| | | | |
|---|---|---|---|
| **Acronyme / Acronym** | **GEMOC** | | |
| **Titre du projet** | Un framework de modèles de calcul génériques pour l'exécution et l'analyse dynamique de modèles | | |
| **Proposal title** | A *Generic Models of Computation Framework* for Model Execution and Dynamic Analysis | | |
| **Axe(s) thématique(s) / theme(s)** | ☐ 1 ☒ 2 ☒ 3 ☐ 4 ☐ 5 | | |
| **Type de recherche / Type of research** | ☒ Recherche Fondamentale / Basic Research<br>☐ Recherche Industrielle / Industrial Research<br>☐ Développement Expérimental : Experimental Development | | |
| **Coopération internationale (si applicable) / International cooperation (if applicable)** | Le projet propose une coopération internationale / International cooperation with :<br>☐ avec un ou des pays spécifiquement mentionnés dans l'appel à projets / countries explicitely cited in the call for proposal<br>☐ autres pays / other countries | | |
| **Aide totale demandée / Grant requested** | 982 720 € | **Durée du projet / Projet duration** | 40 mois (36+4) |

**Submission Context:**

**This project was submitted in 2011 in the same program and was ranked in the complementary list. We thank the reviewers for pinpointing the ambivalence of the project between advanced research and mature platforms. Considering these suggestions, the major change in this new submission consists in a more precise focus on advanced research, validation through prototypes (rather than simulation industrial platform), and strong evaluation with industrial use cases.**

**This major revision appears throughout the proposal in the following points:**

- **INRIA is more involved in research activities and their coordination rather than in tools integration and evaluation**
- **Prototypes are designed to validate industrial case studies. These case studies are chosen by industrial partners in connection with the expected scientific results.**
- **Thales is more involved in the development of these case studies as well as in the validation of prototypes (WP5).**
- **Thales is involved in all other work packages for requirements elicitation (WP2, WP3, WP4) and results dissemination (WP0).**
- **As recommended, we have centralized the results in a reduced list of deliverables clearly identified.**

**It should be noted that this new submission builds upon the results from the French specific initiative ("action spécifique") about software engineering for heterogeneous systems (cf http://gemoc.org/as2011). This initiative was funded by the CNRS GDR GPL (http://gdr-gpl.cnrs.fr), lead by the Triskell and Aoste teams, and involved the other partners of the GeMoC project.**

# 1. EXECUTIVE SUMMARY

Complex software-intensive systems address many different aspects of our daily lives (from online tax payment to on-board airplane control). This broad application scope has major impacts on design processes. GEMOC focuses on three design and simulation issues:

1 **Consider various concerns**. Multiple stakeholders are involved in the design process, each with a specific domain expertise (usability, reliability, etc.). On one hand, stakeholders express their perspective on the system with their own language, but on the other hand all these viewpoints have to be composed for global analysis. The consequence for design is that it is necessary to allow precise domain-specific modeling, while enabling the composition of models from different engineering domains.

2 **Integrate heterogeneous parts**. Technological progress has not only lead to more powerful devices, but also to a broad range of different devices specialized for different applications or usage scenarios. Complex systems have to integrate these different parts to deliver a global service. The consequence for design is the necessity to model communication and synchronization of each part involved, while enabling the composition of these heterogeneous parts to characterize the emerging behavior.

3 **Deal with evolution and openness**. Complex systems must adapt to the evolution of technologies, the emergence of new devices or the appearance of new usages. Consequently it is not possible to establish an exhaustive, finite list of domain languages, communication and timing models at one instant. Therefore engineering tools and environments have to be open and allow the evolution or the creation of domain languages and communication models.

The state-of-the art for complex systems design partially addresses the issues cited above.

*Model Driven Engineering* (MDE) offers a rigorous and homogeneous formalism for the definition of domain specific modeling languages (DSMLs). It is currently possible to define specific languages to model each concern and to ease the tooling of a DSML (e.g., automatically generate graphical editors). MDE partly addresses issue 1 by providing means to leverage domain expertise when designing complex systems and issue 3 because it supports evolution and creation of new DSMLs. However, it is neither possible to compose different DSMLs nor to associate communication and time models to DSMLs to allow synchronization between different concerns.

*Models of Computation and Communication* (MoCC) have been studied for a long time. There exist common MoCCs (discrete-event, synchronous reactive…) to deal with specific concerns. Several MoCCs have been implemented in proprietary environments that currently support some pair-wise hardcoded compositions. The major issue is that classical MoCCs have to evolve constantly to address new classes of problems. However, there is no easy way to integrate the new MoCCs in existing frameworks to support the evolution of the system. GEMOC will leverage the results from this community while benefiting from the MDE technology to develop DSMLs and MoCCs jointly and support the evolution of systems and integration of new concerns.

**GEMOC has the ambition to set up an innovative environment for the design of complex software-intensive systems by providing (i) a formal framework that integrates state-of-the-art from MDE and MoCC to reason over the composition of heterogeneous concerns; (ii) an open-source modeling environment associated to a well-defined method for the definition of DSMLs, MoCCs and rigorous composition of all concerns for simulation purposes.**

This requires addressing two major scientific issues in GEMOC: the design and verification of a formal framework to combine several different DSMLs relying on distinct MoCCs; the design and validation of a methodology for DSMLs and MoCCs development.

In previous years, France has developed a leadership position in model-driven engineering: French research has had a major impact in top level international conferences; a number of French SMEs have proposed innovative solutions to use tool-supported DSMLs, creating high-level software engineering employments; French industry has massively invested in DSMLs to increase productivity in the construction of complex systems.

To keep this excellent position in a highly competitive international landscape, it is now critical for French research and industry to understand how models defined within each DSML can communicate and be composed for global simulation. This consists in integrating heterogeneous MoCCs with multiple DSMLs in a generic, domain-independent simulation platform. Domain-independence is critical to guarantee that the results will be available to the various sectors of French economy that rely on the construction of complex systems. It is also important to notice that an ERC Advanced Grant has been provided to Glynn Winskel on a closely related subject[1]; French research on formal concurrency semantics has proven its efficiency in the past and should stay on hot topics to be competitive.

GEMOC will participate in the development of next generation MDE environments through a rigorous, tool-supported process for the definition of executable DSMLs (xDSMLs) and the simulation of heterogeneous models. This ambitious target for French research and industry, aims at transferring the most advanced research results about heterogeneous modeling in an open source environment for complex system design. This requires (i) a solid consortium that gathers complementary expertise from MDE and MoCCs academic and industrial communities; (ii) a rigorous articulation between solid theoretical results and advanced engineering tasks. In order to satisfy these requirements, GEMOC needs to involve 6 partners whom have to develop a balanced effort for research and development. Consequently, the requested ANR grant reflects this ambitious and challenging nature of GEMOC.

We gather strong complementary expertise from four research institutions (INRIA and IRIT for MDE, ENSTA and I3S for MoCCs), an SME specialized in MDE tools (Obeo) and one major actor in the construction of complex systems (THALES). This project benefits from the support of Airbus who provides a use case, from the OPEES consortium for sustainable exploitation as well as from Atos and the Topcased consortium, and from Colorado State University in USA for scientific issues (see annex). GEMOC is led by INRIA to foster the integration of state-of-the-art research and assist transfer towards industrial needs.

# 2. CONTEXT, POSITION AND OBJECTIVES OF THE PROPOSAL

## 2.1. CONTEXT, SOCIAL AND ECONOMIC ISSUES

From a recent report ordered by the french government [Potier10], eight high priority axes of research and development have been identified. GEMOC is exactly dealing with the two first ones:
1. Model driven engineering for systems and embedded software
2. Verification and certification of system safety and security of embedded software.

The GEMOC project aims at leveraging model driven engineering (MDE) and formal techniques for embedded systems design. MDE is increasingly adopted in important sectors

[1] Cf. http://cordis.europa.eu/projects/98229_en.html

such as automotive, avionics, telephony and more generally in critical and non-critical embedded systems. Several experiments have proven the significant contribution of MDE for the development of industrial complex systems, which coerce designers to start the modeling phase at system level. At this level of abstraction, the systems are necessarily heterogeneous and based on several viewpoints, each dedicated to a special concern. The way to link these concerns together must guarantee the correctness of the system. Since it is of prime importance to analyze such systems (and their composition) at the model level ([Potier10]), the use of adequate formal methods is mandatory. This preoccupation is at the heart of the GEMOC project where all models will rely on a formal semantics. This early validation should reduce the validation cost of low-level models. Moreover it brings the mandatory elements for safe automatic reasoning on high-level models, paving the road for certified code generation or implementation verification. Finally, using MDE and formal methods reduces the time-to-market by reducing the gap between different areas of expertise in charge of producing the system (for instance hardware and software integration).

There already exist some (standardized) modeling languages and approaches for such a goal (like UML, SysML, MARTE, AADL and the associated environments) but on the one hand they often introduce the formal aspects at the end of the modeling phase, *i.e.* without involving them effectively in the process of system development. On the other hand, they do not consider execution semantics and heterogeneity to handle the models.

GEMOC will investigate how it is possible to realize systems that may involve several DSMLs and to what extent this composition of DSMLs is possible and can be correct. Such a composition is not only syntactic but must also take into account the semantics underlying these languages, while allowing their execution.

## 2.2. POSITION OF THE PROJECT

Various projects have been conducted over the last years, mainly in Europe and in the USA, to improve the design of complex systems. These projects can be classified in two categories. The first one promotes the use of models to improve the development cycle at different levels including specification, verification, debugging. A quick overview of this first kind of projects is given:

- OpenEmbedd (ANR project **co-led by the INRIA Triskell team**) that proposed an Eclipse-based "Model Driven Engineering" platform dedicated to Embedded and Real-Time systems (E/RT).
- TopCased is an open-source modeling toolset for real-time embedded systems. It focused on the use of model-driven technologies inside the Eclipse Modeling Framework (FUI project).
- RT-Simex proposed an environment that provides feedback from a system execution at the model level. It uses an explicit and formal specification of time and synchronization at the model level by using MARTE / CCSL [CCSL] (ANR project).
- Movida focused on variability modeling in families of systems, and the systematic analysis of consistency in complex models. This project participated in the current standardization effort for variability modeling (ANR project).
- OPEES targets the implementation of an ecosystem (called Polarsys) for open-source toolsets for the development of embedded systems (ITEA2 project)
- VerifMe targets the development of a verification toolset for AADL, SDL and SysML/UML based on scenario (OSEO project).
- MopCom proposed a MDE design methodology for heterogeneous hardware platforms like SoC/SoPC based on virtual platforms. The design is based on UML and

the explicit allocation of the application on a virtual platform whose semantics is given in Cometa (ANR project and Conseil Régional de Bretagne).

