3.1 Publishable summary

Project context and objectives

Background

FEVs introduce a radical shift in technology, providing new means for energy storage, drive trains with X-by-wire solutions, and advanced embedded control systems. Moving from conventional vehicles to FEV means that appropriate engineering support is needed for the development of concepts for vehicles and support infrastructures. The development of dependable, high performance and affordable FEV challenges the current state-of-the-art in engineering methodologies and poses new requirements for the modelling and analysis techniques that must support the engineering of such systems.

Dependability is an important quality challenge because the vehicle control systems of FEV will have more authority, be more integrated and rely less on mechanical backup. Given the present limitations in the capacity of batteries, and their high cost, FEV will incorporate complex new algorithms for optimizing energy consumption. The correct operation of these algorithms will be critical for safety. FEV will be built on networks of embedded controllers that integrate sensors, actuators and power sources, and by exploiting this capability, they will be able to deliver advanced safety functions. Although this gives the potential to improve the overall system safety, increased reliance on distributed electronic systems - and the increased authority of such systems - also introduces new hazards caused, for example, by classes of failure modes that did not arise in conventional electromechanical designs. Such failure modes include commission failures like inadvertent and incorrect application of braking, steering and propulsion forces. Failure modes may also clearly compromise energy performance. In addition, the distribution of functions across networks of embedded components raises the possibility of common cause failures or that of unpredicted dependent failures of critical functions that could be caused by malfunctions of non-critical functions.

Performance is the second quality challenge for FEV designers, the uptake of which will depend on their success in matching the performance of conventional vehicles in parameters such as the range of travel and lifetime performance of the powertrain system. Batteries have relatively low density of energy and at present only allow a short range of travel. High performance optimization algorithms that reduce energy consumption are therefore important for improved range of travel. The integration and interplay between major subsystems, such as energy storage, electric and hybrid drive trains, and embedded control systems, are of paramount importance for energy performance and optimal designs must balance multiple aspects/factors (including energy and weight). This requires adequate representations of alternative systems designs as a basis for system-level performance evaluation and optimization. There is also a close connection to the safety challenge here: supporting behavioural analysis through model-based testing and fault injection will for example be required for critical FEV functions according to the emerging automotive safety standard, ISO 26262.

Cost constitutes a third challenge for FEV designers. Battery packs, wiring harnesses and general electrical components are costly. Electrical energy is expensive and its consumption must therefore be optimized. Power level also affects component costs and in particular the life cycle cost of batteries can be reduced by adequate energy management and minimized battery wear. Bringing the overall manufacturing and operational costs of the vehicle down to levels comparable with those of conventional vehicles is a substantial design challenge.

In summary, FEV systems introduce new algorithms, new components and new architectures. With such a high degree of novel technologies, there is both the opportunity to do things right, but also the risk involved in the development and use of non-proven technologies. The complexity and criticality of such systems will be high and therefore rigorous engineering support for addressing the dependability, performance and cost challenges of such systems is required.

Work performed since the beginning of the project and the main results achieved so far

The project is organized in one administrative and six technical work packages. The activities and results for the first year can be summarized as follows.

