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Authors

Editor	E-mail
Henrik Lönn	VTEC (henrik.lonn@volvo.com)

Authors	E-mail
The ATESST2 Consortium	

The Consortium

Volvo Technology Corporation (S)	VW/Carmeq (D)	Centro Ricerche Fiat (I)
Continental Automotive (D)	Delphi/Mecel (S)	
Mentor Graphics Hungary (H)	CEA LIST (F)	
Kungliga Tekniska Högskolan (S)	Technische Universität Berlin (D)	University of Hull (GB)

Revision chart and history log

Version	Date	Reason
1.0	2010-06-04	Final

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1 Introduction

Advanced automotive functions are increasingly dependent on software and electronics, *embedded real-time systems.* The complexity and criticality of automotive embedded systems are already an inhibiting factor on further evolution of functionality. This is evident for single automotive systems and even more so for functions that interact between vehicles and between vehicle and infrastructure, *cooperative systems*. These systems are innovative and challenging from both the technical, business and user perception perspectives. The development of appropriate techniques and methodologies that support development, verification and validation (V&V), including field-operational tests, are therefore mandatory to exploit the new opportunities.

ATESST2 contributes to bridging the gap between cooperative systems and enabling design and verification technologies. The basis of the project is the architecture description language EAST-ADL that was refined in the ATESST project. The information structure and ontology for engineering information developed in ATESST makes the development of stand-alone automotive embedded systems more systematic and predictable.

In ATESST2, the EAST-ADL modeling approach is further extended and new results are provided to support development and V&V of cooperative active safety systems. The end results include:

- an architecture description language with improved means for capturing the requirements, characteristics and configurations of cooperative systems and the related analysis and V&V.
- methodology and guidelines supporting language/tool adoption and cost-efficient development and V&V, and
- harmonization of EAST-ADL with relevant standards including AUTOSAR and UML (MARTE/SysML).

The model-based development and V&V approach in ATESST2 contributes to improving a) communication among system stakeholders, b) documentation, and c) V&V capabilities. This is a shift from today's document-driven testing and simulation procedures, to a model–based way of working. This provides means for stakeholders to deal with the complexity and risk management of cooperative active safety systems.

This deliverable describes main project results.

2 General Information

The inclusion of embedded system technology in vehicles has had - and is still having - a radical impact on their development, production and maintenance. Over the past decades, automotive embedded systems have evolved from single standalone computer systems, simple enough to be designed and maintained with a minimum of engineering, to distributed systems including several networks, large numbers of sensors, electric motors and points of interactions with humans. These distributed systems provide enormous opportunities for the future, but at the same time require new skills, methodologies, processes and tools.

Future systems may be distributed over several vehicles and not be contained in one. Co-operative system engineering needs is one area where methodologies needs to be extended. The ATESST2 project has a target to find principles for how the information regarding a multi-vehicle system should be defined for engineering use.

The basis for ATESST2 technology is the EAST-ADL language. EAST-ADL is an Architecture Description Language (ADL) initially defined in the EAST-EEA project. It was refined and aligned with the more recent AUTOSAR automotive standard in the ATESST project. EAST-ADL is an approach for describing automotive electronic systems through an information model that captures engineering information in a standardized form. Aspects covered include vehicle features, functions, requirements, variability, software components hardware components and communication.

EAST-ADL contains several abstraction levels (see Figure 1). The software- and electronics-based features of the vehicle are described at different levels of abstraction. The proposed abstraction levels and the contained elements provide a separation of concerns and an implicit style for using the modeling elements. The embedded system is complete on each abstraction level, and parts of the model are linked with various traceability relations. This makes it possible to trace an entity from feature down to components in hardware and software.

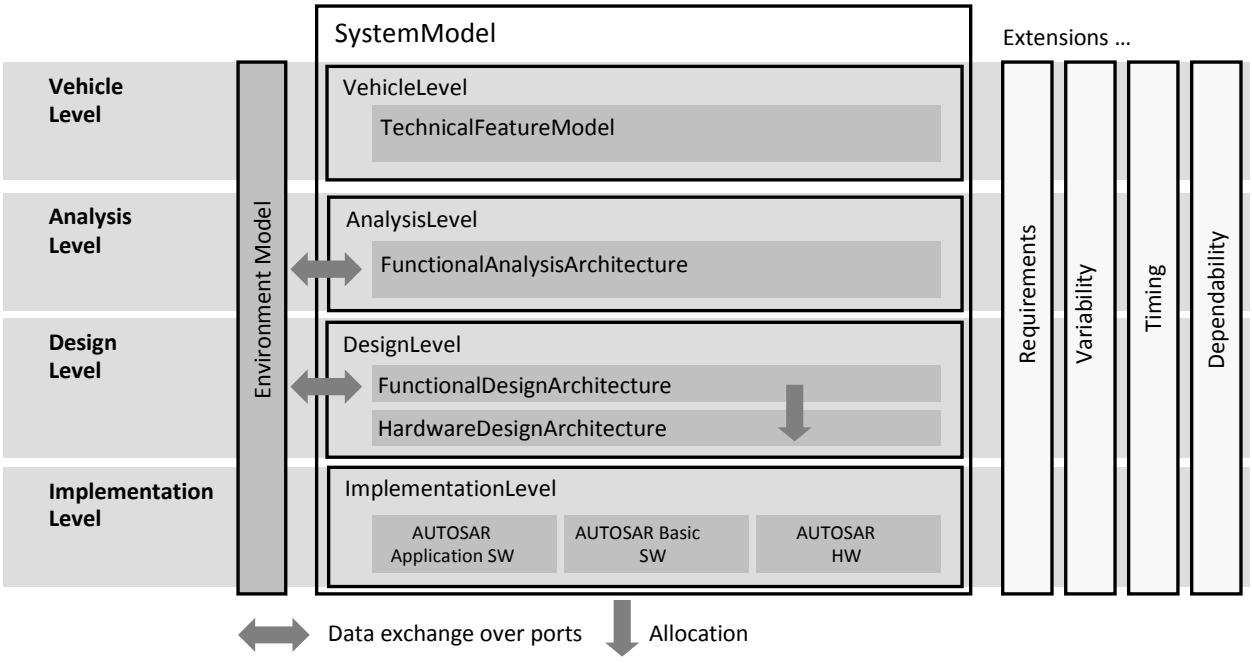

Figure 1. EAST-ADL abstraction levels and model organization.

The features in the Technical Feature Model (VFM) at the vehicle level represent the content and properties of the vehicle from an external perspective without exposing the realization. It is possible to manage the content of each vehicle and entire product lines in a systematic manner.

A complete representation of the electronic functionality in an abstract form is modeled in the Functional Analysis Architecture (FAA). One or more entities (analysis functions) of the FAA can be combined and reused to realize features. The FAA captures the principal interfaces and behavior of the vehicle's subsystems. It allows validation and verification of the integrated system or its subsystems on a high level of abstraction. Critical issues for understanding or analysis can thus be considered, without the risk of their being obscured by implementation details.

The implementation-oriented aspects are introduced while defining the Functional Design Architecture (FDA). The features are realized here in a function architecture that takes into account efficiency, legacy and reuse, COTS availability, hardware allocation, etc. The function structure is such that one or more functions can be subsequently realized by an AUTOSAR software component (SW-C). The external interfaces of such components correspond to the interfaces of the realized functions. The physical topology of the embedded system is represented by the Hardware Design Architecture onto which the functions are allocated.