The second category focuses on specific approaches to tame the development of heterogeneous system projects. These projects are often mainly based on or heavily inspired by tools like Ptolemy [Ptolemy] or Metroplis [Metropolis1]:

- HCDDES MURI - High-Confidence Design for Distributed Embedded Systems: control systems (funded by the Air Force Office of Scientific Research).
- PTIDES - Programming Temporally Integrated Distributed Embedded Systems (funded by the NSF)
- SCOS - Scalable composition of subsystems (funded by the US Army Research Laboratory)

Projects of the first category mainly focus on the improvement of MDE tools, sometimes by using formal methods. The second category focuses on the design of heterogeneous systems but mainly on a semantic point of view (for instance the definition of new models of computation) and without integration with MDE approaches. To the best of our knowledge there is no project that proposes a MDE based formal approach and tool dedicated to the modeling of heterogeneous systems. GEMOC will propose such an approach and the associated open-source tools.

In this context, GEMOC addresses the following topics of the ANR INS call for projects:

- **Main topic "Axe 2: Ingénierie du logiciel et du matériel". GEMOC addresses axe 2 as an open model-driven engineering platform that emphasizes composition of heterogeneous models as a major feature of software development.** The GEMOC platform aims at enabling model-driven development of executable domain specific modeling languages (xDSMLs) and their associated MoCCs. This model-driven approach for language development is expected (i) to offer a rigorous framework for the development of new languages and to increase the flexibility for evolution; (ii) to allow the composition of heterogeneous models for global simulation.
- **Secondary topic "Axe 3: Méthodes, outils et technologies pour les systèmes embarqués". GEMOC addresses axe 3 as a method and a tool to assist the design of heterogeneous embedded systems.** The GEMOC platform for heterogeneous modelling aims at being domain independent, but embedded systems is one of its major targets. Embedded systems have to integrate heterogeneous devices and heterogeneous sources of information (multiple sensors that measure physical values, mixed with a multitude of specific computational devices). Thus this domain is expected to strongly benefit from the GEMOC's abilities at defining and evolving DSMLs and associated MoCCs for a global simulation.

## 2.3. STATE OF THE ART

Nowadays, it is possible to simulate various kinds of models. Existing tools range from industrial tools such as Simulink, Rhapsody or Telelogic to academic approaches like Omega [*Omega*], Xholon [Xholon] or the Turtle toolkit [TTool]. There exist various approaches to build executable DSMLs (xDSMLs), but simulation is always performed in a homogeneous environment. However, systems are more and more heterogeneous. For example, a mobile phone combines various kinds of entities with heterogeneous roles: signal processing, telecommunication, and graphical interface. Modeling such systems is what we call here *heterogeneous modeling*.

GEMOC aims at providing an environment for the definition of xDSMLs according to explicit and heterogeneous MoCCs. Thus, this section consists of two subsections: a synthesis of the main approaches to achieve xDSMLs; an overview of the major definitions and classifications of MoCCs as well as their use. While these sections detail the state of the art, they also emphasize the main gaps GEMOC intends to close.

### 2.3.1 EXECUTABLE METAMODELING

Several possibilities have been explored to implement semantics of DSML [Combemale09]:

- To use an executable metamodeling language to express directly the executable semantics like a set of operations for each concept (e.g., Kermeta [Muller05], xOCL [Clark08], MOF action languages [Paige06] or even Java with the EMF API)
- To use *endogenous transformations* on the abstract syntax. As an example, [Markovic08a] uses QVT [omgqvt1] to express in-place rewriting rules that gradually compute the values of an OCL expression. Topcased currently relies on that approach using SmartQVT.
- To define the executable semantics of a DSML with so-called *translational semantics*. Unlike operational semantics, a translational semantics maps the model elements onto another (formally defined) technical space. Thus, it relies on an existing semantics defined on the target technical space. For instance, translational semantics is used by the group pUML[2], called *Denotational Meta Modeling*, to formalize some UML diagrams [Clark01].

While all these approaches adopt very different strategies to give an executable semantics to a DSML, they all share a common problem: they mix the behavior of the application with the behavior of the domain. The application should focus on the manipulation of the data model while a specific MoCC should drive the behavior of the domain. In GEMOC, we want to separate these two kinds of behavior.
The expected benefits of such a separation are: the ability to identify the MoCC clearly, and consequently the analyses that can be conducted on the model; the ability to equip a same DSML with various MoCCs; the possibility to apply an adequate MoCC explicitly on different entities of the model; the possibility to identify clearly the connections between entities directed by different MoCCs.

### 2.3.2 MOCC AND SIMULATION

- *Definition*

According to E.Lee and S.Vincentelli "*How the abstract machine in an operational semantics can behave is a feature of what we call the Model of Computation of the language. The kind of relations that are possible in a denotational semantics is also a feature of the model of computation*" [Lee97].
With the emergence of DSMLs, it is a first concern to identify how the link between a MoCC and a DSML specification can be relaxed. Following this objective, the definition proposed by [Jantsch03] is more abstract. It proposes a description where four different concerns emerge. A MoCC is related to the representation of time, data, communication and behavior.
GEMOC proposes to distinguish the structural relations between language elements and the specification of the execution rules. Consequently, we want to identify in the previous definition, the concern related to an executable DSML (xDSML) from the one related to a MoCC. This should allow equipping any xDSML with a specific MoCC. This way, the MoCC should explicitly represent the formal dynamic semantics underlying a specific xDSML.

2 *The precise UML group*, cf. http://www.cs.york.ac.uk/puml/

- *Taxonomies/Classification of MoCCs*

[Sangiovanni-Vincentelli09] proposes a classification of different models of computation by demonstrating the relationships that may exist between them. [Lee05] offers a possible classification of MoCCs and their comparison in the context of Ptolemy. It provides a quick view on the refinement relation between MoCC but does not detail the differences from one MoCC to another.

A complementary classification is proposed in the context of the ForSyDe project, based on an abstraction of the time on complex designs [Sander04]. They classify models according to three possible abstractions of time: Untimed MoCC, Synchronous MoCC, Timed MoCC. It results that the abstraction of time is an important concern in the classification of MoCCs. Moreover, by looking at the Tagged Signal definition, it emerges that characterizing the properties of causality relations between events is a good way to represent a MoCC.

GEMOC does not intend to provide new MoCCs or theoretical results about MoCC classification. We will rather provide a language able to specify the classical MoCCs as well as their incremental extensions.

- *Tools for heterogeneous modeling*

**Ptolemy [Ptolemy]**. The initial goal of the tool was to model systems made up of subsystems based on different MoCCs. Ptolemy proposes a common abstract syntax, which represents the description of the model structure. These elements can be decorated using different directors that reflect the application of a specific MoCC on the model element. The work reveals two important drawbacks: (i) it is a proprietary tool, relying on a specific DSML for the structural relation between language elements, *i.e.*, it cannot be linked to a domain-specific language already used by engineers from another domain; (ii) it is not possible to add new MoCCs or extend the pre-defined ones without modifying Ptolemy itself.

**ForSyDe [ForSyDe]** is dedicated to heterogeneous synchronous MoCCs but it is not possible to use a new DSML or a new MoCC.

**Metropolis [Metropolis1, Metropolis2, Metropolis3]** targets platform-based design. The tool provides modeling elements that will eventually be transformed into semantically equivalent mathematical models. Metropolis offers a precise semantics flexible enough to support different models of computation.

**ModHel'X [Modhel'X]** studies the composition of multi-paradigm models relying on different models of computation. ModHel'X separates the behavior of the application and the MoCC, and studies the hierarchical composition of models with different MoCCs. However, ModHel'X is a proof of concept that has hard-wired the MoCCs, which limits customization with a new MoCC or formal analysis.

Two major problems have been identified in the existing tools: (i) they do not let users model with their own DSML, which is a major issue to increase acceptance of the tool by domain specialists; (ii) the support for addition and evolution of MoCCs is limited. GEMOC aims at providing an open-source tool that targets these two main issues by providing both the ability to decorate a DSML entity with a specific MoCC and the ability to specify and extend MoCCs with high-level models.

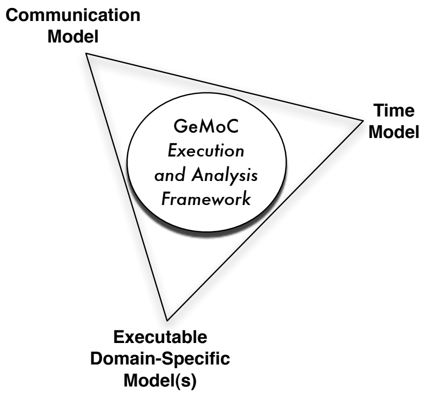
### 2.3.3 PROGRESS BEYOND THE STATE-OF-THE-ART

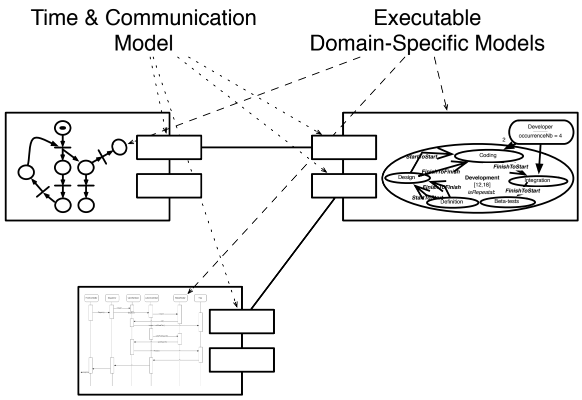
This section provides a concise view of the approaches/languages/tools related to the domain addressed by GEMOC and explain how GEMOC will improve the current state of the art.

| Area | Established state of the art | GEMOC innovation |
|---|---|---|
| **Executable metamodeling** | Three main approaches have been identified to add executable semantics to a DSML: use of an executable metamodeling language, endogenous transformation and transformational semantics. These approaches mix-up the MoCC behavior with the application behavior and consequently hide lots of synchronization information. This makes difficult the use of different MoCCs as required for heterogeneous models. | GEMOC will provide a metamodeling pattern and a methodology to make a clean separation of concerns between the application behavior and the MoCC behavior. This separation is central for a clean heterogeneous modeling since it exhibits synchronizations needed to correctly glue DSMLs controlled by different MoCCs. |
| **MoCC specification** | MoCCs have been largely studied. These studies mainly focus on expressivity, and classification of different MoCCs. | GEMOC objectives are not the study of MoCC themselves. The innovation consists in providing a language that allows the specification of MoCCs independently of a specific DSML. |
| **Heterogeneous tools** | There exist some tools dedicated to heterogeneous modeling. In these tools, MoCCs are always specified over an imposed DSML. As a consequence, it is difficult for domain specialists to use them.<br>Moreover, some of these tools cannot be extended with new MoCCs, making them dedicated to specific domains. When the tools can be extended with new MoCCs, they lack a clear relation between theory and implementation. | In the GEMOC tool, it will be possible to create new DSMLs by following a dedicated metamodeling pattern, and create new MoCCs by using a dedicated language. Additionally, the language dedicated to MoCC specification will be tooled to execute any MoCC specification. This tool will be encoded once and for all. This allows keeping a strong link with the formal semantics of the language for MoCC definition. |

## 2.4. OBJECTIVES, ORIGINALITY AND NOVELTY OF THE PROJECT

Complex system engineering proposes to use cooperative heterogeneous executable domain specific modeling languages (xDSMLs) to separate the expression of the system's various concerns (functional and non-functional requirements, logical and physical architecture, etc.) and to rely on model execution for the validation and verification of the proposed design against the requirements. Building and executing such heterogeneous cooperative models is currently a very complex task. Several projects such as Ptolemy or ModHel'X have relied on the paradigm of MoCCs and tackled successfully the problem with complex, error-prone, ad-hoc and costly engineering work for the development and integration of new xDSMLs and MoCCs. New bridges between each pair of MoCC and xDSML are required to impede significantly their academic and industrial adoption.




