



IST-004527 ARTIST2
Network of Excellence
on Embedded Systems Design

Activity Progress Report for Year 3

JPRA-Cluster Integration
**Development of UML for
Real-time Embedded Systems**

Clusters:

Real Time Components

Activity Leader:

Dr. Sébastien Gérard (CEA LIST)

Policy Objective (abstract)

To develop a framework for handling central aspects of Real time Systems in UML-based notations, and in UML-based system development. This will influence standardization and allow European UML-based tool providers to have a larger impact.

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1. Overview of the Activity

1.1 ARTIST Participants and Roles

Dr. Sébastien Gérard – CEA (Fr)

Areas of his team's expertise: standard modelling and RT/E (Real-Time/Embedded) domains.

Dr. Susanne Graf – VERIMAG (Fr)

Areas of his team's expertise: modelling of real-time components.

Pr. Jean-Marc Jezequel – INRIA (Fr)

Areas of his team's expertise: UML Meta-model.

Dr. Julio Medina - Cantabria university (Sp)

Areas of his team's expertise: model-based schedulability analysis.

1.2 Affiliated Participants and Roles

Pr. Ivica Crnkovic – MdH (Se)

Areas of his team's expertise: component models.

Dr. Stefan van Baelen - K.U. Leuven (Be)

Areas of his team's expertise: QoS specification.

Dr. Bernhard Josko – OFFIS (Ge)

Areas of his team's expertise: real-time UML.

Dominique Potier – Thalès Research and Technology (Fr)

Areas of his team's expertise: standardization and case study from the aerospace or telecommunication domain.

Dr. Matthias Grochtmann – DaimlerChrysler (Ge)

Areas of his team's expertise: specification, design and implementation of automotive systems.

Dr Henrik Lönn – Volvo (SE)

Areas of his team's expertise: specification, design and implementation of automotive systems.

1.3 Starting Date, and Expected Ending Date

Starting date: September 1st, 2004.

Expected ending date: End of the project.

In fact, the expected ending date is setup to the end of the project but this activity will probably continue after because of its OMG expected lifecycle. Indeed, the MARTE standard is now voted and accepted in its Beta1 version. The Finalization Task Force for MARTE has also been launched by OMG within the OMG Brussels meeting in July 29th, 2007. This activity will last for at least one year (its expected deadline is July 2008). After that, it is also expected for a revision of the MARTE standard in order to deal with the issues that it was not possible to handle within the Finalization Task Force. These issues and other possible improvements of the MARTE standard will then have to be taken into account within the expected next step of the OMG standardization process, i.e. the Revision Task Force. This latter activity will provide the version 1.1 of MARTE.

1.4 Baseline

Since the adoption of the UML standard and its new advanced release UML2, this modelling language has been used for development of a large number of time-critical and resource-critical systems. Based on this experience, a consensus has emerged that, while a useful tool, UML is lacking in some key areas that are of particular concern to real-time and embedded system designers and developers. In particular, it was noticed that first the lack of quantifiable notions of time and resources was an impediment to its broader use in the real-time and embedded domain. Second, the need for rigorous semantics definition is also a mandatory requirement for a widespread usage of the UML for RT/E systems development. And third, specific constructs were required to build models using artefacts related the real-time operating system level such as task and semaphore.

Fortunately, and contrary to an often expressed opinion, it was discovered that UML had all the requisite mechanisms for addressing these issues, in particular through its extensibility facilities. This made the job much easier, since it was unnecessary to add new fundamental modelling concepts to UML – so-called “heavyweight” extensions. Consequently, the job consisted in defining a standard way of using these capabilities to represent concepts and practices from the real-time and embedded domain.

Hence, this specification of a UML™ profile adds capabilities on the one hand for modelling Real Time and Embedded Systems (RT/ES), and on the other hand for analyzing schedulability and performance properties of UML specifications. This new profile is intended to replace the existing UML Profile for Schedulability, Performance and Time [UML profile for Schedulability, Performance, and Time, version 1.1., formal/05-01-02, 2005]. This extension, called the MARTE profile, should address specification, design, and verification stages of the development cycle of RT/ES. It wants to address the two branches of the V cycle, i.e. design and validation& verification. Modelling capabilities have to ensure both hardware and software aspects of RT/ES in order to improve communication/exchange between developers. It has also to foster the construction of models that may be used to make quantitative analysis regarding hardware and software characteristics. Finally, it should enable interoperability between developments tools used all along the development process.