The representation of the implementation, the software architecture, is not defined by EAST-ADL but by AUTOSAR. However, traceability is supported from implementation level elements (AUTOSAR) to vehicle level elements.

The Hardware Design Architecture (HDA) should be considered parallel to application development. On the design level, the HDA forms a natural constraint for development and the hardware and application software development needs to be iterated and performed together. There is also an indirect effect of hardware on the higher abstraction levels. Control strategies or entire functions may have to be revised to be implemented on a realistic hardware architecture. This reflection of implementation constraints needs to be managed in an iterative fashion.

To verify and validate a feature across all abstraction levels, using simulation or formal techniques, an environment model is needed early on. This plant model captures the behavior of the vehicle dynamics, driver, etc. The core part of the environment model can be the same for all abstraction levels.

The primary scope of the EAST-ADL modelling concepts used to be the single vehicle and its embedded system. Admittedly, on vehicle level the Features account also for vehicle elements beyond the embedded system such as mechanical components, but still within the single vehicle. During ATESST2, the approach to also represent the interaction with systems in other vehicles and infrastructure is addressed. Cooperative active safety systems rely as much on modeling of adjacent vehicles and systems as on the vehicle-internal environment for its proper specification and validation.

A consequence is that the EAST-ADL2 modelling elements have been organized as a system model that strictly represents one vehicle and its embedded system, and an environment model where models representing adjacent vehicles or infrastructure are placed. A pattern was identified where the environment model is organized as in-vehicle, near and far environment. The in-vehicle environment represents elements of the vehicle that not part of the electrichal architecture. The near environment represents road and wheather interaction that directly and physically influence the vehicle. The far environment represents vehicles and infrastructure that interact logically with the vehicle. In order to represent and configure the set of vehicles and road infrastructure elements, a Product Feature Model is used with feature subtrees for each of these.

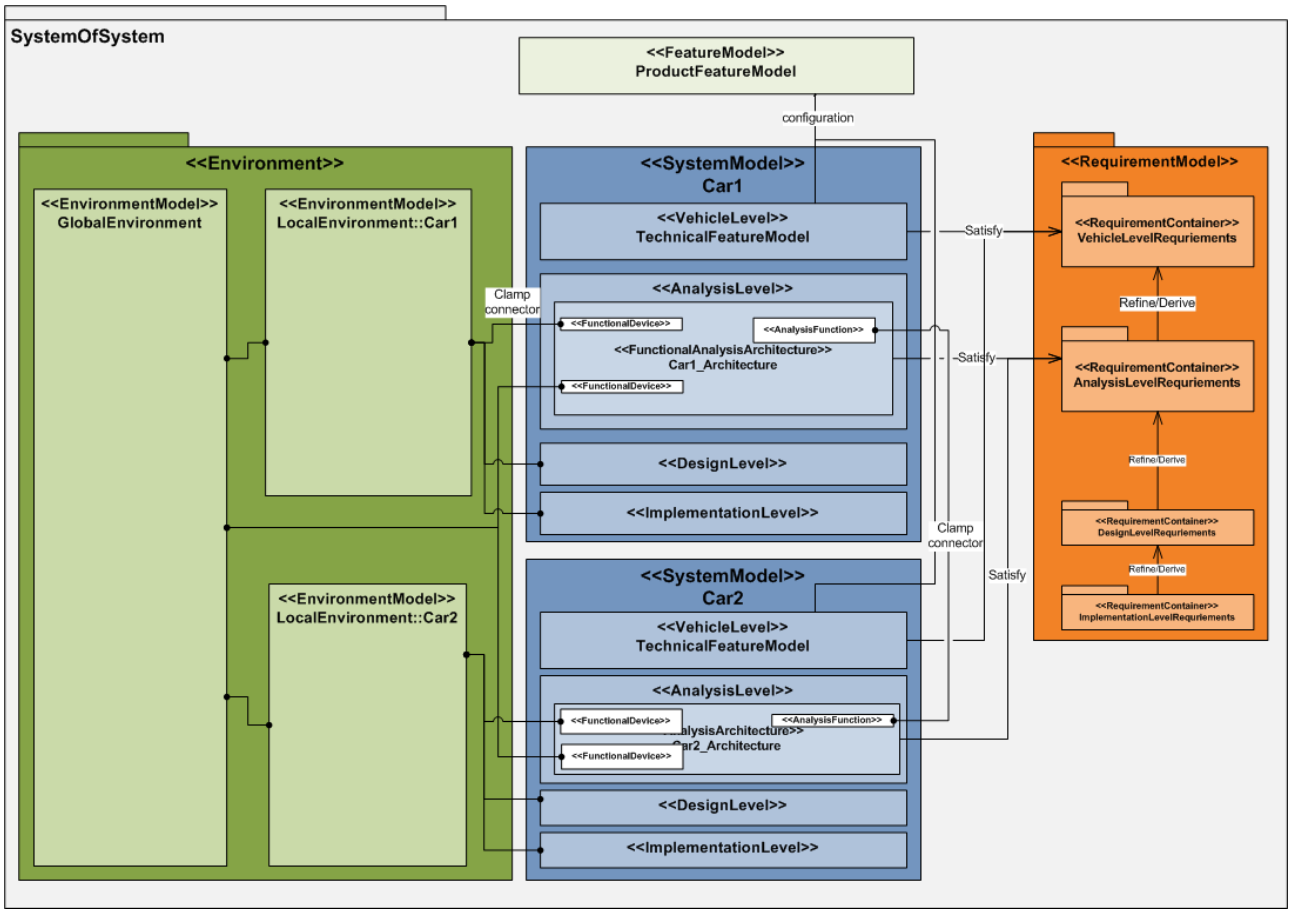

Figure 2. The modeling pattern for cooperative systems

2.1 Project Plan, Milestones and Deliverables

The project delivers

- EAST-ADL Language definition (new release)
- EAST-ADL Methodology
- EAST-ADL UML2 Profile
- ATESST2 Workbench tool suite
- ATESST2 Demonstrators (Examples of EAST-ADL)

ATESST2 has worked iteratively: New releases of the language, tools and examples were delivered several times during the project.

2.2 Technical Approach

- Provision of means to manage the engineering information related to automotive EE systems
- System modeling is based on the EAST-ADL architecture description language
- AUTOSAR models are used for software architectures
- Special attention is devoted to the support for safety, requirements and variability
- Provision of a modeling tool based on UML2, to asses project results.