As illustrated in the previous figure, the GEMOC project targets a language design studio providing methods and tools to ease the design and integration of new MoCCs and executable DSMLs (xDSMLs) relying on the use of proven technologies developed in previous research projects such as Cometa, CCSL, Kermeta and the metamodeling pattern to build xDSML in order to define:

- Modeling languages with associated methods and tools for the modeling of both MoCCs and xDSMLs;
- A single cooperative heterogeneous execution framework parameterized by the MoCCs and xDSMLs definitions;
- A global MoCCs and xDSMLs design methodology encompassing these two items;
- A formal specification of the previous cooperation framework to prove its completeness, consistency and correctness with respect to the cooperative heterogeneous model execution needed.

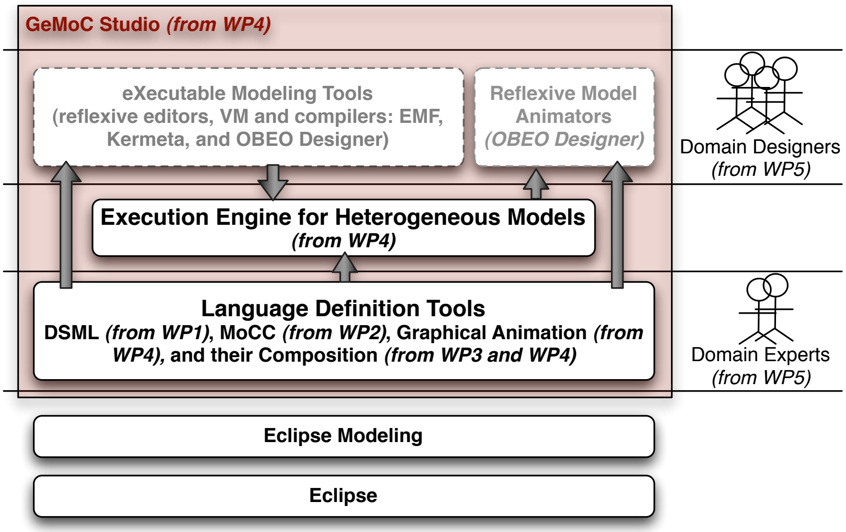
To our knowledge, as shown in the previous state of the art, such language design studio is still a wish to be fulfilled. However, methodological and technological, formal and practical issues still have to be addressed.

Two major scientific issues will be addressed in GEMOC:

- Formal foundations for the language design: The design and verification of a formal, unified, heterogeneous, cooperative, hierarchical framework to combine several different xDSMLs relying on distinct MoCCs. This task will build on: formal xDSMLs and MoCCs modeling facilities, and a formal definition for the cooperative hierarchical integration of the models expressed with such xDSMLs and MoCCs;
- Methodology for the language design: The design and validation of a methodology based on xDSMLs and MoCCs development with associated tools that will allow to express both the xDSML abstract syntax, static and dynamic semantics relying on state/event execution traces; and the MoCCs that will be used to manage the events involved in the execution of models expressed in the corresponding languages and their integration in a cooperative hierarchical model execution platform.

Two major technical issues will be addressed in GEMOC based on the previous studies:

- The implementation of the GEMOC studio in the Eclipse Modeling Platform integrating various independent software components;
- The implementation of the hierarchical cooperative model execution platform parameterized by the MoCCs and xDSMLs specifications.




As shown in the previous figure, the main results of the GEMOC project will be:

- The xDSMLs (in WP1) and MoCCs (in WP2) modeling languages, and the associated methodology and tools;
- The hierarchical heterogeneous model execution framework (in WP4);
- The formal hierarchical cooperation model that will provide the sound, complete and consistent ground for these aspects (in WP3);

And last but not least, their implementation in the GEMOC language design studio (in WP4) and its validation through several industrial use cases (in WP5).

# 3. SCIENTIFIC AND TECHNICAL PROGRAMME, PROJECT ORGANISATION

## 3.1. SCIENTIFIC PROGRAMME, PROJECT STRUCTURE

### 3.1.1 AIMS OF THE PROPOSAL

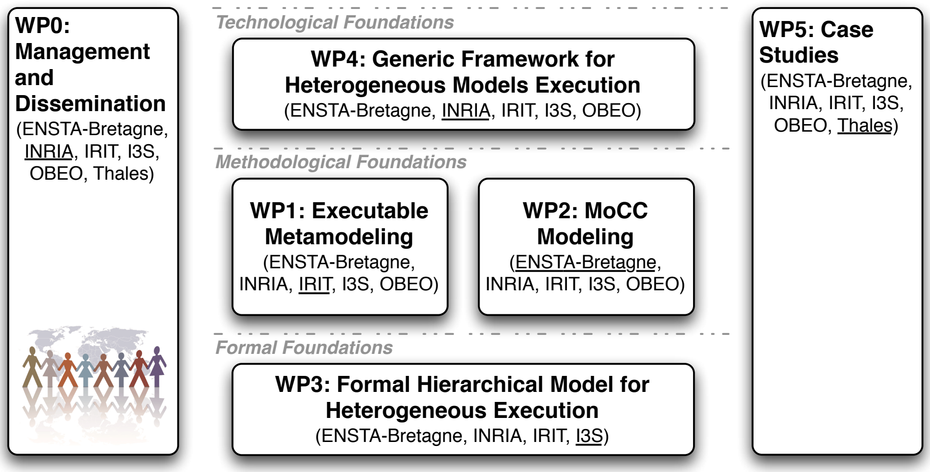
As described in the previous section, the main purpose is the GEMOC project is to propose an heterogeneous models execution framework relying on the specification of executable domain specific modeling languages (xDSMLs) to express the various concerns in a complex system and of models of computation and communication (MoCCs) to describe the exchanges between the various xDSMLs. With this purpose, GEMOC targets:

- A modeling environment for xDSMLs based on Kermeta, the metamodeling design pattern to build xDSMLs and the associated process, methods and tools;
- A modeling environment for MoCCs based on CCSL and Cometa, and the associated process, methods and tools;
- A formal definition of a hierarchical heterogeneous cooperating model integration framework relying on the two previous environments;
- The implementation of this integration framework inside the Eclipse Modeling Framework (EMF);
- The validation of the whole proposal relying on three representative use-cases.

The results of GEMOC will provide both a significant improvement of MoCCs and xDSMLs definition costs and the simulation-based validation and verification of complex systems designed as a hierarchy of cooperative and heterogeneous executable models.

### 3.1.2 TASK DESCRIPTION

The GEMOC project is organized in six work packages as shown by the following figure.




Each WP handles one of the concerns and integrates the various results in the GEMOC studio.

**WP0 (Management and Dissemination)** will ensure that the project is on a good course, gather and manage requirements, synchronize the various work packages, assess and avoid the risks related to the iterative process and disseminate the project results to the academic and industrial communities. THALES and I3S partners involved in the Object Management Group (OMG) will ensure the consistency of the GEMOC activities and of the standardization work conducted inside the OMG. The development work will rely on the Eclipse Modeling Framework. Obeo and THALES already contribute to the eclipse foundation and will ensure the synchronization with the Eclipse Modeling Project. Obeo, Thales, INRIA and IRIT partners currently involved in the OPEES initiative will ensure an easy integration of GEMOC results in this platform.

**WP1 (Executable Metamodeling)** will combine the elements from the "eXecutable DSML" design pattern from the FUI TOPCASED and ITEA2 OPEES projects with the Kermeta metaprogramming language. These elements currently allow defining and integrating xDSML relying on the same MoCC. The key result of this WP is to provide an executable DSML definition framework that will allow the integration of several heterogeneous MoCCs relying on metamodeling technologies (i.e. modeling of MoCCs and xDSMLs, automatic generation of tools based on the information available in the metamodels).

**WP2 (Model of Computation and Communication Modeling)** will combine the work done inside Cometa and CCSL to integrate the state-based modeling of synchronizations, and the declarative clock-based modeling of time. The resulting metamodel will be the core of the toolset. It will allow modeling MoCCs in WP2 and WP5, connecting xDSMLs and MoCCs in WP1, giving a formal account of MoCCs cooperation in WP3; and executing models for heterogeneous simulation in WP4.

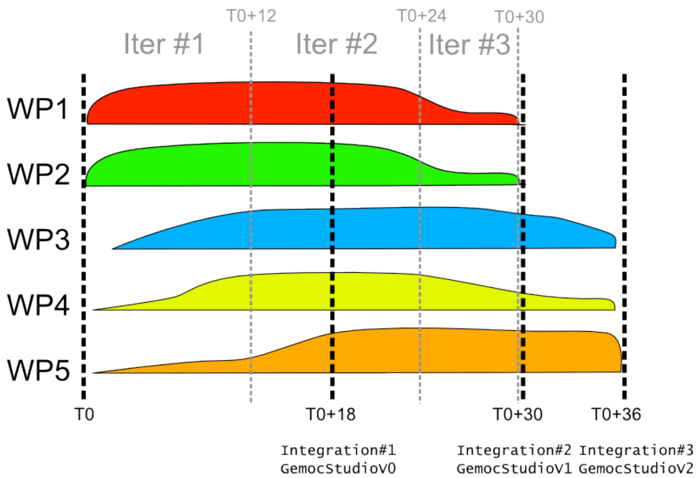
**WP3 (Formal Model for Heterogeneous Computation)** will provide a mathematical account for the cooperation between MoCCs. WP1 and WP2 will rely on it to define MoCCs and related xDSMLs in order to provide heterogeneous modeling and execution concerns. The use of a mathematical structure will provide formal specification and verification technologies. This structure will allow the composition of different xDSML relying on different MoCCs and thus the execution of heterogeneous models. It will be specified using the Coq proof assistant in order to prove its completeness, consistency and correctness and enable the execution of the specification to allow its validation.

**WP4 (Generic Framework for Heterogeneous Models Execution)** will integrate in the GEMOC studio the tools designed in WP1 and WP2, and implement an execution platform for the MoCCs and related xDSMLs based on the formal structure defined in WP3. This platform will rely on the Eclipse Modeling Framework and on evolutions of the Kermeta, Cometa and CCSL toolsets implemented in the project.

**WP5 (Case Studies)** will implement three case studies for the validation of the solutions established in GEMOC. The industrial case studies rely on several heterogeneous cooperative xDSMLs relying on various MoCCs that will be implemented using the GEMOC Studio provided by WP4, using the processes, methods and tools defined in WP1 and WP2 and the formal framework provided by WP3. The experiments will first define the languages, then the models and validate the proposed technologies through the heterogeneous simulation of models.