1.5 Problem Tackled in Year 3

Continue the year1 and year2 work in order to develop a UML-based proposal defining model constructs for modelling and analysing of real-time and embedded systems. Special focus is put on representing resources, timing, RT/E qualities of service, communication modes, execution modes, component model.

Within this year3, we also continued to review and suggest changes to the Object Management Group (OMG - responsible for defining the UML standard) by providing inputs on standardization of UML profiles specific to real-time systems: the UML profile for MARTE.

Experiments on the usage of MARTE, which were started in Year2, have also been continued in order to assess the technical soundness of the MARTE proposal.

1.6 Comments From Year 2 Review

1.6.1 Reviewers' Comments

ACCEPTED

This document could benefit from an editing pass by a native English speaker; this would improve its appearance and appeal. The document content is of very good quality. It clearly shows what has been achieved, what the future work is and what the reasons are for that. It is synthetic, factual and full of references. Integration works between partners would have benefited from some additional details.

The post-review version of the document corrects the typography of the pre-review version. Except in section 1.5 where OMG still stand for "OBJECT management group" rather than "OPEN management group".

The timetable needs to be updated.

1.6.2 How These Have Been Addressed

Integration work has been clarified (hope so).

Meaning of OMG in section 1.5 has been corrected: "Object Management Group" instead of "Open Management Group"

The timetable has been updated.

2. Summary of Activity Progress

2.1 *Previous Work in Year 1*

The first year of this activity has been dedicated to firstly influence on the writing of the request for proposal (RFP) of the new UML profile for real-time and embedded systems. This RFP expresses all the requirements the new standard will have to satisfy. The RFP, document referenced at OMG web server as realtime/05-02-06 (UML Profile for Modelling and Analysis of Real-Time and Embedded systems (MARTE) RFP)) has been voted and accepted in the context of the Real-time, Embedded, and Specialized Systems (RTESS) Platform Task Force in February 2005: UML Profile for Modelling and Analysis of Real-Time and Embedded systems (MARTE) RFP , realtime/05-02-06, <http://www.omg.org/cgi-bin/doc?realtime/05-02-06>.

Within the second half year period, the job consisted in both following action (main part of this work has been performed within the French CARROLL-Protes project):

- To setup an OMG submitter team in order to answer to the RFP. The team that has been organized is called the ProMARTE team: www.promarte.org. This team consists of the main companies (end users and tool providers) involved in this aspect at the OMG. It is composed of: Artisan, Carlton university, CEA, IBM, I-Logix, INRIA, Looked-Martin, Thales, Tri-Pacific.
- To write the initial submission of the ProMARTE team that has been delivered in November 2005: Joint UML Profile for MARTE Initial Submission, realtime/05-11-01, <http://www.omg.org/cgi-bin/doc?realtime/2005-11-01>

Within this first year, in the context of the Omega project, Verimag aimed at the definition of an UML profile appropriate for real-time embedded systems based on the existing SPT profile. The extension done in Omega introduces a notion of "observer" and emphasizes the importance of capturing the relevant events which make reference to the system at execution and is used to capture its dynamic properties.

2.2 *Previous Work in Year 2*

A consolidated architecture for the MARTE profile

The MARTE profile architecture model consists of three main packages:

- The Time and Concurrent Resource Modelling package (TCRM); it defines basic model constructs for time and resource, especially concurrent resources. These foundational concepts are then refined in both of the following package in order to fit with both modelling and analyzing concerns.
- The Real-Time and Embedded application Modelling package (RTEAM); it enables modelling of RT/E application. It concerns mainly defining high-level model constructs to depict real-time and embedded features of application, and to enable the description of execution platforms, software as well as hardware.
- The Real-Time and Embedded application Analysis; it provides a generic support for analyzing annotated models. This generic framework is also refined in order to cope with schedulability and performance analysis. It is also expected that the generic framework for analysis will be specialized/extended to support other kind of quantitative analysis, such as power consumption, memory use or reliability.

