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Design and evaluate vehicle architectures to reach the best trade-off between performance, range and comfort.

Introduction

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Presenter

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Trends driving innovation in today's vehicle market

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Electrification & Hybridization

Local Market Requirements

Powertrain Innovation

Guaranteed Lifetime

Working in the boundaries of a stringent legal & financial environment

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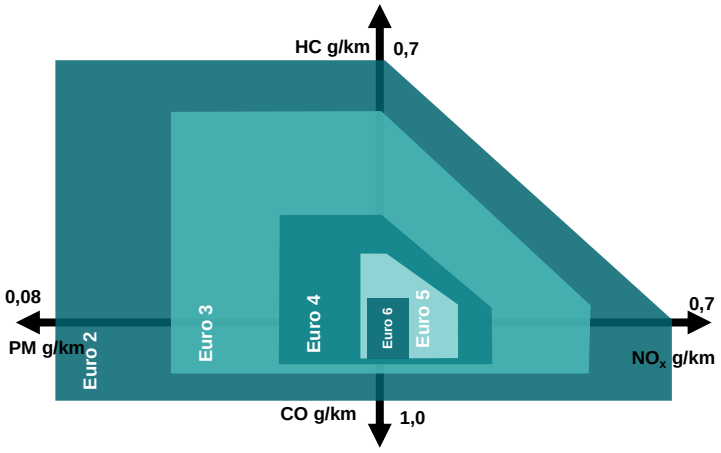
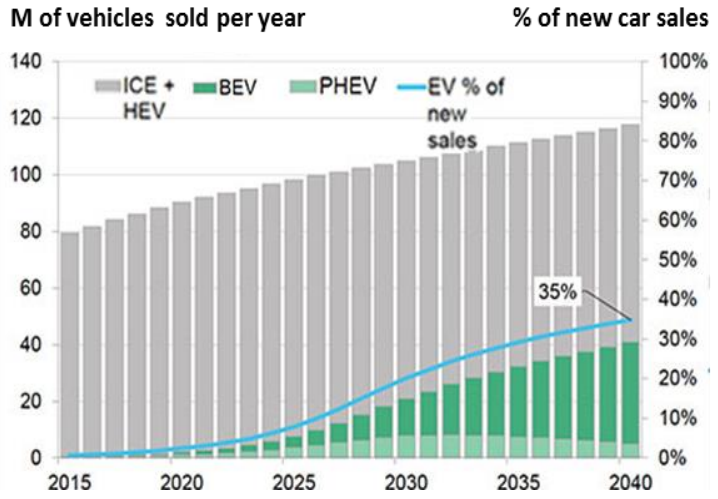
Stricter Regulations
Europe driving emissions control

Digital technology enabling reduced costs, and time to market.



Increased Complexity
Hybrids to full EV

Electric vehicles (HEVs & EVs) share could range from 10-50% of new vehicle sold in 2030.



Source: Bloomberg New Energy Finance

Reduce the development time and cost

Ford will save 4 billion $ in engineering costs over the next five years

"We will do this by increasing common parts, reducing order combinations and building fewer prototypes"

Jim Hackett October 3rd 2017

Source: LA Times

Implications for Vehicle Performance Engineering
Finding the optimal balance between powertrain performances