### 3.1.3 WORKING GROUP FUNCTIONAL DEPENDENCIES

WP1 and WP2 integrate previously existing items to provide technologies used in WP3, WP4 and WP5. The mapping of xDSMLs to MoCCs that links WP1 and WP2 is shallow and allows the work to progress in parallel. WP3 provides the formal foundations for WP1 and WP2 and a framework for hierarchical heterogeneous components execution implemented in WP4. Iterations are mandatory between WP1/WP2, WP3 and WP4 for the integration of WP3 results in WP1/WP2 and WP4, and the handling of feedbacks in WP4. WP4 integrates the tools from WP1/WP2 and implements parts of WP3. Its results are used in the second part of WP5 for the execution of models used for validation purpose. WP5 will validate the results of WP1/WP2 and WP4 relying of the provided use cases.




As the different work packages are strongly interleaved, we propose to follow an iterative process illustrated by the previous picture to ensure the validation of each group proposals by the other groups. In the first iteration between T0 and T0+12, the technologies provided by each partner will be lightly integrated to provide the preliminary results mandatory for the activities in WP4 and WP5. In the second iteration between T0+12 and T0+24, the first version of the execution platform will be developed in WP4 based on this light integration, this version will allow to provide feedback to WP1, WP2 and WP3 to build the final integration. It will also allow starting the application of the resulting technologies to the use cases in WP5. In the third and last iteration from T0+24 to T0+30, the final platform will be implemented and applied for the use cases in WP5. In the last six months, the various results will be finalized.

### 3.1.4 SCOPE

GEMOC provides language design and implementation technologies in the GEMOC studio for the definition of discrete-time MoCCs and their use for the definition of xDSMLs. GEMOC will empower language designers with the expression of the language behavioral semantics; and system designers with heterogeneous modeling and simulation. This scope is quite large. To master the risks, GEMOC will focus on:

- Discrete-time MoCCs and xDSMLs;
- The use of metamodeling technologies to express the MoCCs and xDSMLs using two dedicated metamodeling languages (resp., for the modeling of MoCCs and xDSMLs) based on previous works by the various partners (Cometa by ENSTA, CCSL by I3S, Kermeta by INRIA and the xDSML metamodeling pattern by IRIT and INRIA);
- The integration of the various models for a given system, expressed using the xDSMLs and MoCCs developed using GEMOC Studio, in a single hierarchical heterogeneous model handling the various concerns in the system design and providing execution facilities;
- A precise analysis of existing ad-hoc hand-written MoCCs and xDSMLs to factorize their key elements in metamodeling languages and ease their re-implementation in GEMOC and the definition of new ones;
- The design and implementation of a single cooperative model execution platform parameterized by the MoCCs and xDSMLs models;
- The formal definition of the MoCCs and xDSMLs, and of the heterogeneous cooperative model execution platform to study the consistency, completeness and correctness of the framework;
- The experimentation on several use cases to validate at the language designer and system modeler levels the proposal and the GEMOC studio developed in the project.

Some elements will be taken into account to ease their future integration: continuous time MoCCs, and model execution framework cooperation.

### 3.1.5 DURATION

The proposed project duration is <u>40 MONTHS</u> (36 MONTH EFFECTIVES + 4 MONTHS TO FINALIZE). This duration is mandatory to answer the manifold objectives of this project:

- Significant scientific advances in the field of heterogeneous systems. This objective will be achieved through research breakthroughs, mainly in WP1, WP2, and WP3.
- Implementation of an experimental environment: the GEMOC studio. This objective will be achieved through a strong valorization strategy, coordinated by WP0, and mainly implemented in WP4.
- Validation of this environment in WP5

## 3.2. PROJECT MANAGEMENT

Project management has to handle different needs and requirements for the overall successful execution of the project. These activities will be taken into account in a separate work package: WP0.

The main management challenge of the GEMOC project is the mix of research topics that may be far from being implemented in a concrete framework with some others, which may be closer to the industrial needs. This raises competitive interests in the project that need to

be carefully managed. However, as GEMOC purpose is much focused, the management process will be kept simple with a two level process.
The scientific program will be implemented through regular exchanges between partners and will be organized every 3 months into technical meetings. Moreover, a project management meeting will be coordinated into annual meetings (co-located with the last technical meeting of each year) to monitor: the projects risks, the task progress, the expenses, and the milestones and deliveries.
Each partner will have responsibilities in each task in which it is involved:

- Identifying and reporting its perception of the risks,
- Reporting the progress on its specific activity,
- Reporting the progress in terms of its resource usage,
- Reporting any slippage in milestone or delivery.

Each partner will be in charge of providing this information to the project manager before the project management meeting to prepare a consolidated view of the project situation to the project participants.
Moreover, GEMOC will start with a kick-off meeting and conclude with a workshop and one final review.

**INRIA is in charge of the coordination of the GEMOC project.** It benefits of facilities that include support for audio and visio conferences, hosting web sites and software repositories, legal advices for industrial dissemination, etc. Moreover, all researchers from the Triskell team have a strong experience in project management. **Dr. Benoit Combemale (Triskell team, Inria) is the project leader.** He will coordinate the different meetings, the kick-off meeting and the workshop that are scheduled in the proposal. He will also be in charge of the writing of the annual and final reports and of the project financial management. INRIA will be in charge of the project web site creation and management.

## 3.3. DESCRIPTION BY TASK

We give in the following subsections the description of the work packages of the project. For each work package we describe, the general scientific issues that are tackled and several precise intermediate objectives that will be studied within this project. The cutting in tasks, the partner roles and deliverables are also stated. All dates are given in a basis of 36 months, considering the last 4 months for finalization and valorization of the results.

### 3.3.1 WP0: MANAGEMENT AND DISSEMINATION

| **WP0** | **Management and Dissemination (21MM)** | | | | | **M1→M36** |
|---|---|---|---|---|---|---|
| **WP Leader** | **INRIA** | | | | | |
| **Participant** | ENSTA-B | I3S | **INRIA** | IRIT | OBEO | THALES |
| **Effort** | 4 | 4 | **6** | 2 | 2 | 3 |
| **Inputs from other WP:** | | | **Outputs for other WP: ALL** | | | |
| **Objectives**<br>This work package is in charge of the project management, and encourages a strong exploitation of scientific and technological results of the GEMOC project. Thus, an active policy will be proposed for disseminating results and industrial use. | | | | | | |
| **Partner contributions**<br>• *INRIA:* Project management (coordinator) and technical coordinator | | | | | | |

- *ALL:* Project management (cost statement and project management board), dissemination, exploitation and collaboration

| **Task 0.1** | **Project Management** | | | | | **M1 →M36** |
|---|---|---|---|---|---|---|
| **Task Leader** | **INRIA** | | | | | |
| **Participant** | ENSTA-B | I3S | **INRIA** | IRIT | OBEO | THALES |
| **Effort** | 2 | 1 | **3** | 1 | 1 | 1 |
| **Inputs from other tasks: -** | | | **Outputs for other tasks: -** | | | |

**Description**

Organize good interaction within the project. Ensure compliance with project plans and that the project activities meet the appropriate quality levels. Check and validate the correct scheduling of tasks, manage risks, perform overall legal, contractual, ethical, financial and administrative management of the consortium, coordinate Intellectual Property Right and other innovation-related activities, and manage science and society issues related to the project activities.

**Information and details about project management issues appear in Section 3.2.**

| **Deliverables** | **Type** | **Leader** | **Participants** | **Date** |
|---|---|---|---|---|
| D0.1.1 – Project web site facility | Web Site | INRIA | ALL | M6 |
| D0.1.2 – Project Activity and Management Report, Period 1 | Report | INRIA | ALL | M12 |
| D0.1.3 – Project Activity and Management Report, Period 2 | Report | INRIA | ALL | M24 |
| D0.1.4 – Final Project Report | Report | INRIA | ALL | M36 |

| **Task 0.2** | **Project Dissemination and Exploitation** | | | | | **M1 →M36** |
|---|---|---|---|---|---|---|
| **Task Leader** | **THALES** | | | | | |
| **Participant** | ENSTA/B | I3S | INRIA | IRIT | OBEO | **THALES** |
| **Effort** | 2 | 3 | 3 | 1 | 1 | **2** |
| **Inputs from other tasks: WP1, WP2, WP3** | | | | **Outputs for other tasks: WP5** | | |

**Description**

Definitions of the dissemination and exploitation plans that promote GEMOC results both inside and outside the project consortium and attest a technical and scientific transfer from research work to industrial use. This task will be also in charge to promote and disseminate the GEMOC results inside the industrial community (OMG users groups, industrial conferences etc).

**Details about dissemination and exploitation activities appear in Section 4.**

| **Deliverables** | **Type** | **Leader** | **Participants** | **Date** |
|---|---|---|---|---|
| D0.2.1 – Whitepaper including bibliography of scientific papers based on results from the project | Report | INRIA | ALL | M36 |
| D0.2.2 – Industrial dissemination results and definition of the long-term strategy for the GEMOC Exploitation | Report | THALES | ALL | M36 |

### 3.3.2 WP1: EXECUTABLE METAMODELING

| **WP1** | **Executable Metamodeling (47MM)** | | | | | **M1→M30** |
|---|---|---|---|---|---|---|
| **WP Leader** | **IRIT** | | | | | |
| **Participant** | ENSTA-B | I3S | INRIA | **IRIT** | OBEO | THALES |
| **Effort** | 10 | 6 | 15 | **15** | 1 | - |

| Inputs from other WPs: WP2, WP3 | Outputs for other WP: WP2, WP3, WP4, WP5 |
|---|---|

**Objectives**

Combine elements from the eXecutable DSML metamodeling design pattern and the Kermeta metaprogramming environment. These elements currently allow defining and integrating xDSML relying on the same MoCC.

The key result of this WP is to allow the definition and integration of heterogeneous xDSMLs with respect to heterogeneous MoCCs. The WP will produce both a tool-supported method for xDSML definition relying on metamodeling technologies (i.e. automatic generation of tools based on the information available in the executable metamodels), and the way to bind the various xDSMLs with their respective MoCCs.