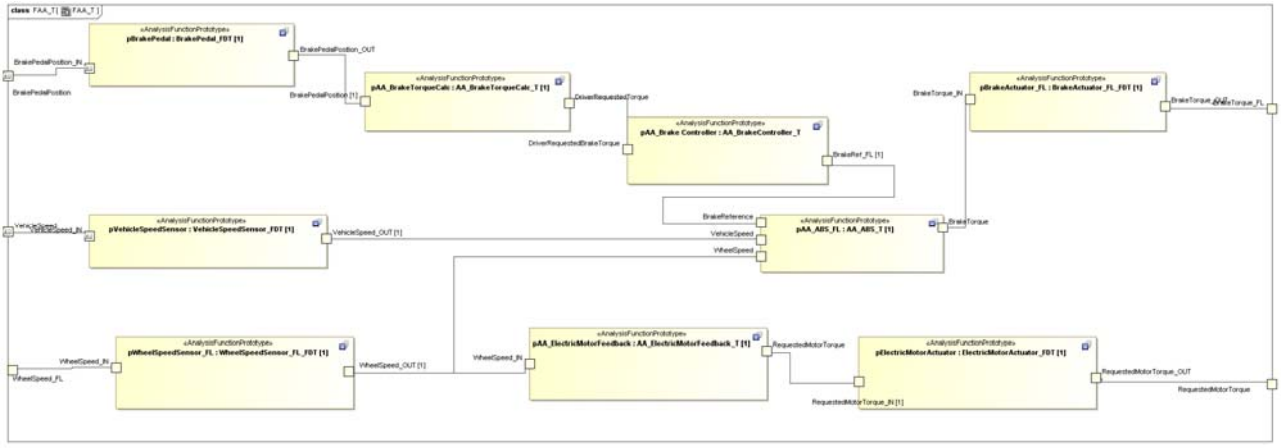

Figure 3. Example of EAST-ADL model: Functional architecture on analysis level

2.3 Achievements

- Reengineering of EAST-ADL to conform to AUTOSAR metamodel
- Reengineering of EAST-ADL to allow modular application of language concepts
- Revised support for the modeling of safety, timing, variability, requirements and cooperative systems
- Proposal of Methodology explaining how the EAST-ADL can be deployed
- Definition of UML2 profile for EAST-ADL which is linked to the OMG MARTE standard
- Interaction with several related projects using or about to use EAST-ADL

2.4 Organisational Information

Budget	4 M€	*Funding*	2 M€
Duration	24 months	*Start*	July 2008
DG	Information Society and Media	*Priority Area*	ICT for cooperative systems
Coordinator	Henrik Lönn, Volvo Technology	*Contact*	henrik.lonn@volvo.com

Partners: Centro Ricerche Fiat, Volvo Technology Corp, VW/Carmeq
Delphi/Mecel, Continental automotive, Mentor Graphics,
CEA, Kungliga Tekniska Högskolan Stockholm, TU Berlin, University of Hull

Website: www.atesst.org

Table 1. Project partners and countries

Beneficiary name	**Beneficiary short name**	**Country**
Volvo Technology Corporation	VTEC	Sweden
Volkswagen/Carmeq Gmbh	CAR	Germany
Centro Ricerche Fiat S.C.p.A.	CRF	Italy
Continental Automotive AG	CON	Germany
Delphi/Mecel AB	MEC	Sweden
Mentor Graphics Hungary KFT	MGH	Hungary
Commissariat a l'Energie Atomique	CEA	France
Kungliga Tekniska Högskolan	KTH	Sweden
Technische Universität Berlin	TUB	Germany
University of Hull	UOH	UK

3 Project objectives

The objectives of ATESST2 are to:

1. Identify and compile stakeholders' needs on an *architecture description language* for development of *cooperative active safety systems*.
2. Harmonize the structural descriptions of EAST-ADL with the latest evolutions of existing approaches, i.e. the AUTOSAR initiative, the OMG (UML2, UML profile for MARTE and SysML) and with the SAE AADL. This will be the back bone onto which further language constructs can be attached. ATESST2 results will be concretized in a new major release of the EAST-ADL.
3. Develop requirements and V&V capabilities to deal with *cooperative active safety systems*. In particular, the V&V aspects of the interaction between the *embedded real-time system*, its environment and the application will be further investigated. Safety related requirements for such systems will be addressed and a way of supporting a *safety case* will be fully incorporated into the language.
4. Develop adequate behavioral modeling for EAST-ADL. The purpose is to capture behavior (including non-desired behaviors) and algorithms of the vehicle systems and its environment, forming the *cooperative active safety system*. This includes developing a native behavioral notation that allows simulation and verification within the defined system model, providing the ability to assess desired as well as emerging systems behaviors.
5. Develop and adapt analysis techniques suitable for assessing safety, reliability, performance and cost, including their trade-offs for *cooperative active safety systems*.
6. Improve the support for *field operational tests* by providing explicit descriptions of desired behaviors, test-cases and test results. This has the potential to enhance the planning, execution and evaluation of field-operational tests. Further, it would reduce the need for a large amount of testing that instead can be covered by model-based simulation and analysis.
7. Investigate, develop, and validate language mappings to Mathworks' Simulink, Safety analysis and other relevant domain-specific modeling tools. This will enable realization of interfaces between external tools and an EAST-ADL tool environment. which in turn will enable V&V of EAST-ADL models using those tools.
8. Develop support for reuse and variability management, especially user support for single product configuration with regard to safety aspects together with the possibility to describe configurations of *cooperative active safety systems*. Identified language constructs will be added to EAST-ADL.
9. Develop methodology and guidelines supporting end user application of the ATESST2 concepts. This is necessary to ensure that end users apply the concepts according to the same principles.
10. Define a language implementation in the form of a UML2 profile and promote it as a standard. The ATESST2 project aims at making the UML profile for EAST-ADL a standard appendix of the incoming new standard for RT/E called the UML profile for MARTE.
11. Develop tools realizations, including an experimental tool, based on the Eclipse framework, as well as the investigation of the support possible through standard UML tools by use of the UML2 profile implementation. Interfaces to external domain tools will be developed for the experimental tool.
12. Develop automotive system application examples for *cooperative active safety systems* that can be used to validate and demonstrate the *architecture description language*, tool and methodology developed in the ATESST2 project.

4 Project Results per Work Package

This section will describe the progress and significant results for each of the 6 research Work Packages of ATESST2.

4.1 WP2 Stakeholders' Needs

The main objective addressed by work package 2 is O1, "Identify and compile stakeholders' needs on an architecture description language for development of cooperative active safety systems." WP2 has resulted in a set of internal project requirements that has also been validated with the project's reference group.

Because WP2 focussed on identifying needs asa basis for initial project requirements, the activity during period 2 has been focussed on maintenance and follow-up.

4.2 WP3 Concepts Development

WP3 is the main WP of the project and this is where the language concepts and their usage are researched. The work tasks of WP3 has made several advances during the period:

WT3.1: Requirements engineering workflow has been addressed and RIF concepts has been assessed. The plugin for requirements interchange with the RIF standard has been implemented. Methodological aspects on representing requirements has been proposed, in particular the role of constraints as a formalization of a requirement. The concept of constraint has been generalized to take into account nonfunctional constraints like cost, safety and timing in a consistent way. EAST-ADL was partly re-engineered during the period which resulted in several modificiations of the Requirements support.

WT3.2: The support for ISO26262 has been further detailed. Concepts for hazard analysis at the vehicle level and how to represent integrity requirements in the form of ASILs at the analysis level has resulted in extensions to the MM. Many of the safety constructs were refined during the ISO26262 compliance work and during the language reengineering.

A concept for allocating safety integrity levels to components was proposed and algorithms investigated. HiP-HOPS has been extended with multi-perspective (H/W + S/W) analysis capabilities and EAST-ADL integration via Papyrus achieved.

State-based error semantics has been investigated and novel work on the conversion of state-machines to temporal fault trees has been presented.

WT3.3: The variability concepts have been further refined and reengineered based on experience from case study work with WP6 and the language reengineering effort. A distinction between feature models for product lines and concrete feature models for architecture realization was introduced. Also, concepts and semantics for defining how vehicle-level features are realized by elements on lower abstraction layers were detailed. The use of variability concepts for optimization has been proposed. Documentation and tutorial on variability concepts has been issued.