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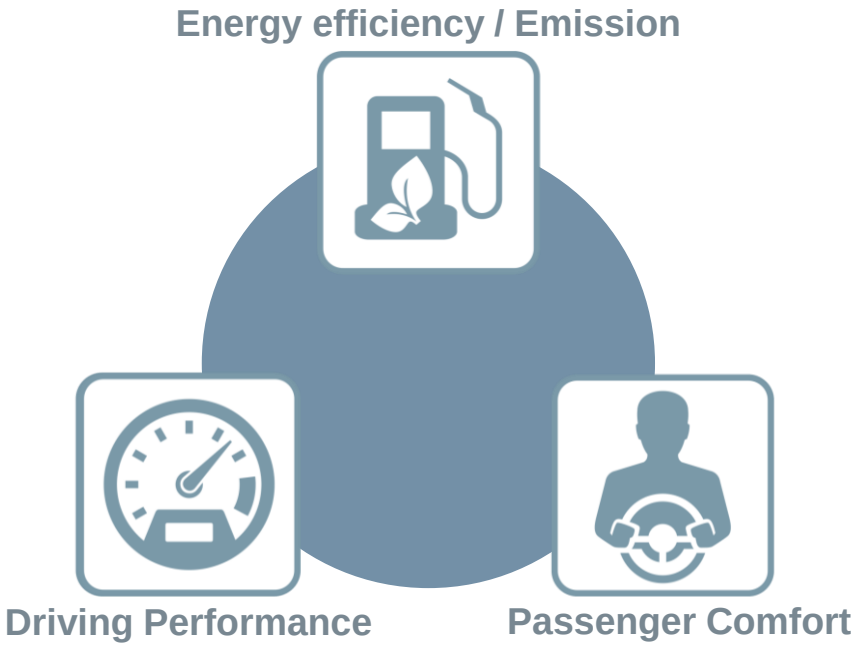
Balance attributes to reach targeted performance levels during integration



Assess the impact of technology implementation on key attributes

Powertrain electrification	Engine control	Performance VS Range	Reliability
Cylinder deactivation	Direct electric drive	NVH	Drivability
Batteries technologies /UCAPS	Emission optimization	Electrical storage & thermal management	Real driving emissions

Vehicle Energy Management system simulation as a critical answer

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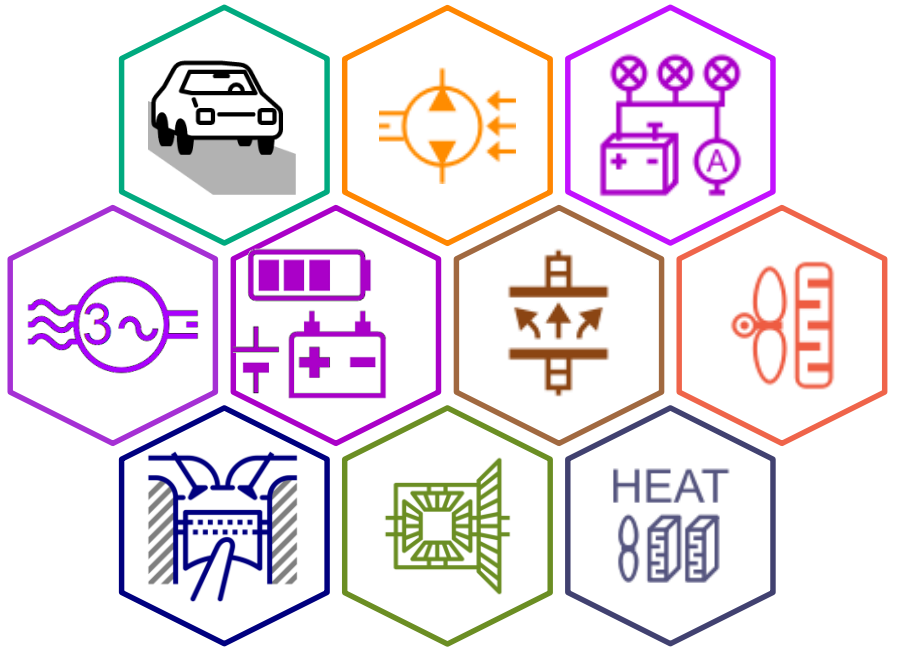
What are the simulation platform requirements allowing efficient modeling for vehicle energy management studies?

