EDONA: an Open Integration Platform for Automotive Systems Development Tools

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Abstract: Launched in autumn 2007, EDONA is a French collaborative effort of automotive manufacturers and suppliers, research laboratories and software vendors. It was built in order to guarantee seamless inter-operation of existing commercial tools and advanced academic technologies necessary to develop automotive software-based systems.
This project aims at developing open development environments supporting the full set of future AUTOSAR™ specifications, as well as the forthcoming ISO 26262 standard for safety of electronics components for the automotive industry.
The article describes the environment frameworks based on a tool repository and a set of interfaces backed by the Eclipse environment, and how tooled solutions will be built for dependability and hard real time support across the whole V-cycle, namely in the following areas:

- System specification and requirement traceability
- Functional and temporal validation
- Safe design of real-time and deterministic solutions
- Integration of MMI component under safety constraints

It concludes on discussing the orientation of the exploitation strategy considered for the project results.

Keywords: Automotive open tool platform, component development, design for safety, model based validation

1. Introduction

A vital goal for automakers and parts manufacturers is to control the quality of embedded systems. Indeed, surviving in global markets, but also increasing market share requires the implementation of differentiating innovations. This leads to significantly increase the complexity and interactions of the developed features. Since most of them are based on the implementation of electronic and software technologies, the volume and complexity of this software is undergoing a very significant growth.
The quality risk there is either to prevent the maturation of innovations involved (thus no tenders on the market -not increased turnover 'affairs), or to generate perceptible non-quality of the products (thus to generate a poor image - decline in sales).

The growth of technological and economic weight of the automotive electronics as well as its increasing complexity requires, in order to guarantee the cost, quality and timeliness of implementation, a comprehensive approach: from product feature specification to electronics and software design and validation. The challenge for the automotive industry is to control these electronic-board computer architectures, in order to:

- ✓ offer a dependability at level of the state of the art (with dependability objectives allocation and evidence demonstration in accordance with ISO 26262 standard recommendations);
- ✓ have the flexibility to provide different configurations (the diversity of features depending on the variety of target markets);
- ✓ have an ability to dissociate electronics and software developments and integrate them into multi-stakeholders (manufacturers, suppliers) processes.

According to these objectives, the automotive industry has launched two important standardisation actions:

- ✓ AUTOSAR™, a standard defining platform architectures, and formats to design, integrate execute and operate software components;
- ✓ ISO 26262, a standard providing automotive risk classes and recommendations regarding all lifecycle activities for safety-related systems comprised of electrical, electronic, and software elements.

The challenge is now to provide efficient processes to each actor of the development of automotive embedded software components according to those standards. Moreover, the wide variety of applications and stakeholders involved in the process cycle leads to integrate a large variety of practices and tools within the constraints and orientations of these standards.
To deal with the consequent tool interoperation complexity, the Num@tec Automotive [1] consortium has set up the EDONA platform project in order to provide an open framework from which dedicated development environments can be instantiated or derived for the needs of each development context.
Next section will discuss some key elements of the automotive standard context. The project approach and framework platform are then presented, followed by four short focuses on complementary development processes:

- ✓ Component architecture modeling process
- ✓ Safety critical component design
- ✓ Matlab®/Simulink® model based validation
- ✓ Man Machine Interface design

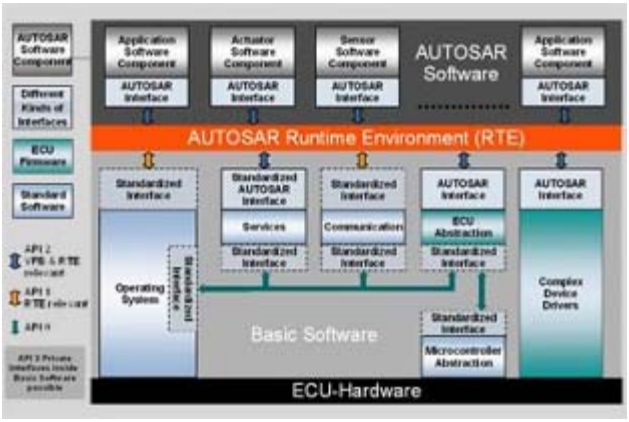
Finally, to conclude, the paper will discuss the perspectives of exploitation of the various projects technologies.

2. Two standards for automotive software

The AUTOSAR™ and the ISO 26262 standards are two very complementary and structuring standards for the development of automotive embedded software components.

2.1. AUTOSAR™ a "business oriented" standard for software component implementation

The AUTOSAR™ consortium has been created to define a standardized way to support component based development of software systems. It focuses on component integration on Electronic Computing Units (ECU), on inter-ECU communications and component reuse or exchangeability. For that purpose, it defines clear interfaces and communications means among components upon a layered execution infrastructure.

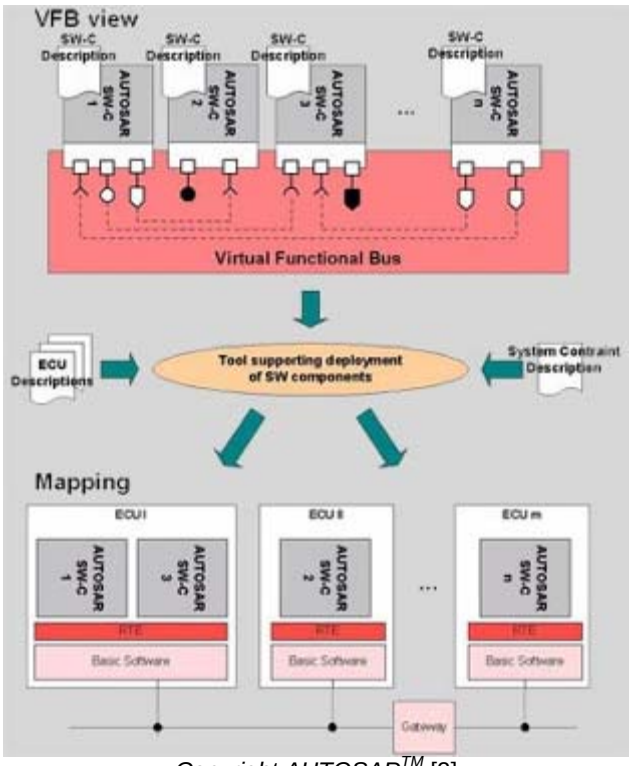


Copyright AUTOSARTM [2]

In the development process, AUTOSAR™ starts at the deployment stage. This means that it specifies how to describe component interfaces, and which underlying architecture will support communication and execution of the components. This gives strong specifications on the last stage tools in the development chain such as the operating system, the communication network or the deployment and configuration tools.