WT3.4: A plugin for the exchange between EAST-ADL and Simulink was completed and supports the latest version of the language. A concept for Physical PowerConnectors was developed and integrated in the language. Modeling and language concepts for the support of Cooperative system modeling were detailed. An assessment of current EAST-ADL behavior support in comparison with AADL, SPIN / Automata has been performed. An approach for model transformation to the SPIN verifier was proposed. A mode concept has been investigated and included in the language. Communication semantics and execution semantics have been consolidated

WT3.5: An approach for multi-objective optimization has been proposed. Two tracks were identified, one with general applicability taking product lines, general constraints and requirementsnito account, and another more pragmatic track with focus on timing, dependability

and cost for a single configuration. Experiments according to the latter track with optimization w.r.t. dependability, cost and timing has been conducted with a recent version of the HiP-HOPS tool.

4.3 WP4 Language Integration, Profile- and Tool Refinement

The EAST-ADL has been through a major revision to improve the quality of language constructs and their documentation, to improve compliance with AUTOSAR and ATUOSAR metamodelling rules, and to modularize the language. Due to the modularization it is possible to use selected packages of the language together with a structural core. It is also possible to apply the extensions to AUTOSAR or other modelling approaches following the AUTOSAR metamodelling approach.

The final results from TIMMO were integrated as EAST-ADL timing constraints, and the same pattern was adopted for safety constraints.

A UML2 profile has been defined which is compliant with the latest version of the EAST-ADL language. The use of the EAST-ADL UML profile with a commercial UML tool, MagicDraw has been successfully tested.

The ATESST2 modelling workbench with palette support for EAST-ADL has been released for the latest version of the language. The ATESST2 analysis workbench, i.e. the set of Papyrus plugins developed in the project has been released for the latest version of the language.

4.4 WP5 Methodology

An ATESST2 methodology has been defined based on the contributions from each area of WP3. A methodology model in the Eclipse Process Framework, EPF has been defined. In harmony with the modularization of the language, the methodology has been modularized, such that a range of 4 method packages from Core methodology with only basic structure modelling up to a complete methodology with requirements, V&V, variability and safety, is available.

4.5 WP6 Case Study and Evaluation

The case studies of the project have been completed, parking brake, steering column lock, cruise control, brake-by-wire, power-assisted steering, a security system and cooperative braking. Case studies have served as examples for the tool and language work packages. Because of extensive collaboration with HaveIt, the project concepts have also been disseminated through the case study work, and valuable challenges have been presented to ATESST2. In particular, safety and variability concepts have been addressed in the HaveIt context. Also, the proposal of a modelling pattern for cooperative systems have relied on case study work in WP6.

4.6 WP7 Dissemination, Exploitation and Standardization

The work on sharing project results has been based on publications, partner internal dissemination and exploitation and exchange of EAST-ADL2 concepts with other projects. Activities related to standardization has been pursued by ensuring compliance with ISO26262 and AUTOSAR, and by aligning the UML2 profile with the OMG MARTE profile. The EAST-ADL annex is now part of the adopted version 1.0 of MARTE. The dissemination activities of the project are listed in chapter 6 below.

5 Deliverables and milestones tables

5.1 Deliverables

Del. no.	Deliverable name	WP no.	Lead bene-ficiary	*Nature*[1]	Dissemi-nation level[2]	Delivery date (proj.month)
D1.1	Project handbook	1	VTEC	R	CO	2
D7.1.1	Dissemination plan	7	KTH	R	PU	2
D7.2.1	Exploitation strategies	7	CAR	R	CO	4
D2.1	State of-practice and state of the art	2	MEC	R	PU	6
D6.1.1a	Case study and demonstrator plan with early case study release	6	CONTI	R	PU	6
D6.1.1b	Case study and demonstrator plan with early case study release	6	CONTI	R	CO	6
D1.2a	Mid-term report on progress	1	VTEC	R	PU	12
D1.2b	Mid-term report on progress	1	VTEC	R	CO	12
D7.3.1	Standardization plan and activities	7	CEA	R	PU	12
D3.1	Summary of EAST-ADL Update Suggestions	3	MGH	R	PU	15
D4.3.1	The EAST-ADL analysis platform	4	KTH	P	PU	15
D3.2	Refined EAST-ADL tool support	3	MGH	P	PU	21
D4.1.1a	EAST-ADL Language definition and Profile	4	VTEC	R	PU	21
D4.1.1b	EAST-ADL Language definition and Profile	4	VTEC	O	PU	21
D4.2.1	The EAST-ADL modeling workbench	4	CEA	P	PU	21
D5.1.1	Methodology guideline	5	CAR	R	PU	21

1 **R** = Report, **P** = Prototype, **D** = Demonstrator, **O** = Other

2 **PU** = Public, **CO** = Confidential, only for members of the consortium (including the Commission Services)

	when using EAST-ADL					
D5.2.1	Guideline for Analysis-driven modeling and architecture evaluation method	5	CEA	R	PU	21
D6.1.2a	Case study	6	CONTI	P	PU	21
D6.1.2b	Case study	6	CONTI	P	CO	21
D1.3	Final report on project results	1	VTEC	R	PU	24
D6.2.1a	Evaluation results	6	VTEC	R	PU	24
D6.2.1b	Evaluation results	6	VTEC	R	CO	24
D7.1.2	Project presentation material	7	KTH	R	PU	24
D7.2.2	Exploitation plan	7	CAR	R	CO	24

5.2 Milestones

The milestones are set out regularly, to mark synchronization points for the EAST-ADL language, tools and examples. At each milestone, a new version of the language is released, supporting the concepts developed until that point. The exact language content is not defined in Annex I, but agreed during the quarter preceding the milestone.

TABLE 2. MILESTONES

Milestone no.	Milestone name	Work package no	Lead beneficiary	Delivery date	Achieved Yes/No	Actual / Forecast achievement date	Comments
0	Project Kick-Off	WP1	VTEC	1	Yes	1	
1	Initial release of refined EAST-ADL	WP1,2,3,4,7	VTEC	4	Yes	4	
2	Intermediate release M2 of refined EAST-ADL	WP1,2,3,4,5,6,7	VTEC	6	Yes	6	
3	Intermediate release M3 of refined EAST-ADL	WP1,2,3,4,5,6,7	VTEC	9	Yes	9	

4	Intermediate release M4 of refined EAST-ADL2	WP1,2,3,4,5,6,7	VTEC	15	Yes	16	
5	Preliminary release of refined EAST-ADL2	WP1,3,4,5,6,7	VTEC	21	Yes	22	
6	Final release of refined EAST-ADL2	WP1,4,6,7	VTEC	24	Yes	24	

6 Impact

The ATESST2 project is addressing a paradigm shift in automotive embedded systems development, where the industry is transitioning from a document-based and social (tacit knowledge) practice to an approach that emphasizes formalized information management, referred to as model based development. Such an approach is considered essential for development to be cost-efficient, to support risk management, appropriate levels of verification and validation for safety critical systems development. The drivers for such approaches are steadily increasing with more advanced applications, typified by active safety systems, where the increasing system complexity and new risks require new methods and tools.