**Partner contributions**

- *IRIT and INRIA* will build on the experiments conducted in the TOPCASED project to define a metamodeling pattern (T1.1) that will ease expressing the behavioral semantics concern in the definition of a domain-specific language (T1.2), and to map the elements from the metamodeling pattern to the generic discrete-event MoCC to define the generic mapping language (T1.3).
- *INRIA* will provide Kermeta as executable metamodeling language.
- *I3S, ENSTA-B, and INRIA* will define the mapping between xDSML (the Kermeta action language) and MoCCs (the CCSL and COMETA languages) in T1.3.
- *OBEO* will define the xDSML tools (T1.2) to prepare the WP4 developments.

| **Task 1.1** | **xDSML definition methodology** | | | | | **M1 → M24** |
|---|---|---|---|---|---|---|
| **Task Leader** | **IRIT** | | | | | |
| **Participant** | ENSTA/B | I3S | INRIA | **IRIT** | OBEO | THALES |
| **Effort** | 4 | - | 5 | **5** | - | - |
| **Inputs from other tasks: WP2, WP3** | | | **Outputs for other tasks: WP2, WP3, WP4** | | | |

**Description**

Define a methodology for xDSML specification relying on the xDSML metamodeling pattern and the Kermeta metaprogramming language.

| **Deliverables** | **Type** | **Leader** | **Participants** | **Date** |
|---|---|---|---|---|
| D1.1.1 – Metaprogramming with Kermeta and xDSML pattern guidelines | Report | IRIT | INRIA, IRIT, ENSTA-B | V0: M6<br>V1: M12<br>V2: M24 |

| **Task 1.2** | **xDSML definition tools** | | | | | **M6 → M30** |
|---|---|---|---|---|---|---|
| **Task Leader** | **IRIT** | | | | | |
| **Participant** | ENSTA/B | I3S | INRIA | **IRIT** | OBEO | THALES |
| **Effort** | - | - | 5 | **5** | 1 | - |
| **Inputs from other tasks: T1.1** | | | **Outputs for other tasks: WP4, WP5** | | | |

**Description**

Define and implement tools to ease the application of the methodology defined in Task 1.1.

| **Deliverables** | **Type** | **Leader** | **Participants** | **Date** |
|---|---|---|---|---|
| D1.2.1 – DSML behavioral semantics definition tools | Software | IRIT | INRIA, IRIT, OBEO | V0: M12<br>V1: M24<br>V2: M30 |

| **Task 1.3** | **xDSML and MoCC mapping** | | | | | **M6 → M30** |
|---|---|---|---|---|---|---|
| **Task Leader** | **ENSTA-B** | | | | | |
| **Participant** | **ENSTA-B** | I3S | INRIA | IRIT | OBEO | THALES |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Effort** | **6** | 6 | 5 | 5 | - | - |
| **Inputs from other tasks: T1.1, T2.1** | | | **Outputs for other tasks: WP4, WP5** | | | |
| **Description**<br>Bridge the gap toward heterogeneous modelling by enabling the definition of mappings between any xDSML definition and any MoCC definition expressed using the results of WP2 relying on the formal model defined in WP3. | | | | | | |

| **Deliverables** | **Type** | **Leader** | **Participants** | **Date** |
|---|---|---|---|---|
| D1.3.1 – xDSML/MoCC mapping language, tools and methodology | Software and Report | ENSTA-B | ENSTA-B, I3S, INRIA | V0: M12<br>V1: M24<br>V2: M30 |

### 3.3.3 WP2: TIMED MODELS OF CONCURRENT ENTITIES

| **WP2** | **Timed Models of Concurrent Entities (59MM)** | | | | | **M1→M30** |
|---|---|---|---|---|---|---|
| **WP Leader** | **ENSTA-B** | | | | | |
| **Participant** | **ENSTA-B** | I3S | INRIA | IRIT | OBEO | THALES |
| **Effort** | **24** | 21 | 6 | 3 | 2 | 3 |
| **Inputs from other WPs: WP1** | | | **Outputs for WP3, WP4** | | | |

**Objectives**

Focus on the definition of a metalanguage dedicated to (timed) Model of Computation and Communication (MoCC). The MoCCs described by using this language may be applied on entities in a DSML or between heterogeneous DSMLs. This language will be defined as a metamodel to stay on the same technological space as DSMLs. More precisely, this work package must integrate two existing metamodels, one based on state machines (Cometa) and the other one based on declarative clock constraints (CCSL). The result of this work provides a metamodel with its editor and operational semantics, key part of the GEMOC studio.

Cometa allows defining the communication concern and its adaptation to the application part. This definition is based on a set of state machines that describe the control part of the communication between the concurrent entities. CCSL allows specifying the possibly timed relations between the events of a system declaratively using logical time and constraints.

The resulting metamodel provides the minimal concepts to take benefits of both approaches while allowing the description of various timed model of computation and communication.

**Partner contributions**

- **ENSTA-B** will provide the results and the experiments achieved in the ANR MOPCOM SoC/SoPC and the iFEST European projects (T2.1). The results are the Cometa metamodel and the Cometa models to define several MoCCs. ENSTA-B will also provide the experiments of the Cometa models describing in UML, the model transformation from Cometa models to UML models, and the knowledge of T1.3 relative to the mapping of the xDSML and MoCCs (T2.2). Finally, ENSTA-B will provide the feedback of the framework implementation task done in the WP4 and the use-case result analysis (T2.2).
- **I3S** will provide inputs from the already existing CCSL metamodel and its pattern that enable the definition of libraries at the model level (T2.1). This metamodel has already been tooled with both a textual editor and an operational semantics [Andre09] in the TimeSquare tool [tsq]. I3S will also provide knowledge on the denotational semantics definition made in T3.1, on the operational semantics previously realized on other languages like SyncCharts,

Esterel, and, of course CCSL, and in previous research projects based on common metamodel like HRC[3] (T2.2).

- **INRIA *and* IRIT** will ensure the transfer of results from, and the consistency with, WP1, WP3 and the GEMOC studio implementation in WP4 (T2.1).
- ***INRIA*** will help in the use of Kermeta for the operational semantics definition (T2.2).
- **Obeo** will provide a set of Obeo designer viewpoints and EMF editors to describe textually and/or graphically the MoCCs (T2.2).
- **THALES** will provide its industrial feedbacks and visions by participating to the technical choices.

| **Task 2.1** | **Definition of the MoCC metamodel** | | | | | **M1 →M12** |
|---|---|---|---|---|---|---|
| **Task Leader** | **I3S** | | | | | |
| **Participant** | ENSTA-B | **I3S** | INRIA | IRIT | OBEO | THALES |
| **Effort** | 8 | **9** | 1 | 1.5 | - | 3 |
| **Inputs from other tasks:** | | **Outputs for other tasks: WP2** | | | | |

**Description**

Identification of the initial version of the metamodel unifying Cometa and CCSL. This work is accomplished taking into account the semantics of the two metamodels. The goal is to compare all the concepts of the two metamodels and to provide a unification of the minimal set of concepts, together with their (static) semantic definition.

During the first experiments of the project, the metamodel is updated according the use cases to provide the final version of the metamodel.

| **Deliverables** | **Type** | **Leader** | **Participants** | **Date** |
|---|---|---|---|---|
| D2.1.1 – Ecore-based metamodel of the MoCC modeling language | Report and Metamodel | I3S | I3S, IRIT ENSTA-B, INRIA, THALES | V0:M6 V1:M12 |

| **Task 2.2** | **Tooling of the MoCC modeling language** | | | | | **M6 →M30** |
|---|---|---|---|---|---|---|
| **Task Leader** | **ENSTA-B** | | | | | |
| **Participant** | **ENSTA-B** | I3S | INRIA | IRIT | OBEO | THALES |
| **Effort** | **16** | 12 | 5 | 1.5 | 2 | - |
| **Inputs from other tasks: T2.1, T3.1** | | | **Outputs for other tasks: WP4, T2.3** | | | |

**Description**

Provide an editor and an operational semantics for the unified language according to the metamodel definition and the formal semantics from WP3.

The editor must provide textual and/or graphical facilities to describe a MoCC and to obtain model library for standard and new MoCCs.

According to the denotational semantics defined in WP3, a conformant operational semantics of the unified language must be implemented. This operational semantics may describe a subset of the solution space described by the denotational semantics.

| **Deliverables** | **Type** | **Leader** | **Participants** | **Date** |
|---|---|---|---|---|
| D2.2.1 – Model editor and Operational semantics of the MoCC modeling language | Software | ENSTA-B | ENSTA-B, I3S, OBEO | V0:M12 V1:M24 V2:M30 |

### 3.3.4 WP3: FORMALIZATION OF THE CONNECTION BETWEEN DIFFERENT MOCCS

3 http://www.speeds.eu.com/index.php?option=com_content&task=view&id=41&Itemid=58

| WP3 | Formalization of the connection between different MoCCs (59MM) | | | | | M1→M36 |
|---|---|---|---|---|---|---|
| WP Leader | I3S | | | | | |
| Participant | ENSTA-B | **I3S** | INRIA | IRIT | OBEO | THALES |
| Effort | 4 | **24** | 9 | 18 | - | 4 |
| Inputs from other WPs: WP1, WP2 | | | Outputs for other WP: WP4 | | | |

**Objectives**

Provide a unified formalization of combined MoCCs applied on xDSMLs (which provide their own operational semantics). More precisely, it will rely on a hierarchical component model where each elementary component uses a MoCC in an xDSML. In this context, the first step is to identify the various composition operators and their formalization. Then, the MoCCs and the DSLs must be abstracted in the same formal model where the composition can be proved to be correct with regards to some properties such as absence of deadlock. The use of a formal model will allow to assess and to ensure its completeness, consistency and correctness.

**Partner contributions**

- ***I3S*** will provide inputs from the already existing semantics of CCSL and its use for MoCC definition and from its participation in previous research projects (e.g., SPEEDS) based on component models with semantics (T3.1). It will also provide knowledge on denotational semantics definition based on the definition previously realized on other languages such as SyncCharts, Esterel, and, of course CCSL (T3.2), and on the semantics of the language used for MoCC description (T3.3).
- ***IRIT*** will provide its expertise about the formalization of components in MDE, and contract algebra for compositional verification (T3.1) as developed in the TOPCASED and CESAR projects (COQ4MDE framework), as well as about the formal definition of operational semantics (T3.3) and the formalization of programming language semantics and static analysis (T3.4). Appropriate tools such as proof assistants will be used to encode the formal specifications.
- ***IRIT and I3S*** will ensure the consistency and the early integration of the work done in T3.2, T3.3 and T3.4.
- ***INRIA*** will contribute by injecting its previous results about model composition (T3.1), by ensuring the link between the definition of the hierarchical component metamodel and its implementation in WP4 (T3.1), and by providing the Kermeta meta-programming language and its environment. INRIA will also provide its expertise Kermeta semantics (T3.3).
- ***ENSTA-B*** will ensure the transfer of results from, and the consistency with, WP1, WP2 and the GEMOC studio implementation in WP4 (T2.1).
- **THALES** will provide its industrial feedbacks and visions by participating to the technical choices.

| Task 3.1 | Hierarchical component model with heterogeneous MoCC composition operators | | | | | M1 →M12 |
|---|---|---|---|---|---|---|
| Task Leader | I3S | | | | | |
| Participant | ENSTA-B | **I3S** | INRIA | IRIT | OBEO | THALES |
| Effort | 2 | **5** | 5 | 4 | - | 1 |
| Inputs from other tasks: | | | Outputs for other tasks: WP4 | | | |

**Description**

Identify and formalize the composition operators mandatory for building of heterogeneous models (MoCCs + xDSMLs). These operators must be integrated in a hierarchical component metamodel.