However the rest of the development tools remain totally open. Actually, the AUTOSAR™ consortium sets only broad lines of action and outlines technology that will have to be controlled by 2010. Because the deployment of AUTOSAR™ systems (2009, 2015) will gradually give the opportunity to independently develop the hardware and the software, it is mandatory to ensure that it can be supported by the different partners in the chain of specification, design, test and validation with numerous interactions and technical exchanges. For that, the productivity control of the whole chain of development is a major issue to support the competitiveness of all the players in the field. There is a need, in particular to:

- ✓ trace, smoothen and optimize the entire development process;
- ✓ provide flexibility with respect to the wide variety of configurations;
- ✓ have a structure adapted to the different players in the field (manufacturers, equipment suppliers of tier one, two, etc.);
- ✓ ensure validation and dependability of the equipment at the required level.



Copyright AUTOSAR™ [2]

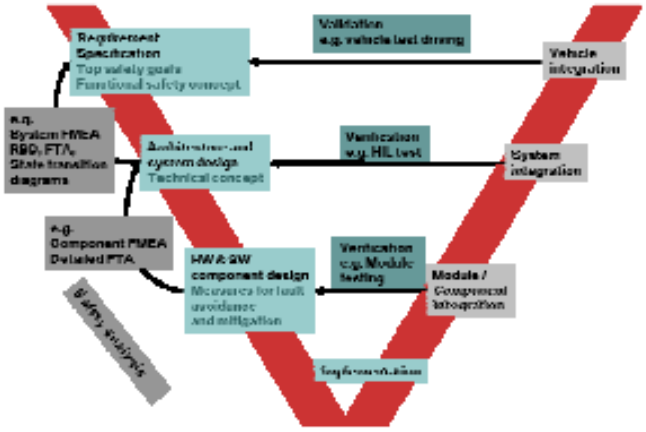
Today the process of developing on-board computers is based on different tools for modeling, production, validation and implementation of functions, software and hardware. These tools and technologies are for the most optimized for automotive and based on heterogeneous formalisms that, moreover, are variable in terms of activities and steps in the process. In the vast majority, the poor interoperability between these tools does not allow users to obtain an integrated development chain ensuring continuity, from the expression of the requirements down to the validation of a system integrating various components.

Some internal projects in the transportation domain, however, show that the establishment of a host platform allowing the building of integrated

development environments that meet the needs of the various players is a major factor in the control and improvement of productivity, but also the quality and safety of these products.
Setting up such a platform for the automotive domain according to AUTOSAR™ orientation is one of the two main objectives of EDONA. The second one is a stronger integration of safety concerns in the development process.

2.2. The "26262", an ISO standard on lifecycle management for safety-related electronic systems

ISO 26262 is an adaptation of the IEC61508 for the automotive industry. It has been motivated by lessons learnt from voluntary application of IEC 61508 in the automotive industry. They underlined that it is not really adapted to real-time embedded systems, nor to automotive development and life cycles. It does not either take into consideration requirements for manufacturer / supplier relationship or 'consumer-goods' orientation of automotive products.
It applies to safety related electrical, electronics and software (E/E) systems installed in road vehicles. It addresses hazards caused by safety related E/E systems due to malfunctions, excluding nominal performances of active and passive safety systems.
One main evolution provided by ISO26262 is the adoption of a customer risk-based approach for the determination of the risks at the vehicle level. This has lead to provide automotive-specific analysis methods to identify the safety integrity level (ASIL) associated with each undesired effects. These ASIL are used for assigning qualitative and quantitative targets to functions to be implemented by E/E automotive systems.
The standard provides ASIL-dependent requirements for the whole lifecycle of E/E system (incl. H/w and S/w components).



Impact of safety analysis on the development cycle - (figure from [3])

As an ISO standard, the 26262 does not specify formally whether to use given development or validation tools of formalisms. However, the recommendations made for the development of the safety-related systems emphasize the interest to use model based testing techniques and advantages of using generation, configuration and calibration tools to produce the code. Moreover, as for all safety critical systems, it is clear that compliance to this standard requires a tight control of the requirement traceability along the whole development process and will benefit from using deterministic computation models for the highest critical functions and components.
Integration of tools and technologies supporting these formalisms thus becomes the second main objective of EDONA.