The ATESST2 project is for these purposes addressing model-based technologies required for future safety critical automotive applications. The ATESST2 project has the following considerations with respect to concurrent developments and evolution:

- Industrial adoption of model based development is currently mainly limited to point efforts, where in particular design flows and tool chains are well established for function/behavior development but lagging for system and architecture level development; corresponding to the targets of the project. The ATESST2 project directly addresses a bidirectional communication with several other industries in the area to make sure that the EAST-ADL is properly disseminated, and that needs from several stakeholders are considered. The automotive effort on software architecture - AUTOSAR - and the forthcoming safety standard (ISO26262) are changing the landscape of embedded systems development and are pushing maturity of the area. This provides excellent opportunities for promoting the EAST-ADL approach.
- Standards: As an indication of the importance of the area, a number of standards are currently in development. The ATESST2 project has as explicit goals to be integrated with, aligned to, or at least related to, relevant standards in the area including with Autosar, UML/SysML, MARTE, ISO26262, SAE AADL and RIF.
- The importance of model based development approach is manifested by the large number of national and international projects that are addressing various aspects of the approach, and for many different application domains. The ATESST2 project is a central player in this area and has established several bidirectional links to other research projects such as the CESAR Artemis project, the ITEA2 TIMMO project and the FP7 HAVE-IT project.
- Tool vendors. Related to the above the ATESST2 partners are through related projects and collaborations cooperating with tool vendors in the area to promote the EAST-ADL approach.

6.1 Publications in ATESST2

The following publications are those published in conference or journals, and also include publications in technical magazines, one PhD thesis and book chapters published in edited books including the Automotive Embedded systems handbook. Additional publications are the ATESST deliverables – these are not listed here.

6.1.1 Published journal papers

Wolforth I., Walker M., Grunske L., Papadopoulos Y. (2010), Generalisable Safety Annotations for Specification of Failure Patterns, *Software Practice and Experience*, 40(5):453-483, Wiley Inderscience. ISSN: 0038-0644.

Wolforth I., Walker M., Papadopoulos Y., Grunske L. (2010), Capture and Reuse of Composable Failure Patterns, *Int'l Journal of Critical Computer-Based Systems*, 1 (1-3): 128-147, Inderscience Publishers, ISSN 1757-8779

Walker M., Papadopoulos Y., Parker D., Lönn H. Törngren M., Chen D., Johansson R. Sandberg A. (2009) Semi-Automatic FMEA supporting complex systems with combinations and sequences of failures, SAE International Journal of Passenger Cars- Mechanical Systems October 2009 2(1): 791-802, ISSN: 1946-4002.

Walker M., Papadopoulos Y. (2009) Qualitative Temporal Analysis: Towards a full implementation of the Fault Tree Handbook, *Control Engineering Practice*, Elsevier Science, 17(10):1115-1125, ISSN 0967-0661

6.1.2 Published book chapters

Invited chapters the *Handbook on Automotive Embedded Systems.* Editors Nicolas Navet and Francoise Simonot-Lion. Taylor and Francis CRC Press - Series: Industrial Information Technology. ISBN: 9780849380266. 2009.

- Martin Törngren, DeJiu Chen, Diana Malvius and Jakob Axelsson. *Model based development of automotive embedded systems.*
- Mathias Weber and Mark-Oliver Reiser. *Product Lines in Automotive Electronics*.
- Henrik Lönn and Ulrich Freund. *Automotive Architecture Description Languages.*

Philippe Cuenot, Patrik Frey, Rolf Johansson, Henrik Lönn, Yiannis Papadopoulos, Mark-Oliver Reiser, Anders Sandberg, David Servat, Ramin Tavakoli Kolagari, Martin Törngren, Matthias Weber. The EAST-ADL Architecture Description Language for Automotive Embedded Software Invited brief chapter in the LNCS volume on "Model-Based Engineering of Embedded Real-Time Systems", Holger Giese, Bernard Rumpe, Bernard Schätz, Editors. In Print.

6.1.3 Published full conference papers

Carl-Johan Sjöstedt, Jianlin Shi, Martin Törngren, David Servat, DeJiu Chen, Viktor Ahlsten, Henrik Lönn. Mapping Simulink to UML in the design of embedded systems: Investigating scenarios and transformations. Invited paper. In OMER 4 Post Workshop Proceedings – Sept. 2008.

Patrik Frey, Rolf Johansson, Henrik Lönn, Martin Törngren. Engineering Support for Automotive Embedded Systems – Beyond AUTOSAR. FISITA world automotive congress, Sept. 14-19, 2008, Munich.

DeJiu Chen, Rolf Johansson, Henrik Lönn, Yiannis Papadopoulos, Anders Sandberg, Fredrik Törner, Martin Törngren. Modelling Support for Design of Safety-Critical Automotive Embedded Systems. SAFECOMP 2008. The 27th International Conference on Computer Safety, Reliability and Security, 22-25 September 2008, Newcastle upon Tyne, UK.

H. Blom, R. Johansson, H. Lönn. Annotation with Timing Constraints in the Context of EAST-ADL2 and AUTOSAR – the Timing Augmented Description Language. STANDRTS'09 (Workshop on the Definition, evaluation, and exploitation of modelling and computing standards for Real-Time Embedded Systems) at ECRTS 2009, Dublin, Ireland.

H. Espinoza, S. Gérard, H. Lönn, R. Tavakoli Kolagari. Harmonizing MARTE, EAST-ADL2, and AUTOSAR to Improve the Modelling of Automotive Systems. STANDRTS'09 (Workshop on the

Definition, evaluation, and exploitation of modelling and computing standards for Real-Time Embedded Systems) at ECRTS 2009, Dublin, Ireland.

Septavera Sharvia, Yiannis Papadopoulos. Model-based Safety Analysis Using Compositional Analysis and Formal Verification Techniques. Accepted for the 5th Int'l Conference on Computer Systems and Information Systems, Athens, July 2009.

Walker M., Papadopoulos Y., Parker D., Lönn H. Törngren M.,,Chen D., Johansson R. Sandberg A., Semi-Automatic FMEA supporting complex systems with combinations and sequences of failures, SAE 2009 World Congress, Paper # 2009-01-0738, 2009.

Mark-Oliver Reiser, Ramin Tavakoli Kolagari and Matthias Weber. Compositional Variability—Concepts and Patterns. In: Proceedings of the 42nd Hawaii International Conference on System Sciences (HICSS-42), IEEE Society Press, 2009.

Andreas Abele, Rolf Johansson, Henrik Lönn, Yiannis Papadopoulos, Mark-Oliver Reiser, David Servat, Martin Törngren and Matthias Weber. The CVM Framework --- A Prototype Tool for Compositional Variability Management. VAMOS'2010, 4th Fourth International Workshop on Variability Modelling of Software-intensive Systems, Linz, Austria, ICB report 37:101-108, ISSN 1860-2770.

