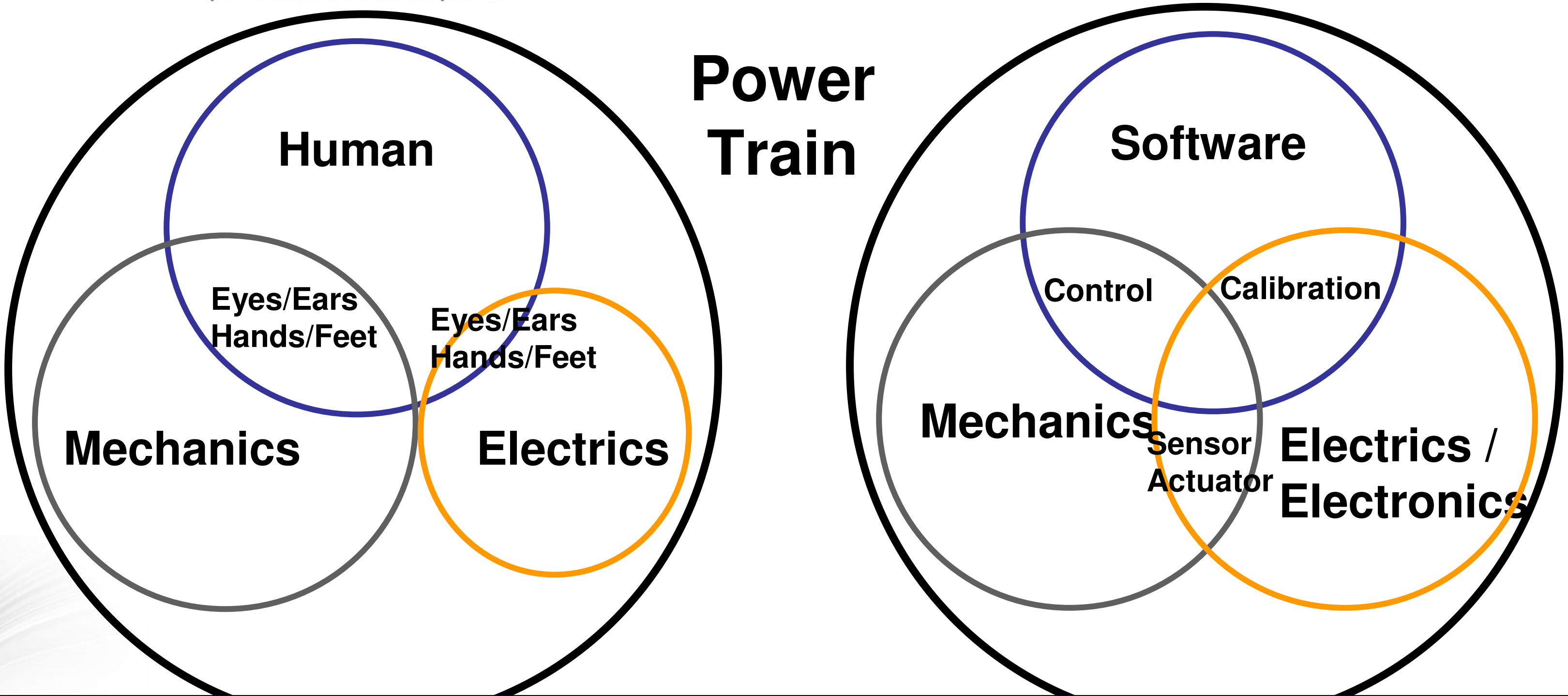
1902

F. Porsche
F. Lohner



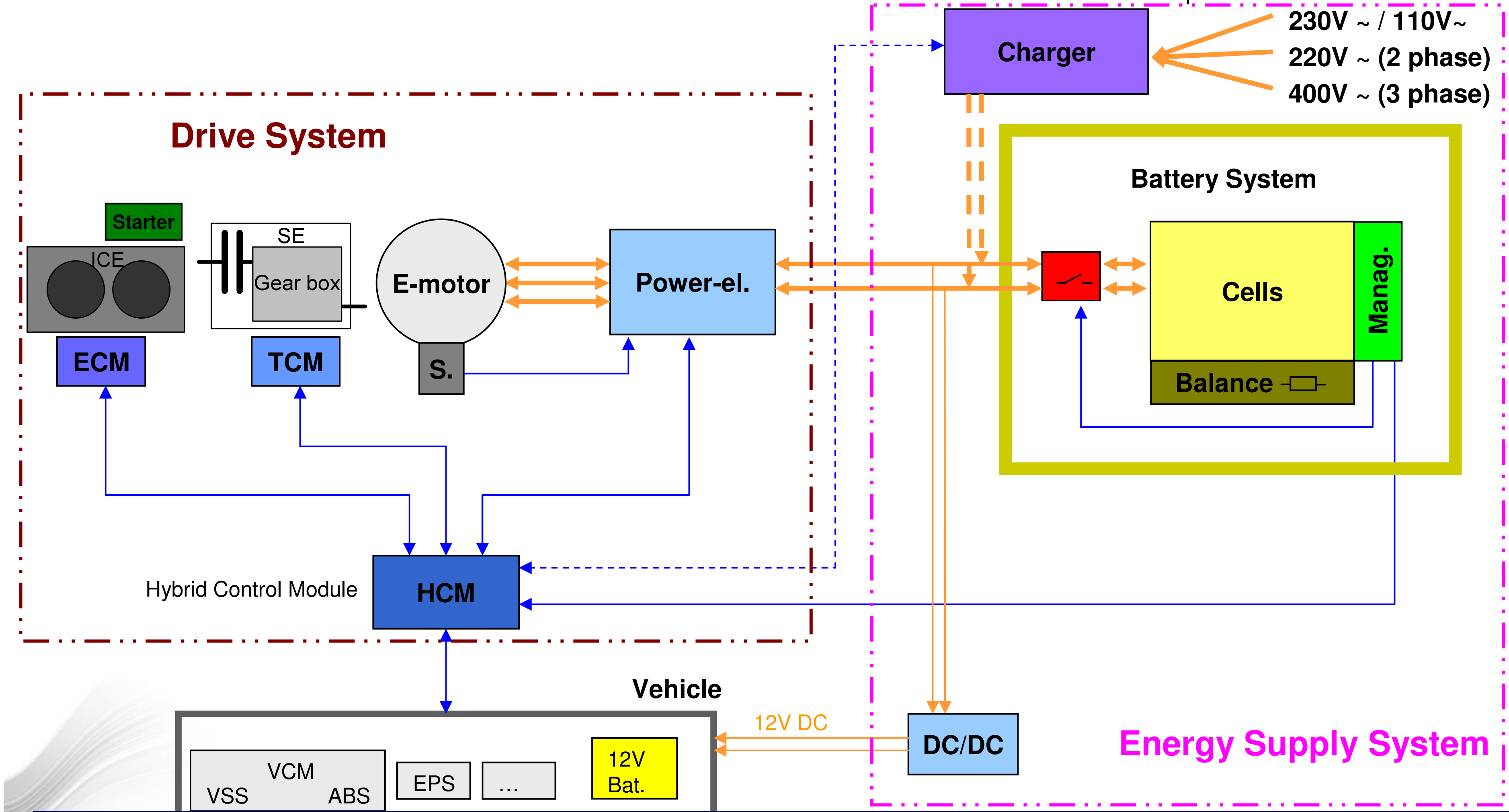
2010

Porsche
918 Spyder



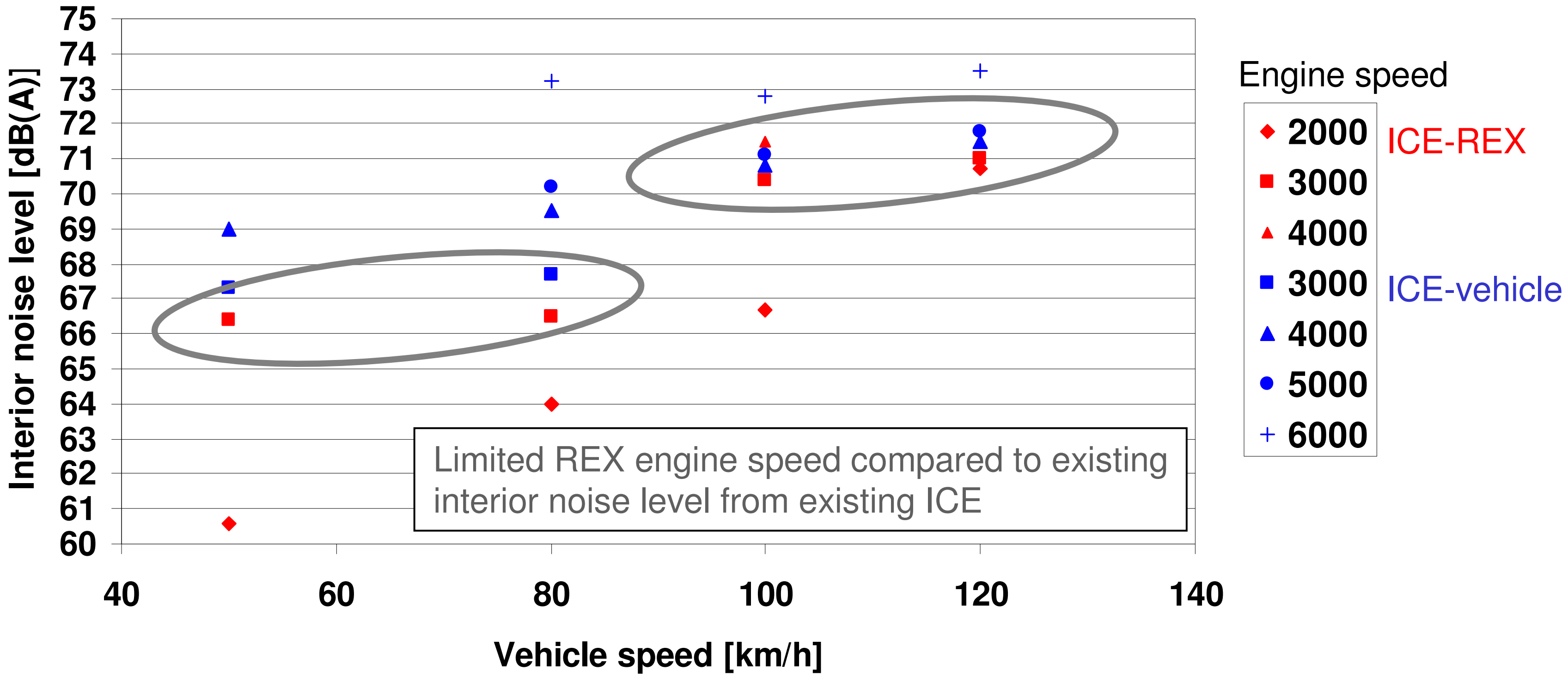
Mechatronics units the principles of mechanics, electric/electronics and software engineering to generate advanced power train architectures and functions

Mechatronic Powertrain
Advanced Architecture



Powertrain development process has to cover a significant higher complexity by continuously increasing demands of development time and cost reduction