3. EDONA approach

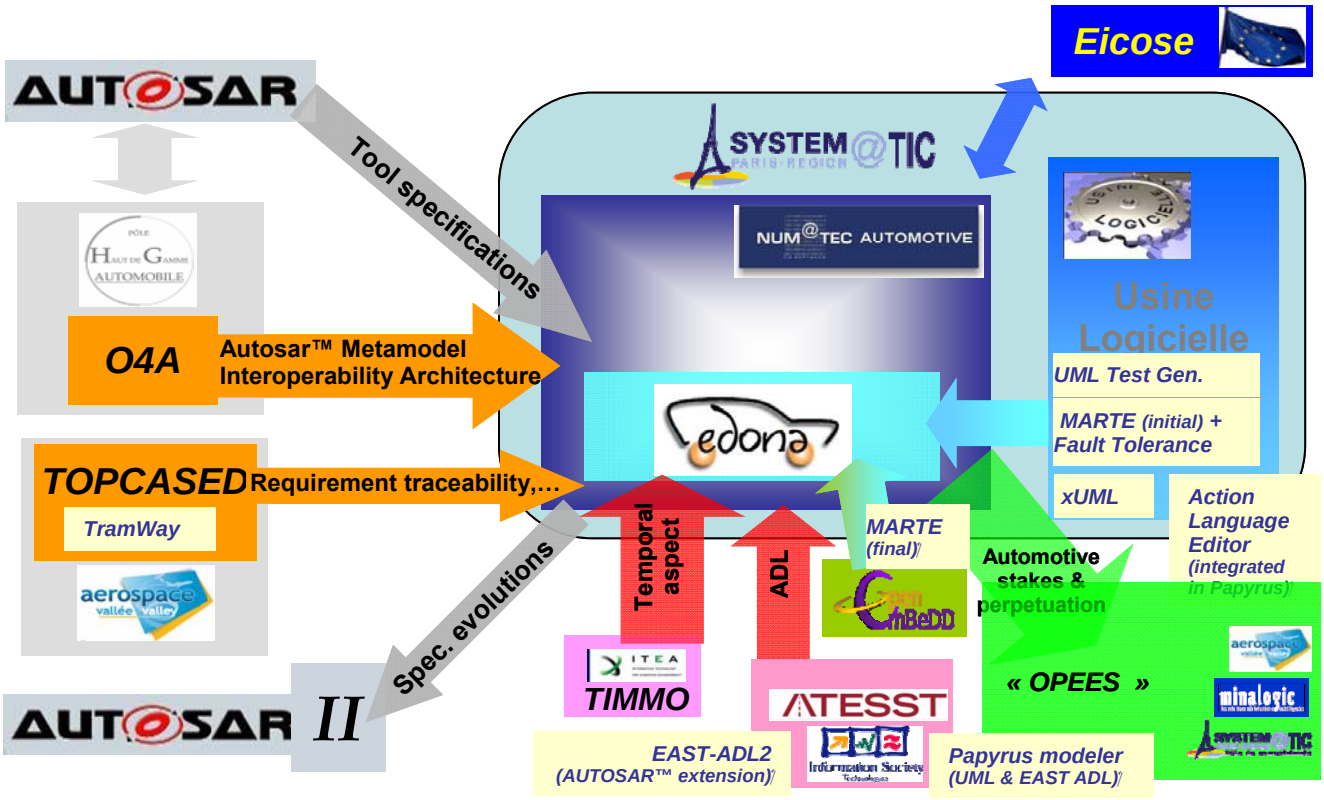
Obtaining integrated development chains open to several leading companies grouped together in a common approach requires to be based on:

- ✓ a standardization (de facto, commercial or normative) of the interfaces and formalisms,
- ✓ interfacing upon these standards the commercial and internal tools, and
- ✓ developing complementary component tools to meet specific needs.

It must be accompanied by substantial work on the data structures and their organizations to enable the construction of libraries of reusable components and applications and to facilitate exchanges between groups working on similar projects.
The platform should enable the construction of tool chains with easy adaptation and customization through parameters or proprietary extension creation for companies seeking to automate certain types of development (e.g.: engine computers). It must be constructed in the form of tool components, at a fine level of granularity. It must ensure sustainability through the simple ability to change or through the replacement of application modules when technological changes or changes in methodology occur, without jeopardizing previous investments in the applications.
EDONA proposes to make possible the implementation of such tool chains through the construction of an open platform for the realization of business dedicated and modular development chains, covering the entire system development cycle and adaptable to the different needs of the actors and business of the automotive industry.
In parallel, several projects are underway that will provide bricks for such tools chains either focused on AUTOSAR™ component based development or on integrating the ISO 26262 in development cycle. EDONA approach is to federate, integrate and capitalize all these elementary results in order to combine them into efficient and business dedicated tool chains.

As illustrated by the following figure, it will intensively reuse results from projects implemented in Num@tec Automotive under the System@tic competitive cluster either for automotive specific technologies (such as: MeMVaTEx, Scarlet, HeCoSim, SysPEO, D2OS [1], [4], [5]), or providing generic technologies partly applicable to the automotive domain (e.g.: Usine Logicielle [6]). It will also benefit from results of projects developed in other competitive clusters (such as O4A from "Automobile Haut de Gamme" cluster [7] or TOPCASED from Aerospace Valley cluster [8]) or in other collaboration frameworks (such as the OpenEmbeDD platform of RNTL French program, the ATESST IST European project or the TIMMO ITEA European project).

The EDONA project is located downstream from these various projects, and includes the goal of integrating for the AUTOSAR™ computers the different outcomes of these projects.



EDONA relation with existing projects and initiatives

Approach

The form chosen for the implementation of EDONA is the creation of a reference technology platform and its specialization based on clear specific needs of particular business sectors.

Each specialized platform will be built on the three following elements:

- ✓ an expression of needs and functional definitions driven by an industrial partner particularly interested in the technology, and carried out jointly by different laboratories and industrial partners;
- ✓ a coherent integration supporting and improving existing work processes. Integration is performed from the generic platform extended by different tool modules provided by the laboratories and SMEs (depending on technology maturity regarding the objectives and standard compliance, these tool modules will be available at the launch of the project, or result from the projects mentioned above, or will be extended / enhanced during the EDONA project itself);
- ✓ a full-scale experiment conducted by at least one industrial for each specific platform.

The project will be conducted to enable iterative integration and tool chain delivery during its whole duration (3 years).