- WP1Project Management
  WP1 has been responsible for the Project coordination and various management tasks
- WP2 Needs and Methodology
  In WP2, project requirements have been collected and organized in a requirements model. Requirements were refined and related to each other, and allocated to work packages.
  WP2 has also defined an EAST-ADL methodology, taking into account multiple aspects including safety, FEV and timing, and organized it according to phases for each EAST-ADL abstraction level. The Generic Methodology Pattern from TIMMO-2-SE has been applied.
- WP3 Modelling, Analysis and Synthesis Concepts
  WP3 has addressed representation and analysis concepts in three areas relevant for FEV, safety, performance and optimization. EAST-ADL Modelling concepts are proposed for each area, along with analysis and optimization algorithms.
- WP4 Language Definition
  WP4 has worked on EAST-ADL language and has released new versions of the metamodel of which V2.1.12 has been accepted as the official EAST-ADL version by EAST-ADL association. Further, profile definition and XML schema definition have been provided.
- WP5 Tooling
  The MAENAD modelling and analysis workbenches have been released in several iterations. Adaptations of two domain-specific tools for EAST-ADL have been provided, and their cooperation capabilities demonstrated. The EATOP EAST-ADL tool platform was initiated and significant contributions to the platform provided.
- WP6 Case Studies and Assessment
  Three validators have been specified: Propulsion, Regenerative braking and Range and Mode control. Models are made and validation of EAST-ADL modelling and analysis concepts have been performed.
- WP7 Dissemination and Exploitation
  Various dissemination activities have been completed including academic publications, project presentations and external collaborations. The EAST-ADL association was formed as a result of an initiative by MAENAD partners in collaboration with others. The mapping to the OMG MARTE UML2 profile is maintained.

The consortium activities can also be described along the four main project objectives.

- (O1) Develop capabilities for modelling and analysis support, following ISO 26262
  Support for automatic ASIL allocation has been prototyped and the elements of a methodology based on EAST-ADL has been described.
- (O2) Develop capabilities for prediction of dependability & performance
  Concepts for annotating EAST-ADL models for analysis have been refined and introduced. Concepts for analysis methods have been introduced for EAST-ADL specific and external notations. Tool prototypes for analysis have been introduced and validated.
- (O3) Develop capabilities for design optimization
  A framework for optimization based on EAST-ADL variability resolution concepts, constraints and product line representation has been designed, prototyped and validated.
- (O4) Verify, validate and explain the above capabilities in practical FEV design
  Three example applications have been defined, modelled and analysed using MAENAD technology.

The expected final results and their potential impact and use

Introducing a refined, formalized description language, tailored to automotive needs, can play an important role in successful systems innovation and deployment. The evolution of EAST-ADL resulting from this project is such a description language.
This technology is particularly applicable when development is more revolutionary than incremental, as this requires efficient organization and analysis of novel solutions. Electrical vehicle development has precisely these conditions.

At present, industrial organizations do not use the full potential of model-based development because of the lack of a standard. As a consequence, much of the communication among stake-holders is informal and based on Word and Excel documents. This leads to longer development cycles and mistakes because of the lack of formality and common terminology as well as the difficulty in carrying out systematic analysis and synthesis.
The availability of an enhanced and standardized ADL and a refined methodology for using it will facilitate communication, analysis and synthesis of automotive embedded systems. The refined ADL will act as an ontology for automotive systems, thus promoting the transition in the transport sector from an informal and ad-hoc approach to a more mature engineering approach using model-based engineering. Such a transition, using a standardized framework, will:

- Substantially increase the overall efficiency of the European automotive industry, allowing the faster development of new ideas and concepts while reducing design and maintenance costs.
- Lead to improved product dependability and quality.
- Provide opportunities to new and existing tool vendors.
- Strengthen European research on model-based development with respect to the USA.
- Promote employment; advanced automotive technology is instrumental for keeping influence and know-how in Europe.

- Enhance competition, since common models/information handling and stringent specifications will make it easier to change suppliers and avoid unhealthy dependencies between suppliers and OEMs.

An appropriate modelling approach will make it possible to represent the FEV system architectures and standards adequately. This is a prerequisite for stakeholders to understand and agree on specifications of the architecture and applied standards. The correct management of needs and requirements through models of the FEV system technology will ensure that a sound technology is developed.
Due to the holistic approach taken in the project, the result will integrate many existing solution elements. Different phases (traceability), multidisciplinarity (interacting specialists) and multiple product variants (compatibility/configuration) are considered as these aspects are central in automotive system development.
World leadership in a complex and innovative technology can only be achieved with state-of-the-art processes. To contribute here, the project identifies methodology to develop systems and architectures in a systematic and efficient manner.

The address of the project public website:

http://www.maenad.eu