- **Model vehicle with the right level of physic** (propulsion, energy storage, cooling, HVAC, vehicle, …) **and embrace market evolution (HEV/EV) providing various modeling level for critical subsystems** (Electrical drives, Batteries, …)
- **Model up-to integration** (thermal, mechanical, …)
- **Provide application oriented libraries**
- **Integrate into one user friendly yet powerful and extensible platform**
- **Connect the models from other departments for advanced studies**

What do we offer as simulation platform to enable multi-level, multi-domain systems modeling for performance analysis?



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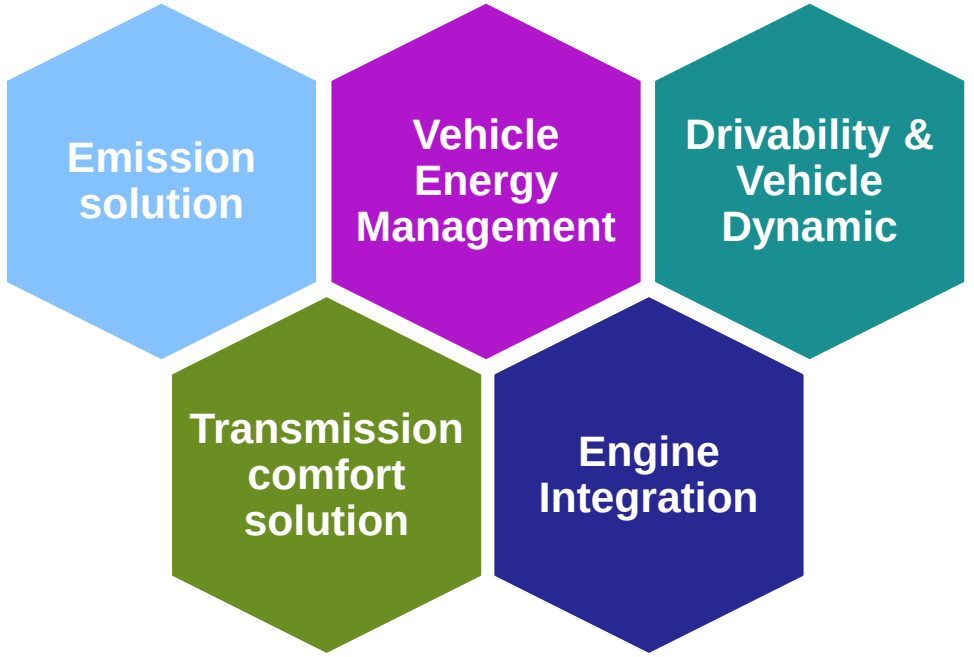

Vehicle Energy Management addressed engineering problems with Simcenter Amesim

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Figure out the best architectures and designs even at early stage relying on objective criteria

Go from compromise between 2 attributes to real multi-attribute balancing

Accelerate the design transition from certification cycles to Real Driving Emission

Identify individual energy losses contributions in a complex system

Safely migrate design workflow, from physical to virtual tests, front loading decisions

Investigate innovative energy recovery system without physical prototype

Electric vehicle powertrain predesign

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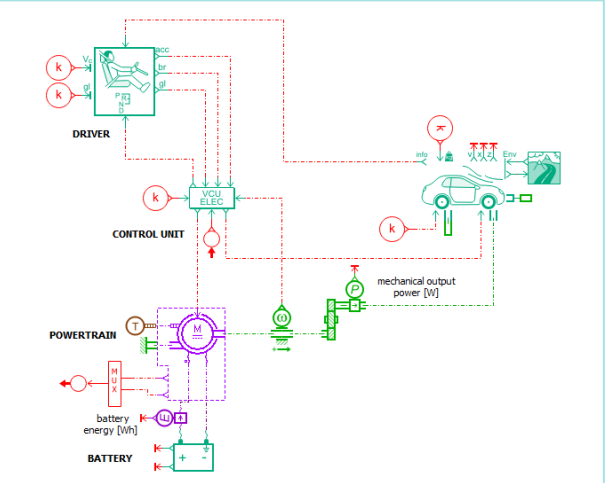
Engineering challenge: Check the powertrain capability to fulfill the vehicle performance specifications