To be compliant to AUTOSAR™ standard, each integrated tool will be associated with its adaptation to the exploitation of AUTOSAR™ architecture and data format. In addition, to allow compliance with ISO 26262 recommendations, a specific focus has been made in order to support model based validation and testing and automatic code generation.

Major technical challenges

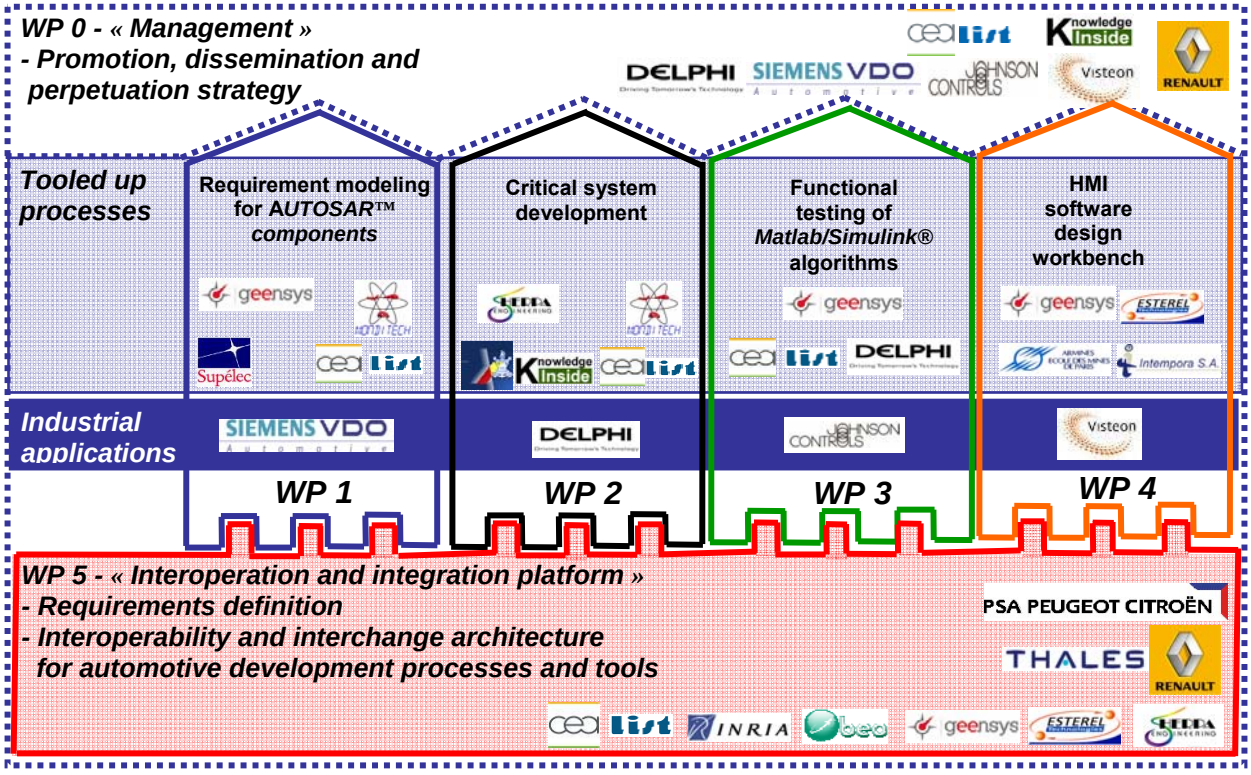
The EDONA project is a project for integration of technology platforms based on the studies, projects and technologies that are already completed or underway. We can consider that the majority of technical challenges for the realization of these platforms have been achieved or will be achieved in the context of the various "source" projects on which EDONA is based.

Thus, the major challenge is on the integration of different bricks to provide technological environments more effective and better tailored to the needs of different actors. That must be addressed from two inseparable and complementary axes:

1: The constitution of a common basis for both technologies (interfaces, formats, communication services, management of consistency, etc.) and concepts (reference meta-models, organizational elements of development and exchange processes, etc.). The conceptual basis will be built on the standards of the automotive domain: AUTOSAR™ and ISO 26262. The first defines a technical target for the deployment of software components and the second criteria for characterizing functions they provide according to their levels of criticality. The hard point here is to trace the design constraints that arise from these standards in the modeling, validation and production environments, while ensuring maximum independence with the modeling formalisms upstream. This is the role of the integration platform subproject (WP5).

2: Integration and finalization of technological bricks issued by upstream projects and dedicated to the automotive domain. In particular:

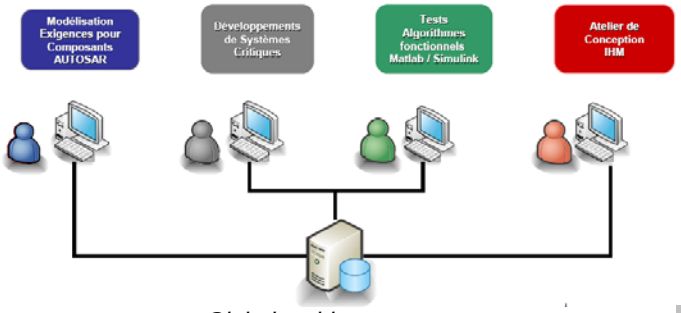
- ✓ introduction of the concept of software component (especially in accordance with its definition given by AUTOSAR™) in the initial phases of the deployment (design, verification) and in the validation methodologies (simulation, verification, test). This will be addressed in a comprehensive manner by WP1 – *Requirement modeling for AUTOSAR™ components*.
- ✓ processing of safety requirements at each step and setting up of involved technology supports (models, compilers, execution infrastructures, etc.). This item, is processed by the WP2 – *Critical system development*.
- ✓ integration of the various tools and used formalisms (such as, Matlab®, C Language, UML) through interoperation interfaces and bridges ensuring semantic consistency of information and correctness of verification / validation or code production. This will be addressed mainly in WP3 - *Functional testing of Matlab® / Simulink® algorithms*.
- ✓ reliable design and validation of automotive HMI is a new topic addressed by Num@tec Automotive; the challenge is to ensure flexibility and completeness of the modeling of the HMI, in particular, on the behavioural aspects and to ntegrate it into the development process tools for effective and incremental validation. It is th purpose of the WP4 – HMI design case tool.