Mechatronic Powertrain
Enabler – Drive system NVH

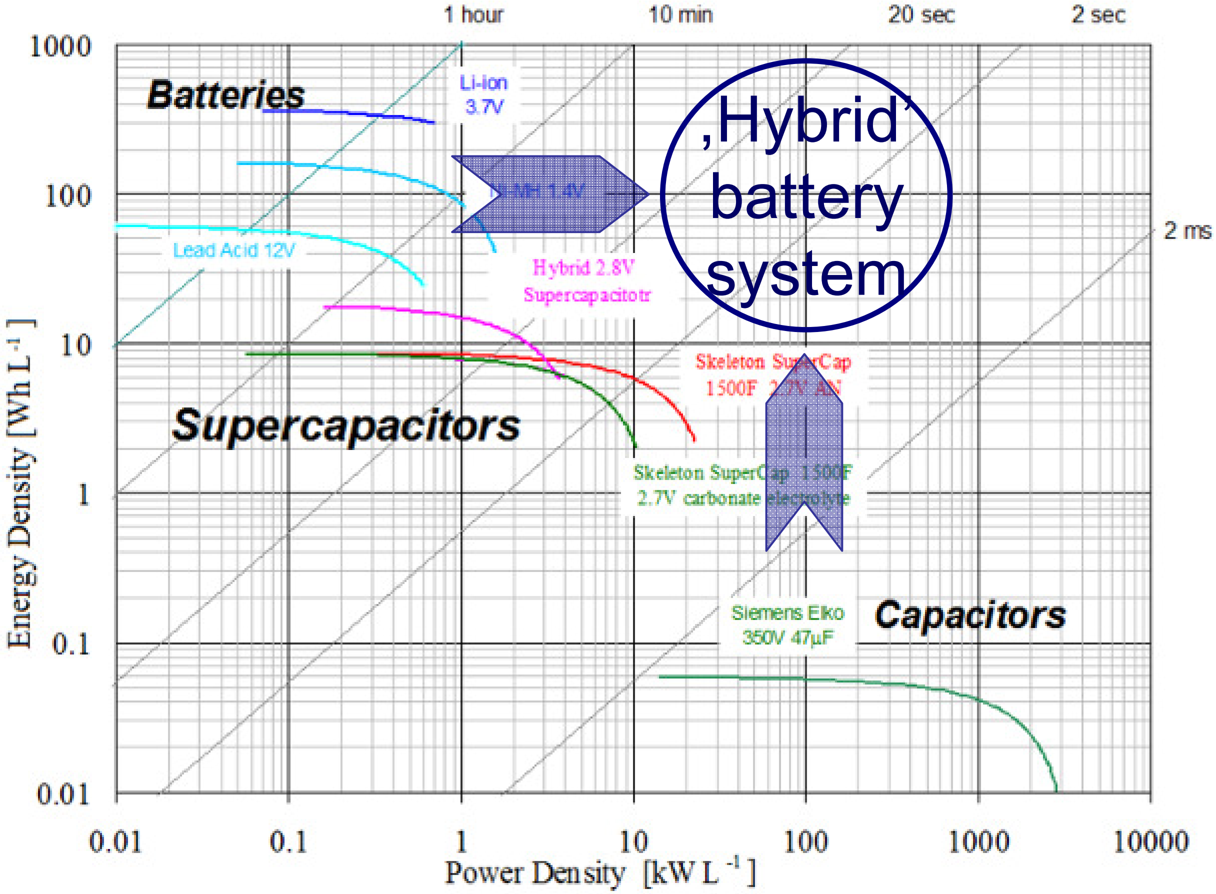


Idle noise level: ICE-vehicle: 49 dB(A)

ICE-REX: 58 dB(A)

Interior noise level impression of ICE-REX compared to existing ICE-vehicle is limiting the REX operating strategy

