**1. Research programme: Assessment of future engine concepts and selection of prospective engine solutions**

**Goal:** Assessing and selecting the best concepts of combustion, charge exchange and boosting for future engines, considering alternative fuels, operation economy, CO2 emissions and pollutants using experiments and simulations. Developing the tools for optimization of previous concepts. Developing the tools for combined simulation-experiment optimization of ICEs.

**Key challenges:** Continuous calibration of simulation codes by inverse algorithms coupled to experiments. Determination of inaccessible values (unsteady temperatures, variable gas compositions, unsteady flow-rates in movable parts of machines, etc.) by iterative co-simulation aimed at the best fit of simulation results to measured ones.Time effective tools for reasonable physics-based accuracy suitable for optimization purposes. Taking the engine train mechanical losses into account during an optimization. Use of alternatives to fossil fuels incl. gases.

**2. Research programme: Selection of concepts and assessment of powertrains with energy accumulation**

**Goal:** Assessing and selecting the reasonable concepts of innovative transmissions-powertrains with power splits used for different lay-outs of accumulation and strategies for hybrid control. Developing the tools for combined simulation-experiment optimization of mechanical transmissions.

**Key challenges:** Continuous calibration of simulation codes by inverse algorithms coupled to experiments. Determination of inaccessible values (unsteady temperatures, variable gas compositions, unsteady flow-rates in movable parts of machines, etc.) by iterative co-simulation aimed at the best fit of simulation results to measured ones. Time effective tools for reasonable physics-based accuracy suitable for optimization purposes. Taking the significant influences into account during an optimization. Application of real vehicle operation modes. Automation of control/shifting.

**3. Research programme: Electric powertrains with energy accumulation**

**Goal:** Assessing and selection of suitable concepts for distributed power sources (ICEs, FCs, accumulators/capacitors) including electric power splitters. Optimizing the systems aiming at expected reduction of road fuel consumption at least by 5% for small cars. Developing the tools for combined simulation-experiment optimization of electric and hybrid drives.

**Key challenges:** Continuous calibration of simulation codes by inverse algorithms coupled to experiments. Determination of inaccessible values (unsteady temperatures, variable gas compositions, unsteady flow-rates in movable parts of machines, etc.) by iterative co-simulation aimed at the best fit of simulation results to measured ones. e-mobility has become a political keyword but its implementation calls for thoroughful analysis of pros and cons due to huge investment costs at electricity providers and car manufacturers, especially considering the form of accumulator service.

**4. Research programme: New tools of mechatronics and vehicle electronics for future automobiles**

Goal: Assessing and selecting the concept of predictive and adaptive control engine-drivetrain or powertrain-vehicle, applying non-linear system approach and model-based control. Creating virtual engine/vehicle model and testing control unit by means of Hardware-in-the-Loop (HiL) technology. Transfer to real engine specimen. Involving X-by-Wire and electric equipment diagnostics into vehicle networks. Developing the tools for optimization of microelectronic systems usable for vehicles. Developing the RT systems based on the results of experimental-simulation optimization of controlled objects.

**Key challenges:** Continuous calibration of simulation codes by inverse algorithms coupled to experiments. Determination of inaccessible values (unsteady temperatures, variable gas compositions, unsteady flow-rates in movable parts of machines, etc.) by iterative co-simulation aimed at the best fit of simulation results to measured ones. Predictive and adaptive control of an engine/powertrain based on non-linear system hierarchy and interaction with transport infrastructure. Vehicle control and power networks/buses, X-by-Wire systems, predictive diagnostics of vehicle electric systems.