EDONA project organisation

4. Integration platform

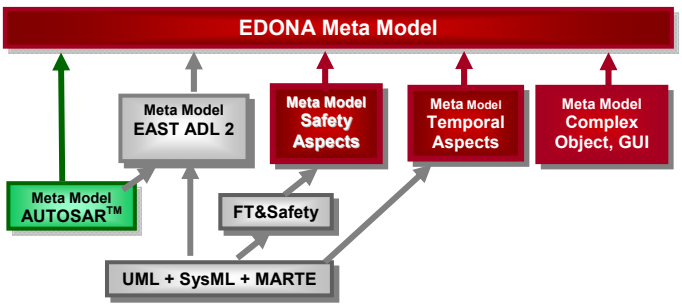
The general principle of the integration platform is to provide access to a common storage space accessible by any tool chain from vertical sub-projects.



Global architecture

For that, the first step is to have a common meta-model to define the data exchanged and integrated between the partners in a project for an automotive electronics system. It will be built from the existing elements, namely:

- ✓ Incoming AUTOSAR™ meta-model (V3) [2],
- ✓ EAST-ADL 2 meta-model for automotive architecture description, defined from UML and SysML meta-models and already aligned to the AUTOSAR™ meta-model [9], [10].
- ✓ Timing aspects provided by the UML MARTE profile [11] that will be integrated at various levels into both the second phase versions of AUTOSAR™ meta-model and the next upgrade of EAST-ADL 2 itself.
- ✓ Safety aspects integrating concepts from an UML extension for QoS, Fault Tolerance and Safety Analysis provided by Usine Logicielle [6]. They will be integrated also to both the second phase versions of AUTOSAR™ meta-model and the next upgrade of EAST-ADL 2.
- ✓ Complex object and GUI definition aspects coming from the second phase versions of AUTOSAR™ meta-model, eventually extended for the needs of the project.

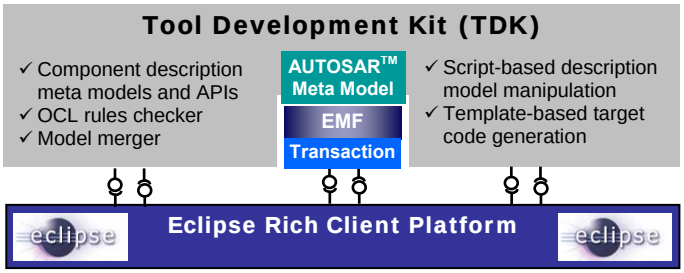


Defining a global and common conceptual reference

The technical architecture is based on the Eclipse Equinox platform and on EMF as a model repository. It is enhanced through various services specialized for AUTOSAR™ in the Tool Development Kit issued from O4A and other collaborative projects involving Geensys. It provides support for automotive component development:

- ✓ Ecore-EMF implementation of AUTOSAR™ meta-model;
- ✓ Tree AUTOSAR™ Basic Editor;
- ✓ Model Merger: includes consistency verification of AUTOSAR™ entities defined in multiple files;
- ✓ OCL Rules Checker for model verification and navigation in AUTOSAR™ context;
- ✓ AUTOSAR™ software component (SWC) Editor;
- ✓ Interface Generator for AUTOSAR™ SWC;

This is completed by generic facilities to manipulate models and generate code through script-based and template-based technologies.



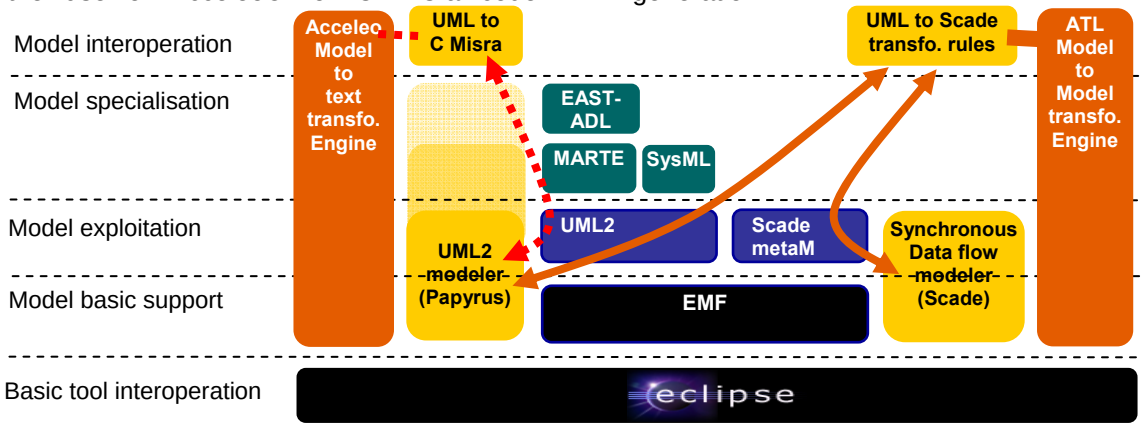
Existing AUTOSAR™ development tools

In addition to these AUTOSAR™ dedicated tools, EDONA platform provides a second set of more generic tools and tool interoperation bridges, all integrated to Eclipse and based on EMF repository usage. They are issued namely from Usine Logicielle, OpenEmbeDD or TOPCASED projects and provide, for instance:

- ✓ EAST-ADL2, an Open Source meta-model defined as an UML 2 profile [9];
- ✓ Papyrus, an Open Source UML editor with extensions for SysML, MARTE and EAST-ADL 2 profiles [12];
- ✓ ATL, an Open Source language and engine, from INRIA for model to model transformation [14];
- ✓ Acceleo®, an Open Source plugin for model to text transformation based on templates and provided by Obeo [];
- ✓ UML to SCADE Suite® bridge developped by Esterel Technologies in Usine Logicielle project and integrated to Eclipse and Papyrus [6].
- ✓ UML to Agatha bridge developped by CEA LIST in Usine Logicielle for automatic test generation from UML specification and instantiation at the TTCN-3 format [6].