Florian Kammüller, Alexander Rein, and Mark-Oliver Reiser. Feature Link Propagation Across Variability Representations with Isabelle/HOL. International Workshop on Product Line Approaches in Software Engineering. In: Proceedings of ICSE 2010

Matthias Biehl, Chen DeJiu, Martin Törngren. Integrating Safety Analysis into the Model-based Development Toolchain of Automotive Embedded Systems. In Proceedings of the LCTES 2010 (13-15 April 2010), ACM Press.Walker M., Papadopoulos Y. A Hierarchical Method for the Reduction of Temporal Expressions in Pandora, *8th European Dependable Computing Conference - DYADEM workshop*, Valencia, Spain, April, ACM Publications, 2010

Papadopoulos Y. Walker M., Reiser M-O, Weber M., Servat D., Abele A., Johansson R., Lonn H., Torngren M., Sandberg A. (2010), Automatic Allocation of Safety Integrity Levels, 8th European Dependable Computing Conference – CARS workshop, Valencia, Spain, April, ACM Publications, 2010

Lei Feng, DeJiu Chen, Henrik Lönn, and Martin Törngren: Verifying System Behaviors in EAST-ADL with the SPIN Model Checker. IEEE International Conference on Mechatronics and Automation. Xi'an, China, August 4-7, 2010.

Anders Sandberg, DeJiu Chen, Henrik Lönn, Rolf Johansson, Lei Feng, Martin Törngren, Sandra Torchiaro, Ramin Tavakoli-Kolagari, Andreas Abele: Model-based Safety Engineering of Interdependent Functions in Automotive Vehicles Using EAST-ADL. Accepted for the 29th International Conference on Computer Safety, Reliability and Security (SAFECOMP). Vienna, Austria. September 14 - 17, 2010.

M. Biehl, C.-J. Sjöstedt, and M. Törngren, "A modular tool integration approach - experiences from two case studies", in 3rd Workshop on Model-Driven Tool & Process Integration at the European Conference on Modelling Foundations and Applications, June 2010.

Mahmud N., Papadopoulos Y. Walker M., Translation of State Machines to Temporal Fault Trees, Dependable Systems and Networks (DSN '2010) – PFARM workshop, June 2010, Chicago, USA.

Nggada S.H., Parker D. J., Papadopoulos Y., Dynamic Effect of Perfect Preventive Maintenance on System Reliability and Cost Using HiP-HOPS, IFAC-MCPL 2010, 5th Conference On Management And Control Of Production And Logistics, 08 - 10 September 2010, Coimbra – Portugal

Walker M., Papadopoulos Y., A Hierarchical Method for the Reduction of Temporal Expressions in Pandora, *8th European Dependable Computing Conference - DYADEM workshop*, Valencia, Spain, April, 2010

Nggada S.H., Papadopoulos Y., Parker D. J., Extending HiP-HOPS with Capabilities of Planning Preventative Maintenance, 6th International Conference On Computer Science & Information Systems, Athens, June 2010.

Dheedan A., Papadopoulos Y., Multi-Agent Safety Monitoring System, *IFAC workshop on Intelligent Manufacturing Systems (IMS'10),* Lisbon, June 2010.

6.1.4 Theses

PhD thesis. Carl-Johan Sjöstedt. Modeling and simulation of physical systems in a mechatronic contexts, 2009-09-06. PhD thesis, Royal Institute of Technology (KTH).

PhD thesis. Martin Walker, Pandora: A Logic for the Qualitative Analysis of Temporal Fault Trees, University of Hull, 2009.

PhD thesis. David Parker, Multi-Objective Optimisation of Safety-Critical Hierarchical Systems, University of Hull, 2010.

6.1.5 Published articles in Technical magazines

Philippe Cuenot, Patrik Frey, Rolf Johansson, Henrik Lönn, David Servat, Ramin Tavakoli Kolagari, Matthias Weber, Martin Törngren. ENGINEERING SUPPORT FOR AUTOMOTIVE EMBEDDED SYSTEMS – BEYOND AUTOSAR
ATZ Autotechnology. Invited technical article. ATZautotechnology 2-2009 (April).

6.1.6 Other papers published by the partners, related to the ATESST2 project

A number of papers and reports have been published by KTH within the DySCAS project. Some of them explicitly reference the EAST-ADL, in particular with reference to the abstraction level hierarchy. A main reference with relevance to model based development is the following one:

DeJiu Chen, Martin Törngren, Magnus Persson, Lei Feng, and Tahir Naseer Qureshi. Towards Model-Based Engineering of Self-Configuring Embedded Systems. Invited chapter in the LNCS volume on "Model-Based Engineering of Embedded Real-Time Systems", Holger Giese, Bernard Rumpe, Bernard Schätz, Editors. In print.

6.2 Presentations, demonstrations and workshops in ATESST2

6.2.1 Participation in events

Participation in IST Coordination/concertation events towards academia and industry – Goal to participate in at least 4 events:

The ATESST2 project has contributed to several EUCAR events, including the EUCAR Reception and Conference on Nov. 26th, 2008, and to the EUCAR Integrated Safety Program Board in Sept. 2008, May 2009, May 2010 and EUCAR Mobility and Transport Program Board, June 2010.

A presentation on Architecture Description languages and EAST-ADL was given at the RTiS Summer School 2009 organized by Swedish National Real Time Association .

6.2.2 Company internal presentations

ATESST2 / EAST-ADL concepts were presented (talk and poster) on the annual Continental internal AUTOSAR conference, September 2009.

ATESST2 / EAST-ADL concepts were presented in several Volvo internal workshops

6.2.3 Press releases and publications in engineering magazines

One publication in the ATZ magazine.

6.2.4 Open workshops organized by ATESST2

Apart from the open workshop towards the end of the project, the project also participated actively in the following workshops:

FESA workshop - http://www.artist-embedded.org/artist/Overview,1937.html (coorganized with ArtistDesign).

TIMMO workshop - http://www.timmo.org/events.htm

6.2.5 International conferences with ATESST2 presence

All of the above conference/workshop papers were presented at the corresponding conferences/workshops.

Apart from this, the EAST-ADL was also presented on 2008-09-29 and 2008-11-11 at workshops organized by the KTH based centre for Embedded systems - ICES. The workshops focused on on Model-based development (http://www.kth.se/itm/centra/ices?l=en_UK) – with close connection to the WP2 – requirements and needs elicitation and state of practice, and including dissemination of the EAST-ADL.

6.2.6 Invited talks regarding EAST-ADL

- Matthias Weber: Invited Talk, Model-Based Development in Automotive Electronics – The EAST-ADL, Invited Talk at Methoden und Beschreibungssprachen zur Modellierung und Verifikation von Schaltungen und Systemen (MBMV 09), Berlin 2009, PDF. (Mattias W.)
- Martin Törngren. Multiparadigm modeling in the Mechatronics domain. 2009 Bellairs Computer Automated Multi-Paradigm Modeling workshop (http://msdl.cs.mcgill.ca/conferences/CAMPaM/2009/).
- Henrik Lönn. Advanced Software Architecture seminar at Chalmers: Invited EAST-ADL presentation May 2010.

- Henrik Lönn. Mälardalen Real-Time Centre, Mälardalens Högskola: Invited EAST-ADL presentation May 2010
- Yiannis Papadopoulos, Invited Opening Talk, Model-based Safety Assessment - Journées MISSA-CISEC, Workshop organised by MISSA FP7 project and the French Safety Critical Systems Club, Institut Aeronautique et Spatial (IAS), Toulouse, France, 8-9 February 2010 (http://cisec.enseeiht.fr)

6.3 ATESST interactions with other project and companies

It is important for ATESST2 to share intermediate results with other projects. In the ATESST1 project, the meta-model was provided to some related projects (with some overlap in partners). This was conceived as beneficial since the ATESST project received feedback and since the ATESST results were also used by other projects (including TIMMO and EDONA).

The projects and standardization initiatives, and tool providers of interest for sharing the EAST-ADL language results (domain model), UML profile and tools are those listed in below and in Section 5.