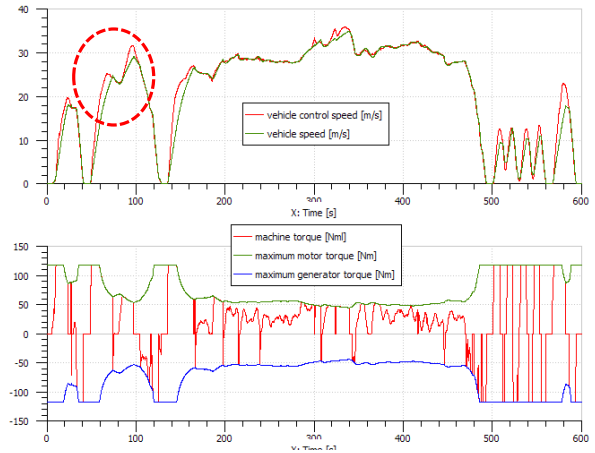
Study workflow :

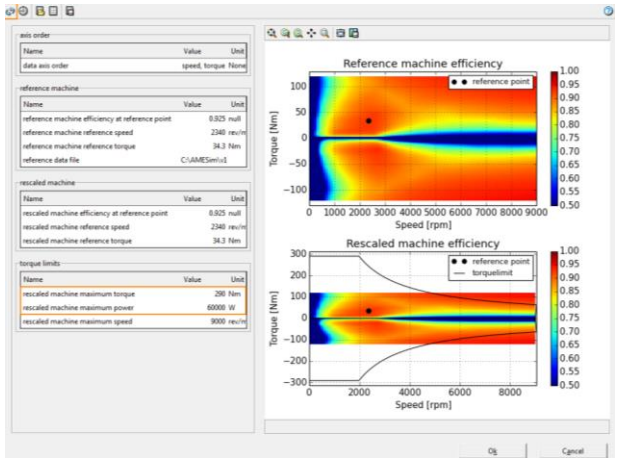
1. Electric motor is undersized
2. Optimize motor using dedicated tool
3. Check that new configuration is correctly sized

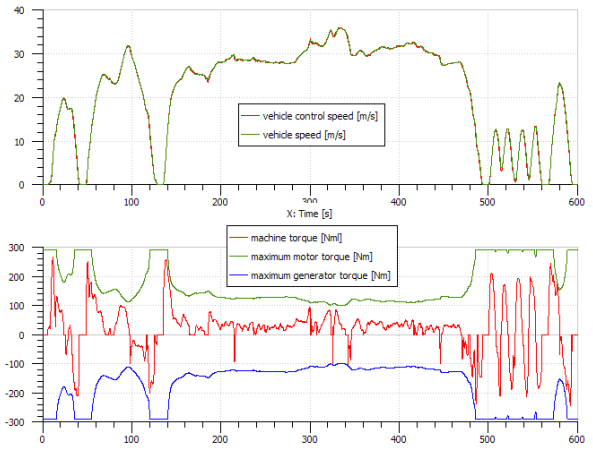
Conclusions from this study :

- Functional submodels for the whole driveline are good enough to evaluate performance
- Direct models allows to immediately detect under sizing issues
- Integrated tools for each purpose save time (electrical sizing tool, mission profile database,…)









Lets make this model more realistic to optimize energy management
Electric vehicle powertrain detail