The following figures illustrate with some of the integrated tools two examples of interoperation architecture. On the right part of next figure, an example is shown of tool interoperation for importing an UML system architecture model into the SCADE Suite® tool. In addition, on the left side, the figure

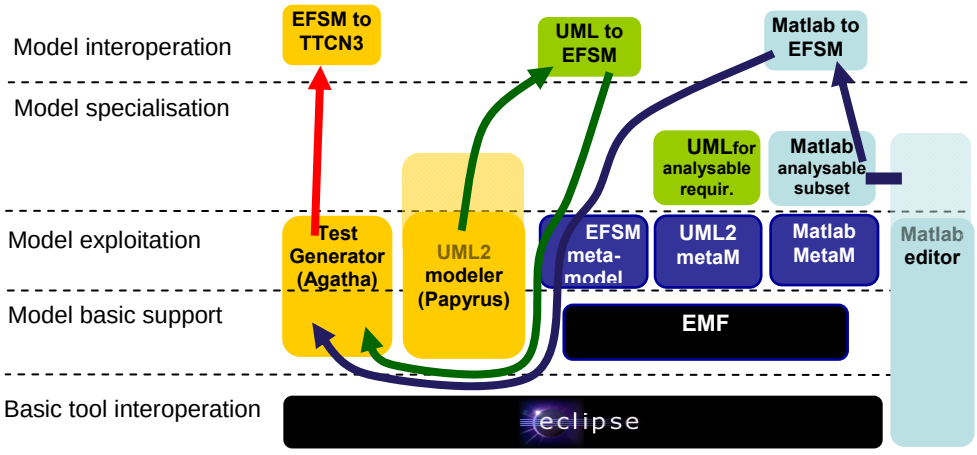
shows the use of Acceleo® for C Misra code generation.



Examples of tool interoperation around Eclipse platform and EMF repository

The next figure illustrates interoperation for test generation. On the right part, it focuses on test generation from Matlab® models:

1. Models are created with the Matlab® editor under the constraint of making the model analyzable through formal execution;
2. They are imported in Eclipse-EMF and translated into an intermediate model based on extended finite state machines (EFSM);
3. This intermediate model is exploited by the Agatha test generator;
4. Results are translated into the adequate output format, e.g.: in the TTCN-3 format as done in the Usine Logicielle project and proposed for AUTOSAR™ implementation testing [6].



Tool interoperation example for model based testing

5. Business instantiations of the platform

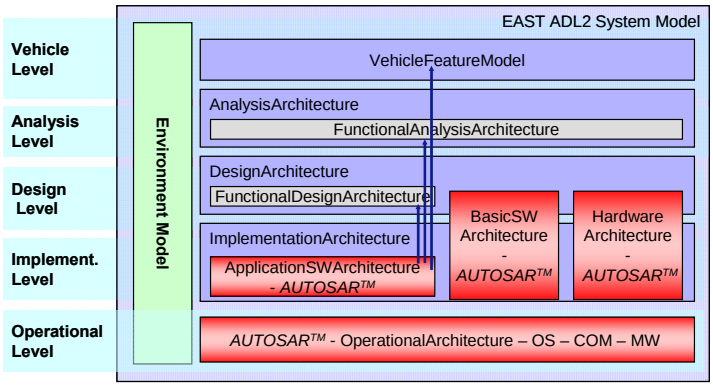
The EDONA platform is used as a basis to build dedicated tool chains for particular purposes and context usages. Four of them have been defined in the project. This initial set of tool chains will be enriched later by additional focused projects and platform promotion activities.

5.1 From requirements to AUTOSAR component architectures

The first vertical sub-project aims to provide a coherent and continuous tool chain for modeling requirements and refining models starting at a high level and until obtaining a detailed architecture description in terms of AUTOSAR™ components ready for deployment. This will be achieved through the integration of a range of existing tools and results of ongoing projects and, in particular, through the industrial transfer of an open source modeler supporting the EAST-ADL2 architecture description language resulting from the project IST ATESST.

EAST-ADL2 aims coverage of the needs and viewpoints specific to the automotive trades from modeling requirements to the implementation models. At the implementation level it is based on the AUTOSAR™ meta-model. This standard covers the last steps of the development process. Its entities populate architectures at the Implementation Level and are referenced from higher levels by requirements, variability constructs or traceability

relations. The behavioral semantics of EAST-ADL2 has been adapted to match the AUTOSAR behavioral concepts.



Relations between EAST-ADL and AUTOSAR™

Technically, the EAST-ADL 2 language is constructed in the form of a dedicated UML profile based on the AUTOSAR™ meta-model [10]. The modeler itself was developed by the CEA LIST on the basis of the open source UML 2 modeler, Papyrus [12]. EDONA will ensure tight interoperation between the EAST-ADL 2 modeler and AUTOSAR™ authoring tool, in order to be able to generate an executable application with the platform.

The management of refining models of requirements and traceability will be achieved by integration of RNTL MemVaTEx project results [13]. MemVaTEx develops a requirement modeling and traceability methodology that will be aligned for using EAST-ADL 2. The TRAMway tool under development in the TOPCASED project will equip this traceability [8].