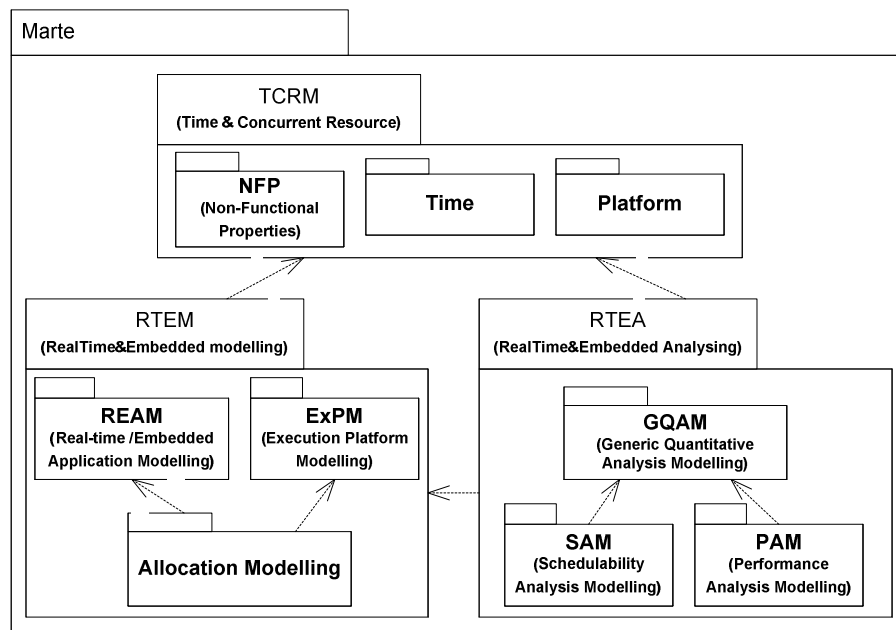


Figure 1. Current architecture of the MARTE profile.

Difficulty: Dissemination issue due to privacy rule of an ongoing work at OMG

Actually, OMG ongoing work performed in OMG consortium such as the ProMarte one is considered to be private until final vote. So, the only available documents related to MARTE in the year 2 was the initial submission that provides only an outline of the proposal; it does not go into the details of the proposed concepts. So, only members of the ProMarte consortium can access the full information of the standard, i.e. CEA (the leader of the activity), INRIA, Thales and Cantabria University.

2.3 Current Results

2.3.1 Technical Achievements

Harmonization of the MARTE standard (CEA, Cantabria University and Thalès Research and Technology)

The works performed within this activity consisted in making consistent the whole specification which is made of several dependant parts. The main goal was then to harmonize/align all sub-profiles contained within the MARTE specification. As for example, both following specific profiles dedicated to platform modelling, the Hardware Resource Model (HRM) and the Software Resource Model (SRM). have been aligned with the more generic profile contains in the MARTE foundation package, the Generic Resource Platform subprofile. This latter defines a set of standard concepts dedicated to model system-level computing platform. <http://omgmarte.org>. All the job performed within this activity led to a new MARTE architecture as shown on the following figure.