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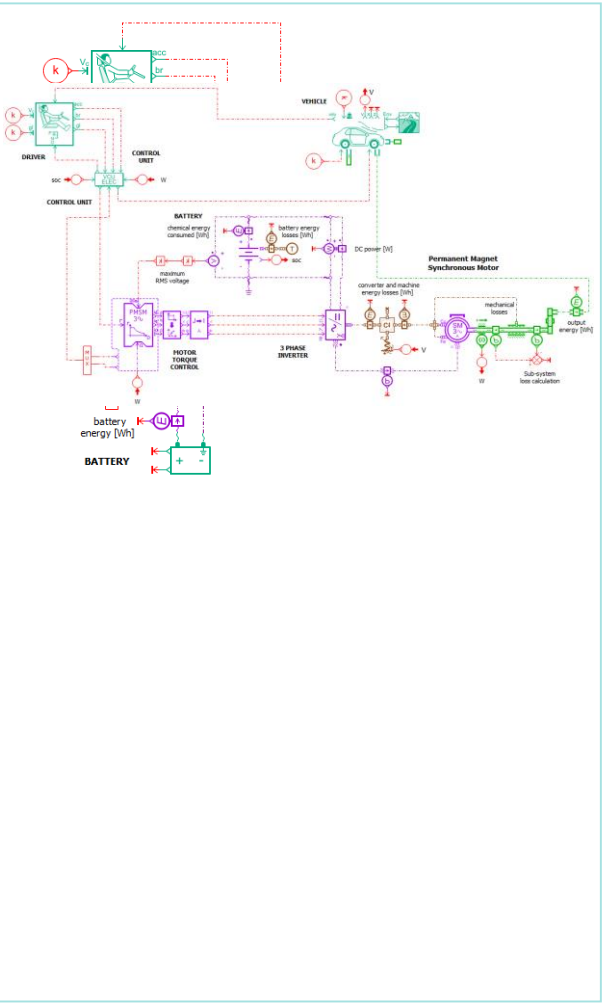
Engineering challenge: Evaluate the electric powertrain dynamic behavior and analyse the performance and consumption taking into account interactions between components

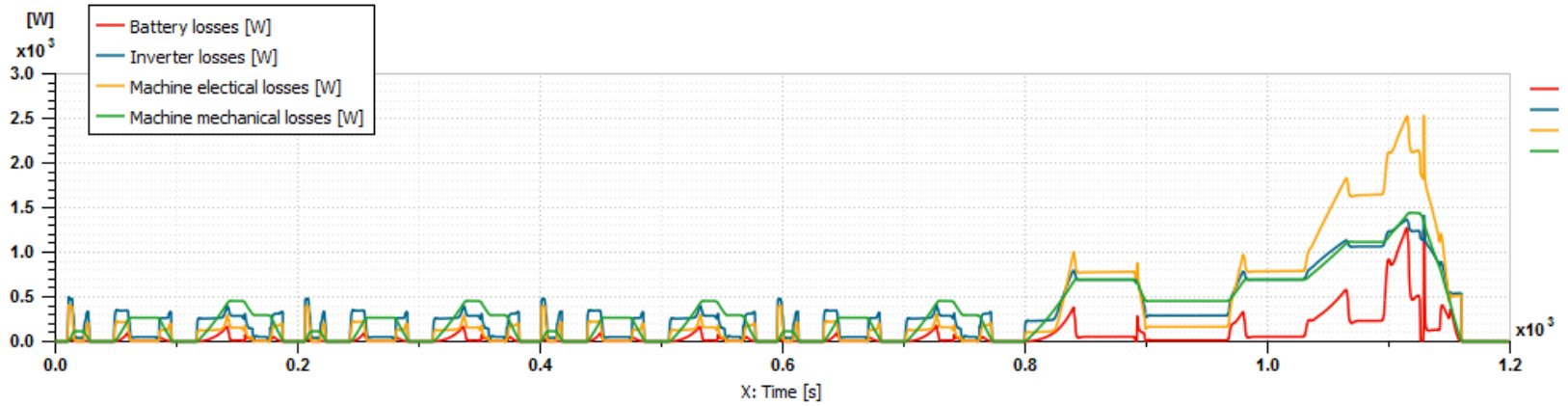
Study workflow :