This is extended by the integration of complementary elements:

- ✓ analyzing model schedulability (this item will benefit from the results related to the standardization of MARTE and results of the ITEA project TIMMO) [17];
- ✓ extending the architecture description language to integrate real-time deterministic specifications according to the OASIS technology used in WP2 for the development of safety critical systems.
- ✓ formalisation of heterogeneous execution model for simulation or formal analysis on basis of the UML profile for modeling computation and communication models [6], [16], [18].
- ✓ studying the ability to generate tests from EAST - ADL2 architecture models having heterogeneous component modeling formalisms; this is based on results from Usine Logicielle [6] (test generation from UML models), WP3 (test generation from Matlab® models) and HeCoSim (Heterogeneous component simulation) [5].

5.2 Safety critical system design

The purpose of WP2 is to ensure the safe implementation of a specification of critical functions. Implementation will be based on the OASIS tool chain developed by the CEA LIST [19] providing a time deterministic programming model and language, an optimized compiler and safe execution with its kernel. This approach is complemented according to several points of view:

- ✓ Because the specifications provided for the applications are already established in Matlab® / Simulink®, bridges between specification expressed in Matlab® / Simulink® and the OASIS programming language will be developed by Monditech.
- ✓ The Matlab® / Simulink® implementation model is based on a model of the computing environment: it is used at design time for simulating the execution of real-time applications, in order to analyze their dynamics. Threfore, the current environmental models, as provided by Sherpa Engineering, must be upgraded in order to provide AUTOSAR™ compliant computing and I/0 models.
- ✓ At the machine implementation level, it remains necessary to check the resolution and accuracy of the digital processing technology compared to the original specifications.

This last point can be analyzed using CEA LIST's approach implemented in the Fluctuat tool [20]. It allows assessment of resolution/accuracy constraints propagated in a program, namely, in a format like Matlab® / Simulink® after its translation into C. These resolution constraints typically come from accuracy constraints identified in the functional design.

5.3 Early validation

The WP3 sub-project aims to integrate a set of tools to achieve validation of Matlab® / Simulink® models. They will establish test cases of both discrete and continuous models developed and implemented on AUTOSAR™ calculators. This work is totally complementary to those of WP2 by focusing on functional and structural validation instead of on the verification of the accuracy of digital processing.

The technical approach adopted has been developed by the CEA LIST and implemented in the AGATHA tool [21]. It consists of using formal techniques (such as symbolic execution) to build automated simulation scenarios (or concrete tests) and representative behaviors of the system, and to demonstrate certain properties on the models tested. Completeness of the simulation can be reached, because the "partitioning" directed by symbolic execution on all possible simulations avoids the combinatorial explosion which might have occurred when using the methods of traditional numerical simulation [22].

The proposed work is the integration of symbolic simulation on the fully discrete or hybrid model to deal with realistic models as built by the automotive

suppliers. It will reuse some results of the SysPEO Eureka project, in particular as regards the treatment of hybrid systems represented in Matlab® / Simulink®.

5.4 AUTOSAR Human Machine Interface design

The WP4 sub-project is to design a tool chain for graphical HMI software development. The goal is to improve, standardize and make inter-operable elements of the different tools to create automobile GUI, all within the constraints of the strong adherence to AUTOSAR™ standards. Particular focus will be kept on the standardization work ongoing in AUTOSAR™ regarding data formats (XML), HMI component APIs and architectures.

Issues related to the internationalization of HMI will be managed: here we will seek to identify the attributes / information to be translated (meta-model) in order to use these descriptions through automated translations using EDONA platform tools.

The tool chain will spread over two axes:

- ✓ Prototyping of innovative applications for prototype cars in the area of intelligent transport systems. These vehicles are equipped with many sensors for analysis. In this context, the execution engine of Intempora (RTMaps® [23] also used for HMI experiment in the IHS1O project) will be used and integrated to EDONA platform.
- ✓ The production of certified applications for vehicle sales, and therefore in compliance with constraints in terms of dependability and certification. In particular, the support of both AUTOSAR™ and the ISO 26262 standards must be taken into account. In this context, the used execution engine will be the SCADE Suite® tools of Esterel Technologies. In particular, the SCADE Display® tool [24] will be first certified to the existing IEC 61508 standard, so that the transition to the ISO 26262 certification can be done easily when that standard exists.

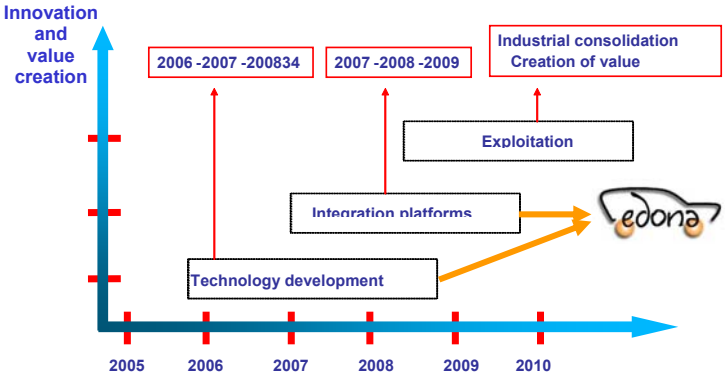
6. Exploitation strategy

The Num@tec Automotive project initiated since September 2003, is strictly focused on software development (tools and applications) which will provide the automobile industry in the short-term (1-3 years) with technological innovations, and in the mid term (2 -- 5 years) with the establishment of companies amplifying a respected position, proportional to the weight of the automobile industry in the economy.