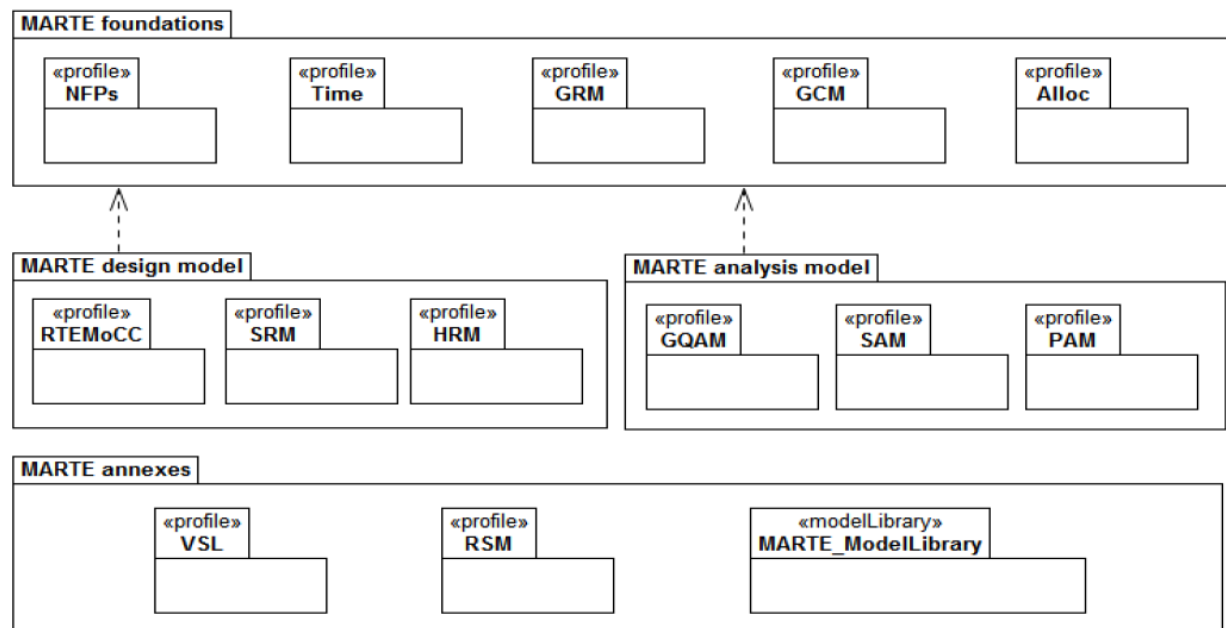


Figure 2. Final architecture of the MARTE profile.

Debugging of the MARTE standard (CEA, Cantabria University and Thalès Research and Technology)

Within this period, we have continued to experiment with MARTE in different case studies. All these experiments were used to debug MARTE and hence have contributed a lot to improve its quality and soundness.

Dissemination (CEA, Cantabria University and Thalès Research and Technology)

The end of this period was also dedicated to build the first materials needed to disseminate MARTE among industry and academics. A web site (hosted by the OMG consortium) has been set up. Among other, this web site gathers all the papers, tutorials and events related to MARTE.

<http://www.omgmarte.org>

2.3.2 Individual Publications Resulting from these Achievements

CEA

S.Taha, A. Radermacher, S.Gerard and J.-L. Dekeyzer, "An Open Framework for Hardware Detailed Modeling", In IEEE Proceedings of SIES'2007, ISBN 1-4244-0840-7, Lisbon, Portugal, July 2007.

S.Taha, A. Radermacher, S.Gerard, and J.-L. Dekeyzer, "MARTE: UML-based Hardware Design from Modeling to Simulation", In Proceedings of the International Conference Forum on Specification and Design Languages (FDL) 2007, Barcelona, Spain, September 2007.

F. Thomas, S. Gérard, J. Delatour and Francois Terrier, "Software Real-Time Resource Modeling.", In Proceedings of the International Conference Forum on Specification and Design Languages (FDL) 2007, Barcelona, Spain, September 2007.

F. Thomas, H. Espinoza, S. Taha and S. Gérard, "MARTE : le futur standard OMG pour le développement dirigée par les modèles des systèmes embarqués temps réel", Génie Logiciel, Volume 80, p.27-31, March 2007.

Thales

M. Faugère, T. Bourbeau, R. de Simone and S. Gérard, "MARTE: Also an UML Profile for Modeling AADL Applications", In proceeding of ICECCS 2007, Auckland, New Zeland, July 2007.

Cantabria University

"RT-CCM: Tecnología de componentes de tiempo real basada en Ada 2005". P.López, P.Pacheco, J.M.Drake and J.L. Medina. II Simposio de Sistemas de Tiempo Real in the 2º Congreso Español de Informática (CEDI 2007), Zaragoza - SPAIN, September 2007

2.3.3 Interaction and Building Excellence between Partners

CEA, Cantabria University, INRIA and Thales:

- Members of the ProMARTE team who have proposed MARTE to OMG
- Members of the OMG Finalization Task Force for MARTE
- Co-writing of a Tutorial for MARTE (www.omgmarte.org)

CEA and Thales:

- Ongoing experiments on the usage of MARTE for Thales Business Units
- Dissemination of MARTE inside Thales Business Units

CEA and Cantabria University:

- Joint work focussed on the usage of MARTE for performing schedulability analysis in a model-driven process (ACCORD)
- Common participation to Tutotials on MARTE (e.g. ECRTS 2007 and FDL2007)

CEA, Volvo and KTH:

- Within the ATESSST project (www.atesst.org) dissemination to automotive industries including Volvo (ARTIST2 affiliated partner) and KTH (ARTIST2 core partner) has been carried out.

2.3.4 Joint Publications Resulting from these Achievements

M. Faugère (Thales), T. Bourbeau (Thales), R. de Simone (INRIA) and S. Gérard (CEA), "MARTE: Also an UML Profile for Modeling AADL Applications", In proceeding of ICECCS 2007, IEEE Computer Society, New Zealand, July 2007.

Philippe Cuenot, DeJiu Chen, Sébastien Gérard, Henrik Lönn, Mark-Oliver Reiser, David Servat, Ramin Tavakoli Kolagari, Carl-Johan Sjöstedt, Martin Törngren, Matthias Weber. Managing Complexity of Automotive Electronics Using the EAST-ADL. In Proc. of the 2nd Int. UML&AADL Workshop (UML&AADL'2007) at the 12th Int. Conf. On Engineering of Complex Computer Systems, Auckland, New Zealand, July 11 - 14, 2007.

