Event: IMeche ICE Gaydon

**Title: MAHLE Modular Hybrid Powertrain**

Authors: Dr. Mike Bassett, Adrian Cooper, Ian Reynolds, Simon Reader, Dr. Martin Berger

## Abstract

Vehicle manufacturers are facing increasing pressure by legislation and economics to reduce vehicle emissions and deliver improved fuel economy. By 2025 significant reductions in carbon dioxide ($CO_2$) emissions will need to be achieved to meet these requirements whilst at the same time satisfying the more stringent forthcoming Euro7 emissions regulations. This focus on techniques to reduce the tailpipe $CO_2$ is increasing the interest in hybrid and electric vehicle technologies. Pure electric vehicles require bulky and expensive battery packs, with a high embedded $CO_2$ content, to enable an acceptable driving range. Range Extended Electric Vehicles (REEVs) partly overcome the limitations of current battery technology by having a range extender (REx) unit that allows a reduction of the traction battery storage capacity, whilst still maintaining an acceptable vehicle driving range.

The present study draws on the experience gained through the development of the downsizing and REx demonstrator engines and examines the powertrain requirements to meet the needs of passenger cars in the 2030 timeframe, and beyond. Legislative drivers are examined and the ability of current internal combustion engines to meet these requirements is examined for a range of vehicle sizes. The technology steps needed to meet anticipated future legislative targets are discussed. Beyond 2025, plug-in hybridisation will be a key technology enabler to achieving fleet $CO_2$ targets.

Once the vehicle has significant electric drive capability, it is possible to remove any dynamic loading from the engine, and allow it to operate in a much more steady-load manner, approaching the operation seen for range extender units, where the target is maintain battery SOC once the battery has become depleted. The most critical parameter to consider when sizing such a dedicated hybrid engine is the steady state

cruising conditions (both on a level road and whilst hill-climbing) considered for charge sustaining operation.

The paper will present results of initial testing undertaken to validate the pre-chamber combustion concept proposed for the dedicated hybrid engine. The combination of the pre-chamber based combustion layout, together with high geometric compression ratio, externally cooled exhaust gas recirculation (EGR) and aggressive Miller-cycle operation enable extremely low brake specific fuel consumption (BSFC) levels to be achieved. Finally, Drive-cycle analysis, based on the engine test results, will also be used to show the efficiency of the entire system.  Finally, the paper will present the scalability of the concept across a range of vehicle classes and performance levels.