1. Reuse previous model and update it with field oriented vector control of PM Synchronous machine
2. Implement brake blending strategy
3. Check energy losses on NEDC

Conclusions from this study :

- Physical models for electric machine and average inverter models are directly available for loss estimation
- Losses in all the major subsystems can be individually analyzed and compared. It can effectively drive design





Lets extend previous model to drivability: Electric vehicle powertrain comfort

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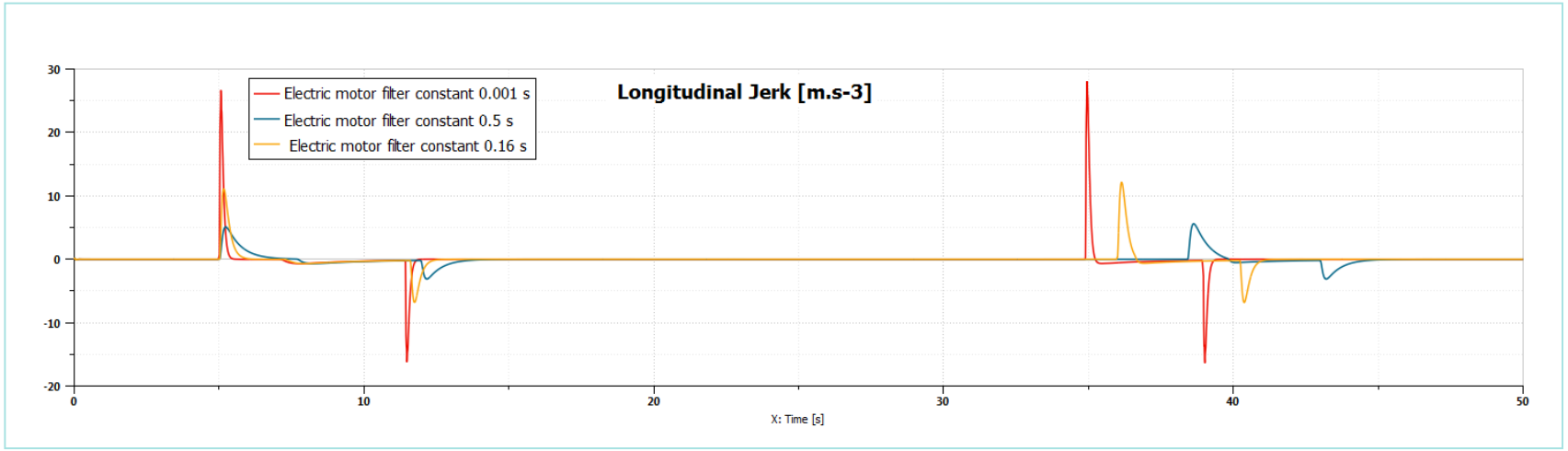
Engineering challenge: Develop an validate control strategy of the electrical machine to optimize passenger comfort

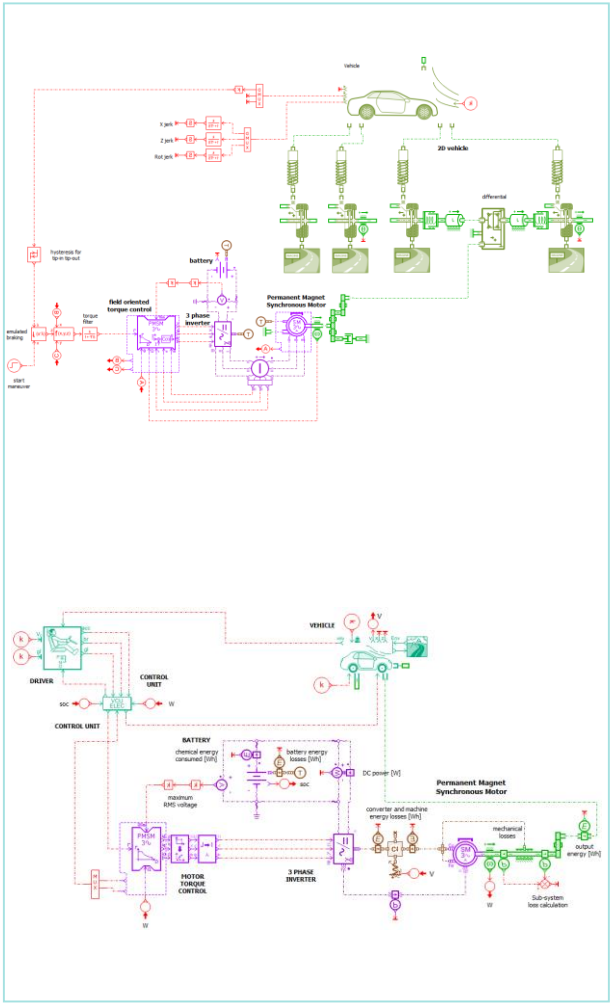
Study workflow :