Philippe Cuenot, DeJiu Chen, Sébastien Gérard, Henrik Lönn, Mark-Oliver Reiser, David Servat, Ramin Tavakoli Kolagari, Martin Törngren, Matthias Weber. Improving Dependability by Using an Architecture Description Language. Accepted book chapter contribution for the forthcoming book Architecting Dependable Systems IV. Editors: Rogerio de Lemos, Cristina Gacek, Alexander Romanovsky. Springer series: Lecture Notes in Computer Science, Vol .4615, 2007. ISBD 978-3-540-74033-9.

2.3.5 Keynotes, Workshops, Tutorials

Tutorial: MARTE: A New Standard for Modeling and Analysis of Real-Time and Embedded Systems, 19th Euromicro Conference on Real-Time Systems (ECRTS 07)

Pisa, Italy – July 3rd, 2007 (around 15 participants)

Sébastien Gérard (CEA), Julio Medina (Cantabria University) and D. C. Petriu (Carleton University) - the purpose of this tutorial has been to introduce the participants to the issues of model-driven development of RT/E applications and present how to use MARTE, the new OMG standard for dealing with model-driven development of RT/E applications. Considering the expertise of the audience in schedulability and performance analysis, special attention was made on the description of the MARTE analysis capabilities.

<http://feanor.sssup.it/ecrts07/tutorial.shtml>

Tutorial: UML Tutorial: MARTE

Forum on specification & Design Languages (FDL'07)

Barcelona, Spain – September 20, 2007 (around 40 participants)

Sébastien Gérard (CEA) with the participation of Julio Médina (CEA & University of Cantabria), - the purpose of this tutorial is then to introduce the participants to the issues of model-driven development of RT/E applications and present how to use the new OMG standard for dealing with model-driven development of RT/E applications. FDL being a conference gathering mainly people work on research areas related to Hardware, this tutorial attempted to put a particular focus on this feature of the MARTE standard.

<http://www.ecsi-association.org/ecsi/fdl/fdl07/>

Keynote: A new standard unified language for real-time and embedded systems

Forum on specification & Design Languages (FDL'07)

Barcelona, Spain – September 20, 2007 (around 100 participants)

Laurent Rioux (Thales) - MARTE (A UML Profile for Modelling and Analysis of Real-Time and Embedded systems) is a new UML profile extension for real-time and embedded systems, which has been standardized in mid 2007 by the OMG (Object Management Group). This standard has been proposed by the "ProMarte" consortium, which consists of OMG end-users, tool providers and academics. MARTE defines concepts in terms of UML extensions needed to model and analyze real-time and embedded systems (RT/ES). MARTE bring solutions for specifying both software (middleware) and hardware platform resources, MDA compliance for separate description of the platform and the application to be allocated on it, and modelling of all kinds of non-functional properties (NFPs) such as time, but also power consumption or memory size. How MARTE is related to other standards like SysML, UML profile for QoS and UML 2? How MARTE can be specialized to address specific embedded domain as SystemC, SoC or AADL? How MARTE meet MDA approach for real-time and embedded systems?

<http://www.ecsi-association.org/ecsi/fdl/fdl07/>

3. Future Work and Evolution

3.1 *Problem to be Tackled over the next 12 months (Sept 2007 – Aug 2008)*

Over next year, we will mainly deal with the three following issues:

- Finalization of the MARTE specification

In June 2007, the OMG voted and accepted the MARTE proposal supplied by the ProMARTE consortium. This document is now referenced as the Beta1 version of MARTE. The normal OMG process of standardization was then to issue the Finalization Task Force which aims in finalizing the document by taking into account all the issues that may be raised (using the OMG issue mechanism which is detailed in the specification). The Finalization Task Force for MARTE will be chaired by CEA and co-chaired by Thales and IBM. This group has to provide its report and the final document for July 2008. At this time, a new document for MARTE will be defined; it will be the version 1.0.

- Continue the experiments

In parallel to the work achieved within the OMG FTF group, we will continue our experiments using MARTE for designing and analyzing UML models of RTE systems. The results of these experiments will be used first to assess MARTE concepts and to provide feedback to the standard raising issues if necessary. The results will also feed the next activity, dissemination, by providing model examples needed to illustrate the usage of the MARTE standard and hence ease its acceptance in industry.