Procedures for interactions with other projects are described in the project handbook.

There are a number of related projects. A complementing survey is provided by the state of the art deliverable. Here are some of the most closely related projects.

SAFESPOT ((http://www.safespot-eu.org/) is a European integrated project (FP6) in the cooperative systems area. The project is relevant for ATESST2 as it lays foundation for cooperative systems, in terms of their applications, architecture, communication and testing. CRF and VTEC are partners of this project.

HAVE-IT (http://www.haveit-eu.org/) is a European FP7 integrated project on active safety/driver assistance systems. Conti and VTEC are members. The HAVE-IT reference architecture model has been used as a case study in ATESST2.

TIMMO (https://www.timmo.org/) is an ITEA project focused on developing a formalized, common language and methodology to deal with timing information in the design of embedded real-time systems. The project uses AUTOSAR and EAST-ADL as a basis and is thus an important partner for harmonization. CEA, CONTI and VTEC are partners. The TIMMO project finishes in Sept. 2009. The ATESST2 project has integrated TIMMO results into the EAST-ADL and also taken over the TIMMO newsletter.

EDONA (http://www.edona.fr/) is a French national project dealing with automotive software development. The project has a close connection to TIMMO and also uses AUTOSAR and EAST-ADL as a basis. CONTI and CEA are partners.

ArtistDesign (http://www.artist-embedded.org/artist/) is the European Network of Excellence on Embedded systems design, thus providing an important interaction forum.

ADAMS – is an EU FP7 dissemination action closely related to MARTE (see next section). CEA and VTEC are partners in this project.

MODELISAR (http://www.itea2.org/public/project_leaflets/MODELISAR_profile_oct-08.pdf) is a new ITEA project on MODELICA+AUTOSAR for systems modeling and in particular co-simulation. VTEC is a member of MODELISAR. Connections and interactions were investigated (VTEC, KTH) and interaction meetings organized.

CESAR (http://www.cesarproject.eu/) is a new ARTEMIS project focusing on design methods and tools for embedded systems over several domains. KTH, VTEC, CEA, CRF and partners in both projects. CESAR aims to establish a reference technology platform (RTP) for safety critical

embedded systems. CESAR started in March 2009, and has shown a strong interest in adopting the EAST-ADL as part of the RTP. Coordination meetings have been carried out with the CESAR coordinator, the EAST-ADL has been disseminated to the CESAR project, and several interactions have taken place with the subprojects of CESAR. ATESST2 has decided to release the new EAST-ADL meta-model to the CESAR project. The CESAR project is adopting the EAST-ADL as a basis for the CESAR meta-model

JASPAR (Japan Automotive Software Platform and ARchitecture) – is a non-profit organization in Japan including automotive OEMs, Tier-1 suppliers, semiconductor venders, software venders, and related companies in automotive technology field. Information has been exchanged through a meeting.

EUCAR (European Council for Automotive R&D) ATESST2 is one of the projects in the Integrated Safety Programme and has been presented in each of the ISP board meetings since 2008.

The ATESST2 partners have excellent connections with these projects and have partners that are members of several of these projects.

6.3.1 Tool vendors

A list of related tool vendors is given here (name and tool profile) with which communication has been performed within the project:

ETAS: Automotive SW development, Autosar

Geensys: Meta-model driven domain specific languages, Autosar

GNOMON: Safety analysis

ISOGRAPH: Safety analysis, interfaces to HiP-HOPS

ITI: Modelica simulator, HipHops support

Mentor Graphics: Autosar, Meta-model driven domain specific languages. A partial EAST-ADL implementation is available in the VSA tool.

Metacase: Meta-model driven domain specific languages. MetaCase: Meta-modeling (DSL) environment. They have implemented the EAST-ADL for at least one automotive customer.

Pure-systems: Variability editor

Systemite: Meta-model driven domain specific languages

MagicDraw: UML tool vendor providing UML2 profile for EAST-ADL

6.4 Interactions with standardization initiatives

The main related ones

MARTE (http://www.omgmarte.org/) is an ongoing OMG effort in providing a standardized UML Profile for Real-Time and Embedded Systems (MARTE), addressing modeling and analysis. The emphasis is in particular on performance and schedulability analysis. EAST-ADL is included as an appendix within the MARTE standard.

AUTOSAR (www.autosar.org) is a major automotive effort for software architecture standardization and component modeling. Automotive software development will be heavily influenced by the AUTOSAR approach and is thus a critical interaction point. ATESST2 results needs to be harmonized with AUTOSAR, and the AUTOSAR community needs to be aware of ATESST2 results to make these generally accepted. The EAST-ADL is developed as a language that complements Autosar. It has been decided within ATESST2 to reinforce the dissemination of

EAST-ADL to Autosar. For the 2nd period, the goals are to set up meetings with the Autosar steering team, making the "M3"-level of EADL conformant to the Autosar M3 level, defining EADL "templates", e.g. functional level similar to Autosar, and in providing a process description explaining how to handle the "integration (process, technology)" from EADL to Autosar.

ISO 26262 – an ISO safety standard being developed for automotive embedded systems. EAST-ADL is being tuned to smoothly support a model-based ISO safety process.

The ATESST2 partners have excellent connections with these efforts and have partners that are members.

The **ProSE** project (www.prose-project.eu) is a supporting action in the Framework Programme, in the field of Embedded Systems, addressing objective FP7-ICT-2007.3.7 (Networked Embedded Systems & Control Systems/Middleware/industry-driven initiatives for standardization activities in the broader embedded systems domain). ProSE aims to make recommendations for purposeful and efficient standardization in Embedded Systems, facilitating the evolution of synergies across business domains.

At the ProSE open workshop in Darmstadt on 26.11.2009 (http://www.igd.fraunhofer.de/igd-a1/prose-survey/workshop.html), the EAST-ADL was presented by Continental as a candidate for standardization.

6.5 ATESST2 web-site

The ATESST2 web-site constitutes an important means for disseminating results. The web-site: www.atesst.org was established during the predecessor project and at this point in time contains a description of the first ATESST project including a large amount of accessible material (deliverables, publications, poster, downloadable tool, etc.).

The www.atesst.org web-site has been restructured to make clear distinctions between the projects (ATESST and ATESST2) and the language assets (EAST-ADL).

6.6 Web site statistics

The ATESST2 web site has had about 1800 hits per month on average from April 2008 to April 2009.

6.7 Other supporting ATESST2 dissemination material

To assist in the dissemination of ATESST2, a number of different supporting materials have been developed during ATESST2, These are briefly described in the following.

6.8 Posters

A poster has been developed. This was revised for the planned Sept. 2009 exhibition, the TIMMO final workshop and finally the ATESST2 open workshop.

6.9 Brochure

A brochure has been developed for the ATESST2 final workshop.

6.10 Concept presentations

During the M2 meeting of the ATESST2 project it was agreed that more introductory material to the EAST-ADL and its various aspects was required.

Since then concept presentations addressing more than 15 aspects of the language have been developed and made available on the project website.

6.11 Electronic newsletter and Reference group

Already during the predecessor project, an email list was set up. This was continued during ATESST2, in order to provide dedicated information on ATESST2 events and new results. A newsletter has been published regularly, take-over from the TIMMO newsletter when the TIMMO project finished in September 2009.