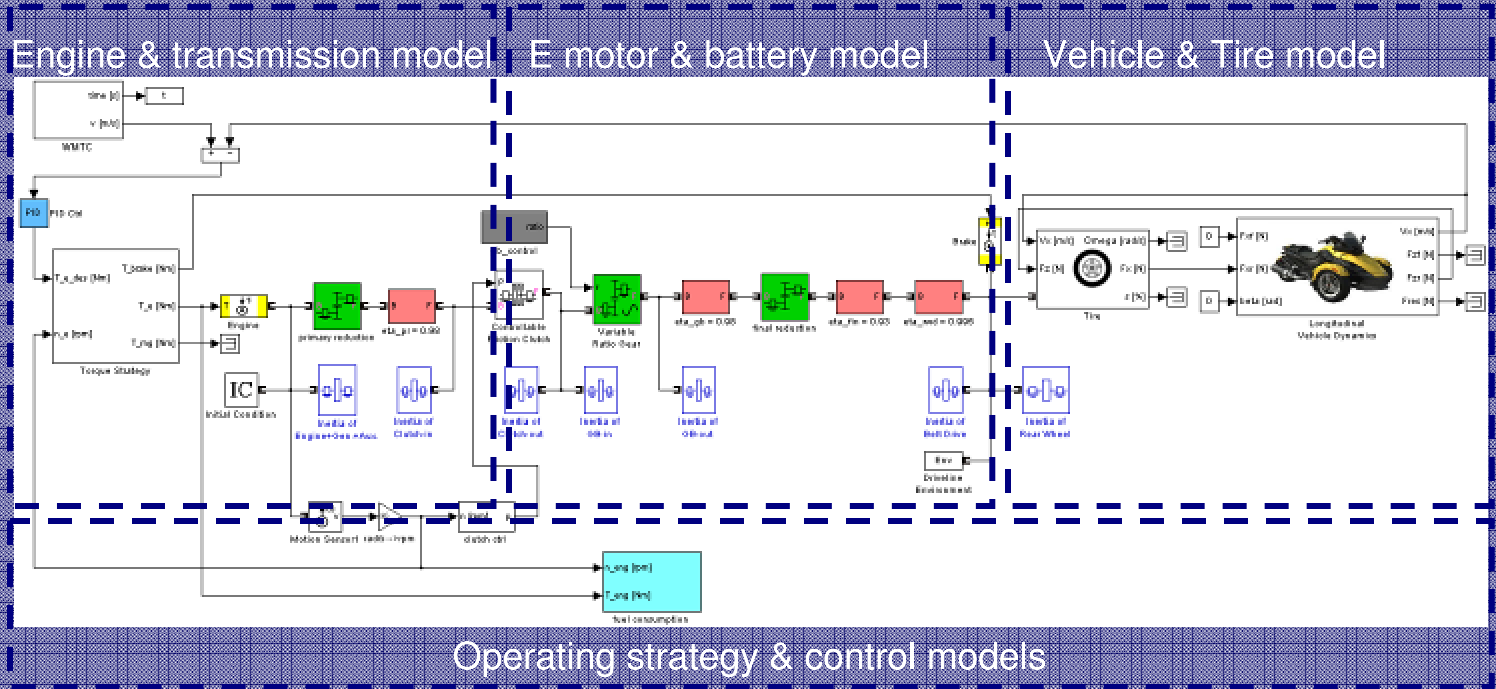
Mechatronic Powertrain
Enabler - Battery system



Existing battery concept are optimized towards energy density, for future propulsion systems we would need higher power density as well, to optimize the operating strategy and increase the over all efficiency.