1. Reuse previous model and update it with 3DOF chassis model
2. Adapt maneuvers : Tip In/Out (torque control / Jerk)

Conclusions from this study :

- One model includes detailed modeling of machine and control, detailed vehicle with suspension and tire without sacrificing performance (50x faster than real time)
- It is possible to optimize the compromise between response time and maximum jerk for the driver
- Frontloading multi-attribute studies (comfort / range / perfo) will lead to best designs





Bring simulation forward: from homologation cycle to Real Driving Emission or any other operating cycle

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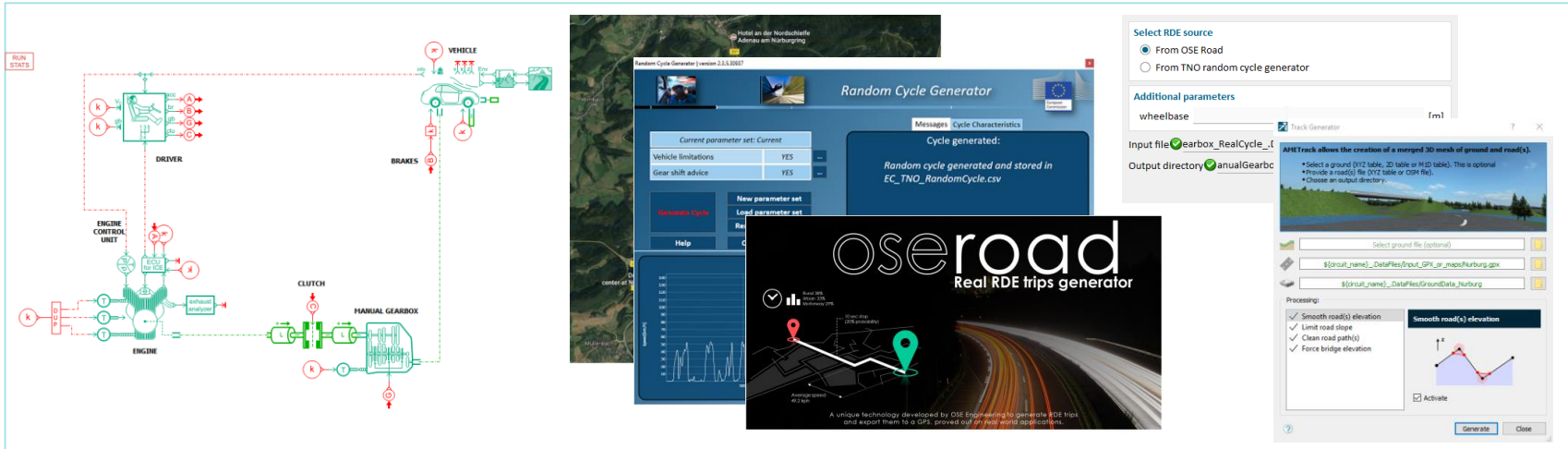
Engineering challenge: Use system simulation model over realistic driving cycles from several provider