| Deliverables | Type | Leader | Participants | Date |
|---|---|---|---|---|
| D3.1.1 – Identification and formal characterization of the operator for composition and Eclipse-based hierarchical component metamodel | Report and Metamodel | I3S | I3S, IRIT, INRIA, THALES, ENSTA-B | V0:M6 V1:M12 |

| **Task 3.2** | **Denotational semantics of the MoCC metamodel** | | | | | **M1 →M18** |
|---|---|---|---|---|---|---|
| **Task Leader** | **I3S** | | | | | |
| **Participant** | ENSTA-B | **I3S** | INRIA | IRIT | OBEO | THALES |
| **Effort** | - | **11** | - | 4 | - | 1 |

**Inputs from other tasks: WP1, WP2** | **Outputs for other tasks: WP4, T2.5**

**Description**

Provide a formalization of the metamodel resulting from WP2, in a denotational way. This semantics must conform to the association of CCSL and Cometa underlying semantics and be adapted to the proof of a maximum of relevant properties. It will be used by WP2 as a guide to implement an operational semantics.

| Deliverables | Type | Leader | Participants | Date |
|---|---|---|---|---|
| D3.2.1 – Description of the denotational semantics of the behavior of the WP2 metamodel | Report | I3S | I3S, IRIT | M18 |

| **Task 3.3** | **Integration of DSLs operational semantics** | | | | | **M1 →M24** |
|---|---|---|---|---|---|---|
| **Task Leader** | **IRIT** | | | | | |
| **Participant** | ENSTA-B | I3S | INRIA | **IRIT** | OBEO | THALES |
| **Effort** | 2 | 3 | 4 | **4.5** | - | 1 |

**Inputs from other tasks: WP1, T3.2** | **Outputs for other tasks: WP4**

**Description**

Establish the formal link between the language for MoCC definition and the domain specific concern in a specific xDSML. More precisely, the goal is to define both an adequate abstraction of the operational semantics language used in WP1 as well as restrictions on the implementation language used in WP4 (Kermeta) to avoid side effects in both xDSML and MoCC definitions. This work takes place at the specification level, as it must define the minimum relevant numbers of concepts which would give in our sense an operational semantics, but also at the implementation level, as it must provide a formal semantics, respectful of the specification, to a reasonable subset of Kermeta, the concrete language in which many operational semantics of xDSMLs will be implemented.

| Deliverables | Type | Leader | Participants | Date |
|---|---|---|---|---|
| D3.3.1 – Formalization and restriction for the DSL operational semantics | Report | IRIT | IRIT, I3S, INRIA, THALES, ENSTA-B | V1: M18 V2: M24 |

| **Task 3.4** | **Formalization proof** | | | | | **M12 →M36** |
|---|---|---|---|---|---|---|
| **Task Leader** | **IRIT** | | | | | |
| **Participant** | ENSTA-B | I3S | INRIA | **IRIT** | OBEO | THALES |
| **Effort** | - | 5 | - | **5.5** | - | 1 |

**Inputs from other tasks: T3.1, T3.2, T3.3** | **Outputs for other tasks: WP4**

**Description**

Encode the whole formalization provided in the other tasks of this package relying on the most appropriate tools such as proof assistants, but not limited to these ones. The goal is to guarantee the completeness, consistency and correctness of the previous formalization. The main objective is to provide formal proofs regarding the correctness of the composition operators, but also more

specific properties of some MoCCs and xDSMLs, whose semantics are embedded in these tools. Depending on the selected tools during the project, it should be possible to provide almost for free, a correct-by-construction simulation framework derived from the proof of correction.
This framework, even if not scalable and thus suitable for industrial use, will serve as a safe reference basis to confront the prototype issued from WP4 with. In this respect, it may be used either as a real simulation engine, or as an oracle, deciding whether an execution generated by the WP4 prototype is correct or not. In this last case, error and discrepancy reporting should be as precise as possible, to help finding the cause of a problem.

| Deliverables | Type | Leader | Participants | Date |
|---|---|---|---|---|
| D3.4.1 – Encoding of the formal model (composition operators and MoCCs/xDSMLs) | Report and Software | IRIT | IRIT, I3S | M30 |
| D3.4.2 – Experimental validation (comparison with WP4 prototype) | Report | IRIT | IRIT, I3S | M36 |

### 3.3.5 WP4: GENERIC EXECUTION FRAMEWORK FOR HETEROGENEOUS MODELS

| **WP4** | **Generic Execution Framework for Heterogeneous Models (71MM)** | | | | | **M1→M36** |
|---|---|---|---|---|---|---|
| **WP Leader** | **INRIA** | | | | | |
| **Participant** | ENSTA-B | I3S | **INRIA** | IRIT | OBEO | THALES |
| **Effort** | 12 | 4 | **36** | 4 | 13 | 2 |
| **Inputs from other WPs: WP1, WP2, WP3** | | | **Outputs for other WP: WP5** | | | |

**Objectives**

Provide an Eclipse-based environment to describe executions combining different DSMLs and MoCCs, execute a set of heterogeneous domain-specific models to produce a global simulated execution trace and use the simulated trace to animate models.

**Partner contributions**

- ***INRIA*** will lead the architectural design of the GEMOC Studio, and the integration of the Eclipse plugins coming from this WP as well as from WP1 and WP2, to build and disseminate the GEMOC Studio as an Eclipse-based open platform (T4.1). INRIA will also provide an important engineering effort to support the development of the generic execution engine (T4.2). INRIA will support this task thanks to the resources provided by its specific experimentation and development unit (SED, *Service d'Expérimentation et de Développement*). INRIA will provide Kermeta as a core model execution platform.
- **OBEO** will tune and extend generic Eclipse open-source plugins (EMF, EEF) and Obeo designer viewpoints to provide the editor of the GEMOC Studio according to the language defined in the WP3 (T4.1). Obeo will lead this task to ensure the consistency between the WP1 and WP2 integration and the GEMOC editor production. Obeo will also specify and develop the editor, the engine and the GMF connector for model animation (T4.3).
- ***INRIA*** and ***OBEO*** will coordinate T4.2 and T4.3 outputs to integrate them in a specific trace metamodel (T4.4).
- ***IRIT*** will contribute the results of the experiments conducted in the TOPCASED project on i) the definition of the model execution engine architecture based on the xDSML metamodeling pattern (T4.1); ii) the building of model execution engine based on the xDSML metamodeling pattern (T4.2); iii) the automatic generation of parts of model animators based on the xDSML metamodeling pattern (T4.3); iiii) the results of experiments conducted in TOPCASED related to the EDMM and TMMM parts of the xDSML

metamodeling pattern (T4.4).
- *I3S* will provide its expertise in the formalization made in WP3 (T4.1), will contribute on the definition of the API between the local and the global interpretation, based on the semantics defined in WP3 and WP2 (T4.2), and will bring its expertise on the trace model developed in the ANR Project RT-Simex and integrated in TimeSquare (T4.4).
- *ENSTA-B* will provide its experience relative to the implementation of Cometa in the ANR Mopcom-SoC/SoPC and the European iFEST projects, as well as the work done in the WP2 (T4.1 and T4.2).
- **THALES** will provide its industrial feedbacks and visions by participating to the technical choices.

| **Task 4.1** | **Execution Environment for Heterogeneous Models** | | | | **M1 →M36** |
|---|---|---|---|---|---|
| **Task Leader** | **OBEO** | | | | |
| **Participant** | ENSTA/B | I3S | INRIA | IRIT | **OBEO** | THALES |
| **Effort** | 4 | 1 | 12.5 | 1 | **3** | 0.5 |
| **Inputs from other tasks: WP3** | | **Outputs for other tasks: WP5** | | | |

**Description**
Definition of an Eclipse-based editor to model heterogeneous models execution according to the language defined in the WP3. Seamless integration of the Eclipse plugins from WP1 and WP2 to design executable domain-specific languages and MoCCs.

| **Deliverables** | **Type** | **Leader** | **Participants** | **Date** |
|---|---|---|---|---|
| D4.1.1 – GEMOC architectural description | Report | INRIA | INRIA, ENSTA-B, I3S, OBEO, IRIT, THALES | M6 |
| D4.1.2 – Eclipse-based tool to model heterogeneous model execution and GEMOC Studio | Software | OBEO | INRIA, ENSTA-B, I3S, OBEO, IRIT, THALES | V0: M18<br>V1: M30<br>V2: M36 |

| **Task 4.2** | **Generic Execution Engine** | | | | **M1 →M24** |
|---|---|---|---|---|---|
| **Task Leader** | **INRIA** | | | | |
| **Participant** | ENSTA-B | I3S | **INRIA** | IRIT | OBEO | THALES |
| **Effort** | 5 | 1 | **17.5** | 1 | 3 | 0.5 |
| **Inputs from other tasks: WP1, WP2, WP3** | | | **Outputs for other tasks: WP5** | | |

**Description**
Implementation of the execution engine that globally interprets the heterogeneous DSMLs (from WP1) as well as the different MoCCs (from WP2) through the Kermeta virtual machine and/or compiler. In particular, the engine includes
- a local interpretation of each domain-specific model according to its operational semantics;
- a global interpretation according to a global model (from WP3) hierarchically combining the various domain-specific models and their communication through heterogeneous MoCCs. MoCCs are interpreted by using the CCSL and COMETA operational semantics

| **Deliverables** | **Type** | **Leader** | **Participants** | **Date** |
|---|---|---|---|---|
| D4.2.1 – Generic Engine for heterogeneous models execution | Software | INRIA | OBEO, INRIA, IRIT, ENSTA-B | V0: M12<br>V1: M24<br>V2: M30 |

| **Task 4.3** | **Generic Animator Framework** | | | | **M1 →M24** |
|---|---|---|---|---|---|
| **Task Leader** | **OBEO** | | | | |
| **Participant** | ENSTA-B | I3S | INRIA | IRIT | **OBEO** | THALES |

| **Effort** | 2 | - | 2 | 1 | **6** | 0.5 |
|---|---|---|---|---|---|---|
| **Inputs from other tasks: WP1, WP2, WP3** | | | **Outputs for other tasks: WP5** | | | |

**Description**

Provide a set of Eclipse-based plugins for the GEMOC studio end user, i.e. the user who wants to graphically animate its models in conformance with its computation model descriptions. In practice, the expected animation framework will be able to animate the user models from the execution engine results, i.e the GEMOC traces.

The animator framework will be generic, i.e. GEMOC users can adapt the animation actions (reveal forms, hide forms, move forms) for their specific business needs.