Mechatronic Powertrain
Enabler - Model based simulation

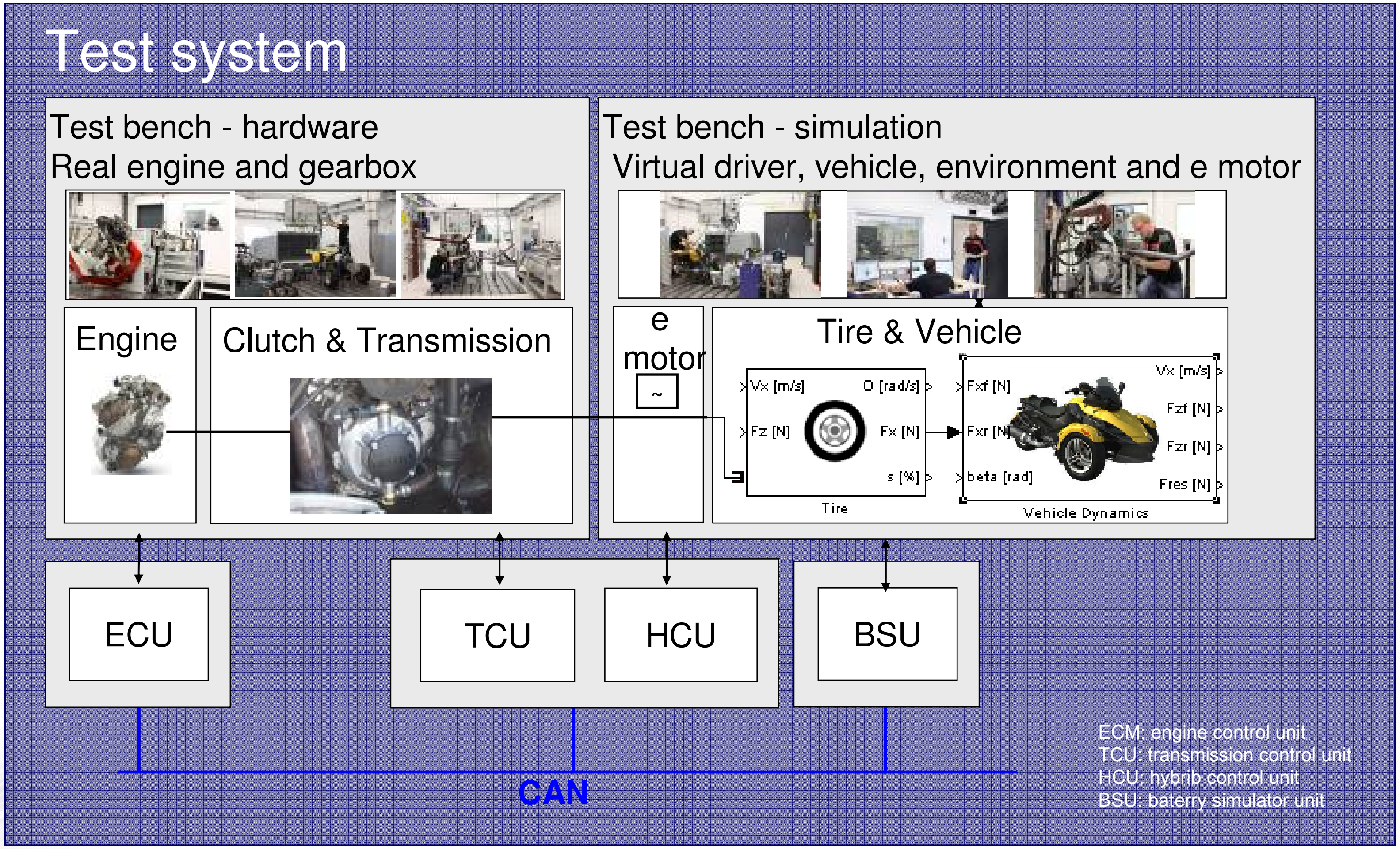
Simulation system



Model based simulation / tools are a key success factor for advanced power train function design in terms of time to market and development cost

Mechatronic Powertrain

Enabler – Model based testing



Model based testing / tools are a key success factor for advanced power train function test/validation in terms of time to market and development cost

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Summary
Key Issues

Situation

- Efficiency increase, emission reduction to „Zero emission“ and renewable energy sources will drive the development of future propulsion systems -> ICE, Hybrid and e.
- Many countries worldwide have strategies announced to substitute crude oil by alternative fuels or renewable energy sources -> energy shift.
- Mechatronic units mechanical, electric/electronic and software engineering to design advanced power train architectures and functions.

Challenges

- Many technical options are available to work on efficiency increase and emissions reduction, it will not be one solution / technology for the world -> investment justification
- The Powertrain development process has to cover a significant higher complexity by continuously increasing demands of development time and cost reduction -> time to market
- The war of talents for the future will increase significantly.

Messages

- The combustion engine will continue to dominate the mobility in the next 20 years.
- The mechatronic architecture will allow us to define solutions with the necessary flexibility for the future.
- The e mobility hype will change into a sustainable mobility orientation for the future.

Key Issues

#1: Efficiency increase	**#2: Emission reduction**	**#3: Battery Power density**	**#4: Investment justification**

OUR PRIORITY: INNOVATION

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