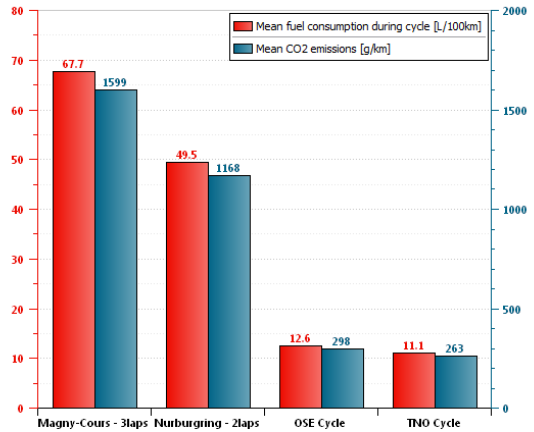
Required simulation model :

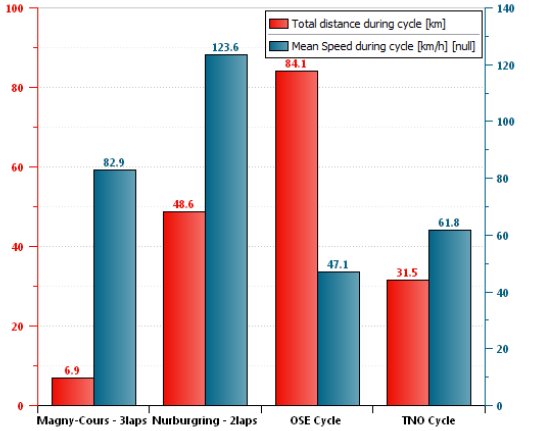
1. Let's use a classic simple but not simplistic range VS performance model for any given architecture
2. Generate driving cycles using available sources : GIS with gpx import, TNO Random cycle generator, OSE Roads generator, customer database, ….
3. Import the results in the model using the dedicated interface and optimize trajectory if relevant

Conclusions from this study :

- One single model will provide results for multiple realistic yet very different driving cycles
- Real customers and fleets emission simulations are easily accessible







Lets face the real deal

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Accurately model energy consumption in vehicle require a lot of data, for an Electrical Vehicle :

- Electric motor performance
- Battery performance
- Vehicle characteristics:
  - Aerodynamic
  - Transmission / drivetrain
  - ….

Getting all this information at an early design stage is nearly impossible. Thanks to all the available Simcenter Amesim resources, we'll be able to provide valuable results with very limited data.

Demo session: Let’s build a virtual Tesla S out of public data

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Target Setting and Benchmarking with Vehicle Energy Management

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In Vehicle Testing

Vehicle Cell

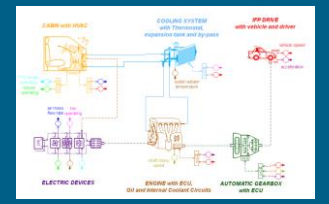
Robot driver

Dedicated instrumentation

An **integrated** process for the best of test and simulation
Create added value to your tests and robust model

Combine both simulation and test worlds for thorough analysis of system behavior and performances

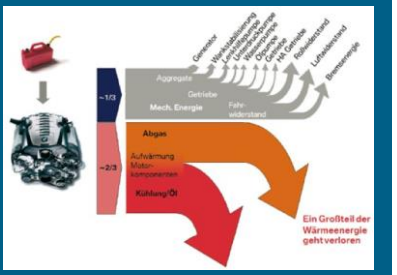
Simulation



- *Plant model*
- *Multi level*
- *Multi physic*

Analysis

- *Post processing*
- *Virtual investigation*
- *Validation by test*
- *Fuel eco optimization*



Test and system simulation synergy designed to customers targets

Addressing these challenges requires an integrated approach

We propose the tools that let you focus on your engineering problem and solve it with the available data

Thank you for attending