The objective of Num@tec Automotive is to create a European platform for innovation, research and development for the automotive industry in the field of software and complex systems. The realization of this platform is organized into two sets of activities:

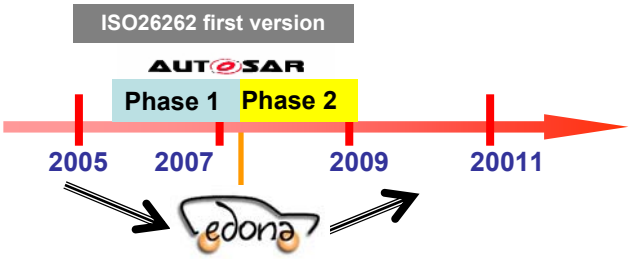
- ✓ Tools for the design of electronic systems ensuring the realization of software technology bricks for the automotive domain;
- ✓ Platforms for integrating these bricks and innovative results into the development of prototypes.

The EDONA project is the first instance of the second set, "Integration platforms".



Num@tec Automotive organization

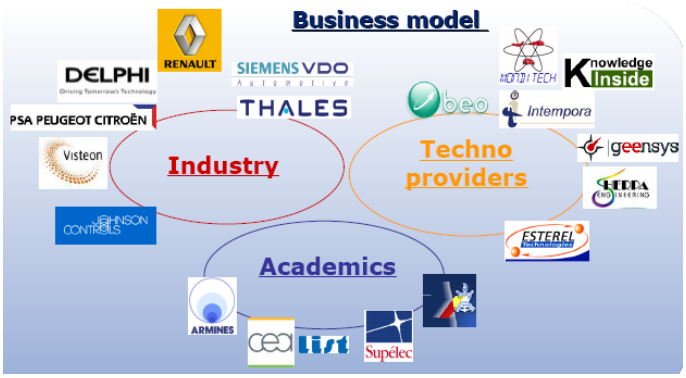
Its launch is strongly synchronized with the schedule of the two major standards for the domain: it can benefit from all the results of AUTOSAR™ phase 1, can contribute to some evolutions done in phase 2 and will still be active and ready to integrate the last results obtained at the end of the second phase. In parallel, works on ISO 26262 are sufficiently advanced to provide some guidelines and main orientations on how to deal with safety aspects regarding this standard.



EDONA synchronization with activities on standards

Value creation in EDONA is based on technology transfer in association with three key stakeholder types: industry users, technology and service providers and academics providing innovations.

The EDONA consortium is well balanced to represent all these stakeholders, with almost all the key French players of the field. Regarding the exploitation rules fixed by AUTOSAR™ consortium, it is considered that all partners willing to exploit the results will become AUTOSAR™ members with the support of EDONA partners already being core and premium members.



The virtuous triangle

At least 32 technologies (components tools) will be integrated, transferred or developed in a context of strong industrial exploitation, with: 10 transfer of technology from laboratories; 15 innovations from technology providers; 3 innovations from laboratories; 4 common innovations from a joined work of the whole consortium. 13 of these technologies are foreseen to be exploited through open source or EDONA common source strategy creating a strong link between the project consortium and existing or emerging open source communities in the domain of embedded systems development, locally like the OPEES initiative or more widely with the Eclipse community. This is the challenge to be addressed in the next 3 years.

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8. References

[1] www.numatec-automotive.com

[2] www.autosar.com

[3] Matthias Findeis, Ilona Pabst: *Functional Safety in the Automotive Industry, Process and methods*, VDA Alternative Refrigerant Winter Meeting, Saalfelden, Austria, 16-02-2006 - http://www.vda-wintermeeting.de

[4] www.memvatex.org (*Modeling Methods for Validation and Traceability of software Requirements*)

[5] projet-hecosim.org (*Heterogeneous co-simulation & Hybrid simulation of Systems*)

[6] www.usine-logicielle.org (*Tool platform for model driven design, validation and component based execution of complex systems*)

[7] www.poleautomobilehautdegamme.org (*project "Open for AutoSar" – O4A*)

[8] www.topcased.org (*Open Source development environment for embedded systems*)

[9] www.atesst.org (*Enhancing the EAST-ADL architecture description language for safety related system design upon AUTOSAR™*)

[10] P. Cuenot et al.: *Managing Complexity of Automotive Electronics Using the EAST-ADL*.. in proc IEEE ICECCS, Los Alamitos, CA, USA, August 2007.

[11] www.omgmarte.org (*UML profile for Modeling and analyzing Real Time Embedded systems)*

[12] www.papyrus-uml.org (*Open UML 2 modeling tool)*

[13] A. Albinet, et al.: *Model-based methodology for requirements traceability in embedded systems*, 3rd ECMDA workshop on traceability, June 07, Haifa, Israel

[14] www.eclipse.org/m2m/atl (*Model to model transformation engine*)

[15] www.acceleo.org (*Model to code transformation engine*)

[16] www.thesys.eu.org (*Tackling heterogeneity for embedded system development*)

[17] H. Espinoza et al.: *Towards a UML-Based Modeling Standard for Schedulability Analysis of Real-Time Systems*, in proc of MARTES Workshop at MODELS Conference, 2006, Jamaica.

[18] C. Hardebolle et al.: *Execution Framework for Models of Computation*, in proc. MOMPES, Braga, Portugal, 31 mars 2007

[19] D. Chabrol et al.: *Deterministic Distributed Safety-Critical Real-Time Systems within the Oasis Approach*, in proc. PDCS 2005, Phoenix, AZ, USA, nov. 2005.

[20] S. Putot, et al.: *Static Analysis of the Accuracy in Control Systems: Principles and Experiments*, in proc. FMICS 2007, Berlin, Germany, July 2007.

[21] C Gaston, et al.: *Symbolic execution techniques for test purpose definition*, in proc. TestCom 2006, Springer - LNCS 3964.

[22] S. Labbé, et al.: *Slicing Communicating Automata Specifications for Efficient Model Reduction*, in proc. ASWEC'07, Australia, 2007.

[23] www.intempora.fr/maps (*RTMaps® execution engine for advance HMI*)

[24] www.esterel-technologies.com (*Scade Suite and Scade Display development environments*)