- Foster dissemination

Finally the third important activity within this last period will be to foster the usage of MARTE within industrials and academics. For the former, the idea is to prepare as much as possible educational materials (e.g. tutorials and examples) in order to promote and ease the usage of MARTE in industry. For academics, we will promote MARTE as a vector of integration and dissemination of academics results (as for example academics results related to formal analysis of real-time systems) towards the industry.

3.2 *Current and Future Milestones*

- Year 1: preliminary work for standardizing an OMG profile for real-time and embedded systems.
 - Vote the MARTE RFP (realtime/05-02-06) *achieved in February 2005.*
 - MARTE initial submission (realtime/05-11-01) *achieved in November 2005.*
- Year 2: Revised version of the standard. The official revised version of the standard documents was initially due to Q4 2006, but has been postponed to Q1 2007.
- Year 3: Follow-up of the revised version of the standard.
 - Vote of the MARTE revised version scheduled for March 2007. *The vote of the standard has been shift for one OMG cycle meeting (i.e. 3 months) in order to be able to finalize some minor sections and to make sub profiles of MARTE more consistent together. The vote has then be done in June 2007.*
 - Milestone 4 (scheduled within Q4 2007): Artist feedback report on MARTE. *The work for this milestone still needs to start. This action did not yet start*

because of the delay of the MARTE vote. Now as MARTE has been accepted (Beta1 version) and because its finalization task force has been launched, this work should be started as soon as possible. It is scheduled to start this activity in October 2007.

- Year 4: MARTE Finalization Task Force.
 - **Milestone 5 (scheduled for Decembre 22nd, 2007), MARTE Issues:** the purpose of the work to perform to achieve this milestone is to continue to review the MARTE standard documents and to experiments its concepts in order to detect remaining errors/missing in the specification. And when some errors or missing information are detected, one may raise issues using the OMG' Issue Reporting procedure as describe in page 5 of the document. All these issues received before Decembre 22th, 2007 will be registered by OMG and the Finalization Task Force dedicated to MARTE will have to deal with them when defining the final version of MARTE.
 - **Milestone 6 (scheduled for June 2nd, 2008), MARTE Finalization:** the expected output of this milestone is firstly a report explaining how all issues received before Decembre 22nd, 2007 have been managed, that is to say what have been the decision and underlying modifications in the specification. Secondly, the Finalization Task Force will also provide a new document that will be the version 1 of MARTE if the previous report is accepted by the OMG Architecture Board.

3.3 Indicators for Integration

Joint work of members of this cluster on requirement analysis of RT/E domains for modelling has contributed to the success of the standardization of the Request for Proposal of the UML profile for MARTE.

Workshop organization related to this subject, the MARTES workshop series held within the Models conference series is another indicator of integration: first edition was collocated with Models2005 in Montego Bay (Jamaica) and the second edition will be held within the Models2006 in Geneva (Italy).

Participations of Artist members have been either active organizers or lecturers of the summer school MDD for DRES held in Brest (France) in September 2006.

Last, but not least, common work of Artist members that are also OMG members (i.e. CEA, Thales, INRIA and Cantabria University) has been a major input and driver of the MARTE standard. Moreover, these partners will continue to work together on the MARTE standard within the OMG Finalization Task Force. Let's also note that CEA is the chair of this OMG group and Thales is co-chair of it.

CEA and Cantabria will continue to work together on MARTE and MDD, specially working on the ability to connect the CEA toolbox (ACCORD) for designing RTE systems and the Cantabria Toolbox (MAST) for schedulability analysis. Julio Medina who did his PhD thesis in Cantabria and a post doc position in CEA, will go back to Cantabria and he will be key person for continuing this collaboration.

CEA and Thales have also closed collaboration on the usage of MARTE within an MDD process for designing their RTE systems.

3.4 Main Funding

The activity is mainly funded by the CARROLL initiative, a common research programme between Thalès, CEA and INRIA. In particular, by the PROTES and CORTESS projects of CARROLL which aims to initiate within the OMG an RFP (Request For Proposals) and submit a proposal for a UML profile for embedded systems.

The IST project ATESSST (<http://www.atesst.org/>) is also contributing to fund this activity for CEA, as well as both French projects Usine Logicielle (from “Pole de compétitivité Sysm@tic”) and OpenEmbeDD.

4. Internal Reviewers for this Deliverable

Martin Törngren (KTH, Se)

Eugenio Villar (University of Cantabria, Sp)