For that, this task implies the development of an editor to describe the animation models; a generic animator engine; and a set of connectors to Eclipse-based graphical modelers (Graphical Modeling Framework (GMF-based) editors).

| **Deliverables** | **Type** | **Leader** | **Participants** | **Date** |
|---|---|---|---|---|
| D4.3.1 – Animation engine Eclipse-based plugins | Software | OBEO | OBEO, INRIA, IRIT | V0: M24<br>V1: M30 |

| **Task 4.4** | **API for Trace Management** | | | | **M12 →M36** |
|---|---|---|---|---|---|
| **Task Leader** | **I3S** | | | | |
| **Participant** | ENSTA-B | **I3S** | INRIA | IRIT | OBEO | THALES |
| **Effort** | 1 | **2** | 4 | 1 | 1 | 0.5 |
| **Inputs from other tasks: T4.2** | | **Outputs for other tasks: WP5** | | | |

**Description**

Define an API that provides an abstract and dedicated interface to handle the execution traces provided by the execution engine. This API must be used to establish the bridge between T4.2 and T4.3, and/or complex external execution tools such as simulators (batch or interactive), model checkers. In practice, this API is defined by a specific and tool-supported metamodel.

| **Deliverables** | **Type** | **Leader** | **Participants** | **Date** |
|---|---|---|---|---|
| D4.4.1 – API for Trace Management | Report and Metamodel | I3S | INRIA, OBEO, IRIT, I3S, ENSTA-B | V1: M24<br>V2: M30 |

### 3.3.6 WP5: GEMOC EXPERIMENTATIONS

| **WP5** | **GEMOC Experimentation (55MM)** | | | | | **M1→M36** |
|---|---|---|---|---|---|---|
| **WP Leader** | **THALES** | | | | | |
| **Participants** | ENSTA-B | I3S | INRIA | IRIT | OBEO | **THALES** |
| **Efforts** | 6 | 1 | 6 | 6 | 12 | **24** |
| **Inputs from other WPs: WP4; WP5** | | | **Outputs for other WP: WP3** | | | |

**Objectives**

Use the GEMOC languages, methodology and tools to specify and simulate heterogeneous systems. Besides, application of GEMOC in large industrial cases will give insights to assess whether the framework satisfies its objectives.

**3 different Use Cases:**

- **IRIT (assisted by AIRBUS and OBEO):** The FCGU (Flight Control & Guidance Unit) in the A380 airplane gather information coming from sensors including the pilot controllers (joystick, foot pedal, throttle, etc), together with data from many other systems, then compute the commands sent to various other systems and actuators in the plane (FADEC - Full Authority Digital Engine Control, fins, ruder, flaps and other aerodynamic control surfaces). This system is the most critical one in the plane. It is thus the subject of many sophisticated and stringent validation and verification activities. It is composed of several subsystems that are modeled with different languages with different MoCC (synchronous, asynchronous, concurrent, sequential, etc). It is thus an interesting use case for multi-MoCC model execution. The purpose of this use case is to express subsets of the various parts of the FCGU (relying on the use case models designed in the ITEA GeneAuto and FUI Projet P projects), then to connect them using the tools developed in the GEMOC project and then simulate the whole FCGU.

- **THALES** will provide a use-case based on a real industrial development, specifically a Radar application. This application is representative of a new generation of Radars being developed by the company where more control is added. It mixes several subsystems having different characteristics in terms of computation, communication, time or data. Hence, the heterogeneity that characterizes such a system makes the design and analysis really difficult. Besides, the development of such a system requires a good design space exploration through several levels of abstraction enabling good decision-making. Besides, such development requires managing the consistent refinement of the system model leading to a specification semantically rich enough to avoid snowballing errors and to allow relevant implementations. As such, the challenges posed by this UC are completely in line with the objectives of the project since the management of the MoCCs is crucial for the early verification and validation of the system, as well as for its consistent refinement. Moreover, this use case is complementary to the one developed by the IRIT as it differs partly in the kind of models and in the domain (Signal Processing and Mission Management).
- **Exploratory:** The operational semantics of fUML is clearly stated in the specification, but its model of computation is partially undefined. For instance, the concurrency is not well established and let the possibility to use different MoCCs. This use case will apply the GEMOC framework for the fUML language. This experimentation will be used as a benchmark during the implementation of the different tools in WP1, WP2, and WP4, before their use for the industrial use cases.

**Description**

- Requirements and assessment criteria, either qualitative or quantitative
- Identification of the industrial cases
- Experimentation of the GEMOC framework in the use cases
- Assessment of the GEMOC framework

**Partner contributions**

- ***IRIT, THALES*** and ***INRIA*** will define (T5.1), and will implement the xDSMLs and MoCCs (T5.2), as well as the models (T5.3) for respectively the Airbus A350 FWS use case, the Radar use case, and the exploratory use case. They will also provide the evaluation on their respective use cases (T5.4).
- ***OBEO*** will provide the requirements for the end-user that would describe its MoCC (T5.1), and will experiment the description of computation models upon fUML with the WP1, 2 and WP4 editors, to provide preliminary feedbacks to the implementations (T5.2). Obeo will also support THALES and IRIT in using the GEMOC model editors and the GEMOC model animator engine (T5.3).
- ***I3S*** will study the use cases to identify to most prominent MoCCs that must be manageable by the meta-language for the description of MoCCs (T5.2), and will provide a support to THALES and IRIT for the use and training on tools delivered in WP2 and WP3 (T5.3).
- ***ENSTA-B*** will provide feedbacks from WP2 and WP4 to help in the choice of the MoCCs regarding the different use cases (T5.2), and in the use of the tools (T5.3).

| **Task 5.1** | **Requirements and Assessment Criteria** | | | | | **M1 →M6** |
|---|---|---|---|---|---|---|
| **Task Leader** | **THALES** | | | | | |
| **Participants** | ENSTA-B | I3S | INRIA | IRIT | OBEO | **THALES** |
| **Efforts** | - | - | 1 | 1 | 1 | **2** |

| **Inputs from other tasks: none** | **Outputs for other tasks: WP2, WP3, WP4, T5.4** | | | |
|---|---|---|---|---|
| **Description**<br>Identify the technical requirements from the uses-cases for all the technical work in the GEMOC project (WP2, WP3 and WP4). Besides, this task will identify metrics, which will be evaluated at the end of the project to evaluate precisely the benefit of the project. | | | | |
| **Deliverables** | **Type** | **Leader** | **Participants** | **Date** |
| D5.1.1 – Technical Requirements, uses-cases specification and metrics for experimentations | Report | THALES | THALES, OBEO, IRIT, INRIA | M6 |

| **Task 5.2** | **Definition of DSL and MoCCs for Use Cases** | | | | | **M6 →M30** |
|---|---|---|---|---|---|---|
| **Task Leader** | **IRIT** | | | | | |
| **Participants** | ENSTA-B | I3S | INRIA | **IRIT** | OBEO | THALES |
| **Efforts** | 3 | 1 | 3 | **3** | 3 | 6 |
| **Inputs from other tasks: WP2; WP3** | | | **Outputs for other tasks: WP4; T5.3** | | | |
| **Description**<br>Use tools provided by the GEMOC framework to define the DSL required to implement the use cases. The definition of DSL includes the definition of the underlying MoCCs that will be interpreted by the GEMOC framework in purpose of simulation. | | | | | | |

| **Deliverables** | **Type** | **Leader** | **Participants** | **Date** |
|---|---|---|---|---|
| D5.2.1 – DSMLs and MoCCs for Use Cases | Software | IRIT | OBEO, I3S, INRIA, IRIT, ENSTA-B | V0: M18<br>V1: M24 |

| **Task 5.3** | **Framework Experimentations** | | | | | **M12 →M36** |
|---|---|---|---|---|---|---|
| **Task Leader** | **THALES** | | | | | |
| **Participants** | ENSTA-B | I3S | INRIA | IRIT | OBEO | **THALES** |
| **Efforts** | 1 | - | - | 1 | 4 | **14** |
| **Inputs from other tasks: WP4** | | | **Outputs for other tasks: WP2, WP3, WP4, T5.4** | | | |
| **Description**<br>Industrial partners will experiment the GEMOC framework in order to implement their use cases and do the simulation. | | | | | | |

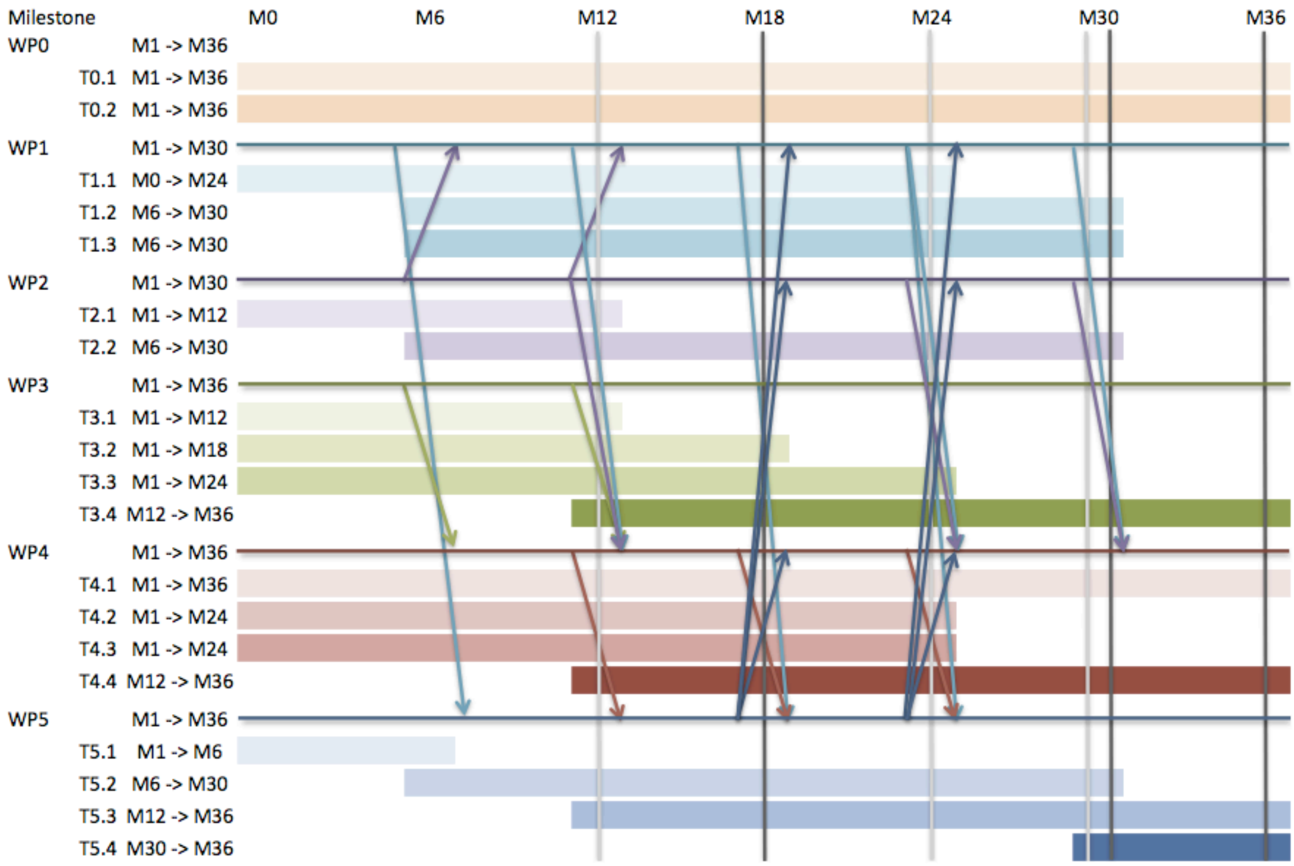
| **Deliverables** | **Type** | **Leader** | **Participants** | **Date** |
|---|---|---|---|---|
| D5.3.1 – Uses-case models and simulation | Software | THALES | IRIT, ENSTA-B, THALES, I3S | V0: M24<br>V1: M36 |

| **Task 5.4** | **Experimentation Analysis** | | | | | **M30 →M36** |
|---|---|---|---|---|---|---|
| **Task Leader** | **OBEO** | | | | | |
| **Participants** | ENSTA-B | I3S | INRIA | IRIT | **OBEO** | THALES |
| **Efforts** | 2 | - | 2 | 1 | **2** | 2 |
| **Inputs from other tasks: T5.1** | | | **Outputs for other tasks: none** | | | |
| **Description**<br>Evaluate the metrics defined in the Task 5.1 on different uses-cases and analyse the results for their exploitations. Determine whether the GEMOC framework succeeds to provide means to help the definition of DSML and the design of complex real-time systems. | | | | | | |

| **Deliverables** | **Type** | **Leader** | **Participants** | **Date** |
|---|---|---|---|---|
| D5.4.1 – Experimentation results analysis | Report | OBEO | THALES, OBEO, IRIT, INRIA, ENSTA-B | M36 |