In addition, a reference group has been formed to provide feedback on project directions, technical requirements and results.

The reference group includes representatives from identified stakeholders such as tool providers, research and governmental institutes including those working on certification, and additional automotive companies. With respect to tool provides, the specification of tools to support the methodology defined in the project will be provided to external parties. In return, practitioners will be invited to present actual tool features and give feedback to the project concepts. Moreover, the reference group will investigate the capabilities and possible adaptation of existing tools to the new methodology. These activities will be facilitated by open workshops and a platform for information exchange.

The current reference group (persons who agreed to act as reviewers of selected project results or answer questions) is listed here.

Tool Vendors
Alain LeGuennec, Esterel technologies
Andreas Uhlig, ITI GmbH
Danilo Beuche, pure-systems
Jan Söderberg, Systemite
Juha-Pekka Tolvanen, Metacase
Pascal Gula, Geensys
Patrick Frey, ETAS
Steve Flanagan, ISOGRAPH
Ulrich Freund, ETAS
Vassiliadis Vangelis, GNOMON SA

Institutes
Anders Haggard, Swedish Road Administration
Arnaud.de_La_Fortelle, INRIA
Bengt Hallström, Swedish Road Administration
Jan Jacobsson, SP
Jonas Jansson, Swedish National Road and Transport Research Institute
Jeff Sanders, UN University
Martin Hobelsberger, University of Applied Science, Regensburg
Karl-Henrik Johansson, Automatic Control, KTH
Prof. Pierre-Alain Müller, Université Haute Alsace

Related Projects/Companies
Andras Kovacs, Efcon Ag
Hans Alminger, Volvo Cars
Roberto Brignolo, CRF Coordinator, SafeSpot
Stefan Kuntz, Continental - VDO Automotive AG

6.12 Conclusions and Contribution to overall ATESST2 objectives

Bidirectional dissemination is essential for the ATESST2 project, and is taken seriously, including interactions with related projects, standardization activities as well as other stakeholders.

Referring to the goals as stated in the DoW, the outcomes from the project dissemination are summarized here:

- Conference publications (15) – Achievement: **23**
- Participation in IST Coordination/concertation events (4) – Achievement: **5**[3]
- Dissemination of project activities and results to the public (2) – Achievement: 4[4]
- Directed, Open Seminars (1) – Achievement: **3**
- Interactions with related projects (5) – Achievement: **10**
- Interaction with Reference group (4) – Achievement: **4**

In conclusion, ATESST2 has been performing well indeed with respect to dissemination.

6.13 List of larger major events where EAST-ADL dissemination was performed

The ATESST2 project has on a number of occasions been presenting the EAST-ADL language. This includes events such as academic workshops, larger project meetings/workshops, open workshops and through presentations at exhibitions. The following is a list of such events.

- Contributions to the EUCAR Reception and Conference on Nov. 26th, 2008, and to the EUCAR Integrated Safety Program Board in Sept. 2008, May 2009 and May 2010.
- ICT, European Commission conference, Spring 2009 in Stockholm - ATESST2 presentation through a poster.
- Public PhD defense - PhD thesis. Carl-Johan Sjöstedt. Modeling and simulation of physical systems in a mechatronic contexts, 2009-09-06. PhD thesis, Royal Institute of Technology (KTH).
- Presentation of EAST-ADL concepts for a delegation from Jaspar, Jan 2009
- Presentation on Architecture Description languages and EAST-ADL at the RTiS Summer School 2009 organized by Swedish National Real Time Association .
- Participation of ATESST2, with EAST-ADL poster at the TIMMO open workshop,. Sept. 2009.
- ProSE open workshop, Darmstadt on 26.11.2009 (http://www.igd.fraunhofer.de/igd-a1/prose-survey/workshop.html) - EAST-ADL presentation by Continental as a candidate for standardization.
- Formalisms for Embedded systems architecture description and visualization – workshop part of the CPSweek including presentation and demo of the EAST-ADL, KTH, April 2010. http://www.artist-embedded.org/artist/Overview,1937.html

[3] One IST event and four EUCAR events.

[4] One technical magazine publication and one PhD thesis including its public presentation and defence.

- CESAR project internal meetings: Several presentation of the EAST-ADL during 2009-2010.
- Presentation including a demo of the EAST-ADL as part of the CESAR ARTEMIS project review, May 2010.
- AUTOSAR Timing Team Meeting: Presentation of EAST-ADL concepts for abstract system content, May 2009
- AUTOSAR Safety Team Meeting: Presentation of EAST-ADL concepts for safety life cycle information representation, October 2009.
- Final Open Workshop of the ATESST2 Project, 21 June 2010, Frankfurt
- Presentations of the EAST-ADL within meetings part of standardization work, including ISO26262 and MARTE (OMG)
- Presentations of the EAST-ADL at the iFEST ARTEMIS project kick-off, April 14, 2010.
- Presentations of EAST-ADL at the ADL workshop at CPS Week, April 2010, Stockholm
- Presentations of conference papers including the following:
    - SAFECOMP 2008. 27th Int. Conference on Computer Safety, Reliability and Security. 22-25 September 2008, Newcastle upon Tyne, UK
    - Beyond AUTOSAR. FISITA world automotive congress, Sept. 14-19, 2008, Munich.
    - SAE 2009 World Congress,
    - ECRTS 2009, STANDRTS Workshop, June 2009, Dublin, Ireland
    - 5th Int'l Conference on Computer Systems and Information Systems, Athens, in July 2009.
    - 42nd Hawaii International Conference on System Sciences (HICSS-42), IEEE Society Press, 2009
    - VAMOS'2010, 4th Int. Workshop on Variability Modelling of Software-intensive Systems, Linz, Austria
    - CPSWeek, LCTS conference, April 2009
    - 8th European Dependable Computing Conference – CARS workshop, Valencia, Spain, April, 2010
    - Dependable Systems and Networks (DSN '2010) – PFARM workshop, June 2010, Chicago, USA
    - SafeComp 2010, forthcoming
    - Henrik Lönn and Gerhard Stempfer: Experience of AUTOSAR-compliant development of a Power-Shift-Transmission-Control and outlook to future standards including ISO 26262, Modelisar and EASTADL VDI Transmissions in Vehicles June 2010, Friedrichshafen
- Invited talks regarding the EAST-ADL:
    - Matthias Weber: Invited Talk, Model-Based Development in Automotive Electronics – The EAST-ADL, Invited Talk at Methoden und Beschreibungssprachen zur Modellierung und Verifikation von Schaltungen und Systemen (MBMV 09), Berlin 2009, PDF. (Mattias W.)
    - Martin Törngren: Multiparadigm modeling in the Mechatronics domain. 2009 Bellairs Computer Automated Multi-Paradigm Modeling workshop (http://msdl.cs.mcgill.ca/conferences/CAMPaM/2009/).

- Henrik Lönn and Daniel Karlsson: EAST-ADL Overview, invited talk at Chalmers University of Technolgy, Advanced Software Architecture seminar series .
- Henrik Lönn: ”Tooling strategy for the EAST-ADL language”. First Workshop on Hands-on Platforms and tools for model-based engineering of Embedded Systems (HoPES'10), in Sixth European Conference on Modelling Foundations and Applications

In addition several company and University internal presentations have been carried out. For example, ATESST2 / EAST-ADL concepts were presented (talk and poster) on the annual Continental internal AUTOSAR conference, September 2009.