## 3.4. TASKS SCHEDULE, DELIVERABLES AND MILESTONES

| Deliverables | Type | Leader | Participants | Date |
|---|---|---|---|---|
| D0.1.1 – Project web site facility | Web Site | INRIA | ALL | M6 |
| D0.1.2 – Project Activity and Management Report, Period 1 | Report | INRIA | ALL | M12 |
| D0.1.3 – Project Activity and Management Report, Period 2 | Report | INRIA | ALL | M24 |
| D0.1.4 – Final Project Report | Report | INRIA | ALL | M36 |
| D0.2.1 – Whitepaper including bibliography of scientific papers | Report | INRIA | ALL | M36 |
| D0.2.2 – Definition of the long-term strategy for the GeMoC Exploitation | Report | THALES | ALL | M36 |
| D1.1.1 – Metaprogramming with Kermeta and xDSML pattern guidelines | Report | IRIT | INRIA, IRIT | V0: M6 |
| | | | | V1: M12 |
| | | | | V2: M24 |
| D1.2.1 – DSML behavioral semantics definition tools | Software | IRIT | INRIA, IRIT, OBEO | V0: M12 |
| | | | | V1: M24 |
| | | | | V2: M30 |
| D1.3.1 – xDSML/MoCC mapping language, tools and methodology | Report and Software | ENSTA/B | ENSTA/B, I3S, INRIA | V0: M12 |
| | | | | V1: M24 |
| | | | | V2: M30 |
| D2.1.1 – Ecore-based metamodel of the MoCC modeling language | Report and Metamodel | I3S | I3S, IRIT, ENSTA/B, INRIA | V0:M6 |
| | | | | V1:M12 |
| D2.2.1 – Model editor and Operational semantics of the MoCC modelling language | Software | ENSTA/B | ENSTA/B, I3S, OBEO | V0:M12 |
| | | | | V1:M24 |
| | | | | V2:M30 |
| D3.1.1 – Identification and formal characterization of the operator for composition, and Eclipse-based hierarchical component metamodel | Report | I3S | I3S, IRIT, INRIA | V0:M6 |
| | | | | V1:M12 |
| D3.2.1 – Description of the denotational semantics of the WP2 metamodel | Report | I3S | I3S, IRIT | M18 |
| D3.3.1 – Formalization and restriction for the DSL operational semantics | Report | IRIT | IRIT, I3S, INRIA | V1: M18 |
| | | | | V2: M24 |
| D3.4.1 – Encoding of the formal model in Coq (composition operators and MoCCs/xDSMLs) | Report and Software | IRIT | IRIT, I3S | M30 |
| D3.4.2 – Experimental validation (comparison with WP4 prototype) | Report | IRIT | IRIT, I3S | M36 |
| D4.1.1 – GeMoC architectural description | Report | INRIA | INRIA, ENSTA-B, I3S, OBEO, IRIT | M6 |
| D4.1.2 – Eclipse-based tool to model heterogeneous model execution and GeMoC studio | Software | OBEO | OBEO, INRIA | V0: M18 |
| | | | | V1: M30 |
| | | | | V2: M36 |
| D4.2.1 – Generic Engine for heterogeneous models execution | Software | INRIA | OBEO, INRIA, IRIT, ENSTA-B | V0: M12 |
| | | | | V1: M24 |
| | | | | V2: M30 |
| D4.3.1 – Animation engine Eclipse-based plugins | Software | OBEO | OBEO, INRIA, IRIT | V0: M24 |
| | | | | V1: M30 |
| D4.4.1 – API for Trace Management | Report and Metamodel | I3S | INRIA, OBEO, IRIT, I3S | V1: M24 |
| | | | | V2: M30 |
| D5.1.1 – Technical requirements, uses-cases specification and metrics for experimentations | Report | THALES | THALES, OBEO, IRIT, INRIA | M6 |
| D5.2.1 – DSL and MOCC for Use Cases | Software | IRIT | OBEO, I3S, INRIA, IRIT, ENSTA/B | V0: M18 |
| | | | | V1: M24 |
| D5.3.1 – Uses-case models and simulation | Software | THALES | IRIT, ENSTA, THALES, I3S | V0: M24 |
| | | | | V1: M36 |
| D5.4.1 – Experimentation results analysis | Report | OBEO | THALES, OBEO, IRIT, INRIA | M36 |



# 4. DISSEMINATION AND EXPLOITATION OF RESULTS, INTELLECTUAL PROPERTY

For the successful exploitation of the GEMOC scientific and technical outcomes, dissemination and exploitation activities should run in parallel with the project management to coordinate the various activities concerned with the successive knowledge transfer. Disseminating and exploiting GEMOC achievements is an integral part of all tasks (WP0) and a responsibility for all partners. Integrity and consistency of all dissemination and exploitation efforts and materials are to be supervised by the project Manager.

## 4.1. DISSEMINATION

A dissemination strategy consists of dissemination policies and is intended for the transfer of project achievements and lessons learnt. The planning of dissemination policies, which is a horizontal procedure along the overall project lifecycle, will start immediately after the first results. We distinguish three types of dissemination policies: *scientific*, *technologic*, and *industrial*. Each policy will be based on three major dissemination channels (i.e., *on-line*, *non-electronic* and *interactive* dissemination) and their corresponding dissemination activities. Each dissemination policy will be designed as a blend of dissemination activities from one or more channels, with respect to the respective target group(s) that aims to address.

| DISSEMINATION | Online | Non-Electronic | Interactive |
|---|---|---|---|
| **Scientific** | A website will provide a first access point for interested scientific parties into the GEMOC project. This website will publish all scientific publications as well as will advertise the research objectives of GEMOC. | Journals, conferences, and workshops within software engineering in general, as well as more specialized ones within fields such as MDE, MoCC, and simulation. Include but are not limited to *ICSE, MoDELS, TOOLS, AOSD, IEEE TSE, ACM TOSEM, ASE, FMICS, SLE*. | Individual interactions in academic conferences both national and international. Scientific dissemination will also leverage close collaborations with research teams in other countries, in particular with the Colorado State University in USA (see annex). |
| **Technological** | The website will be combined to the INRIA forge to ensure a broad access to the GEMOC studio. The long-term objective of the website is to create a community of interested parties around the project. | Classical vehicles of knowledge transfer such as articles in publications in broadcast media and monographs focus on the dissemination of project results, mainly to experts and professionals. | Individual interactions in exhibitions (e.g. around Eclipse community). |
| **Industrial** | The website provides industrial partners who are not involed in GEMOC the benefits both from the open-source platform, and the experiments conducted in the project. | Industrial users working group, industrial conferences and workshop. OMG, Internal THALES promotion (internal workshops). Classical vehicles of knowledge transfer such as brochures (company newsletters). | Individual interactions in industrial conferences (e.g. ERTS and "journées INRIA-Industries"), ANR organized events, trade fairs and exhibitions. |

The impact of GEMOC will become a reality if the project results are disseminated through the appropriate channels.

| Project result | Potential users | Dissemination |
|---|---|---|
| New knowledge on the integration of MoCC and MDE | Applied and fundamental researchers | Publications in reputable journals, conferences and workshops |
| Reports on results | Academic lecturers | Through courses given in master and PhD programmes |
| Tool technology | Labs, R&D departments in large-scale companies | Proof of concepts and evaluation of this new technology in complex systems definition and simulation. |
| Use cases | Applicants as proofs of concept | Journals about practice and case studies |

## 4.2. Exploitation of Results

The outcomes of this project address scientific and technological advances in the field of complex systems heterogeneous modeling and simulation. We describe in this section the exploitation strategy of the GEMOC results.

### 4.2.1 Results Exploitation at OBEO

Obeo expects to provide mature enough solutions to 1) share some results with Topcased and Eclipse open source communities; and 2) integrate others as commercial features of the Obeo Designer suite. The open-source exploitation intends to enrich Eclipse modeling plugins and Topcased modeling plugins with technical solutions developed by the GEMOC project. This will ensure international promotion of the GEMOC results. The second exploitation is an industrial one: provide means to define executable DSML and the animation of the conforming models. Intended market places are complex and multi-engineering systems (aeronautic, railway and automotive industrials) that imply behavioral constraints (real-time systems, reactive systems, safety systems). The Obeo designer suite will be enriched with GEMOC results.

### 4.2.2 Results Exploitation at Thales

One of the major challenges in complex systems industry is to find a tradeoff between cost and delay reduction and propose innovative design solutions. In this objective, the expected results of GEMOC for THALES are

- Methodology and solution to facilitate the simulation and tests.
- Solutions for formal analysis of heterogeneous viewpoints.
- Mastering the integration of heterogeneous software (synchronous, control-flow, etc).

These solutions will be integrated in the THALES' model-driven system design process.

### 4.2.3 Results Exploitation in the OPEES Platform and the Eclipse IWG Polarsys

As indicated in the support letter (cf. annex), the results of the GEMOC project will be evaluated in the context of the OPEES' labeling process. The main objective is to ensure a sustainable exploitation and valorization through the new Eclipse Industry Working Group Polarsys (cf. http://www.polarsys.org).

## 4.3. Intellectual Property

The general guideline for the Project Consortium Agreement is the following:

*Background knowledge:* The partners will list all their background knowledge related to the project and needed by the other partners for the project. The partners will also list the necessary conditions to use this knowledge with an indication if this knowledge could be put in open-source;

*Results:* Although the consortium agrees on the importance of the IPR protection, the partners agree that a conservative position could be counterproductive for the project's success. Therefore a balanced approach is agreed along the following principles:

- The principles and technologies that are foundations for the building of an engineering will be preferably delivered in as open source way in order to enable the quick adoption of the project's results by the SME's and end user's community.
- The added value technologies developed on top of these foundations, and that may be considered, as commercial differentiators by the project's actors, will be preferably kept as proprietary solutions by their owners.

In the case of results belonging to more than one partner, those partners will need to make a cross-agreement for the rights of use the co-property.

*Management & Confidentiality:*
Besides the ownership of the results and IPR, the consortium agreement will also cover:

- Confidentiality of the partners background and restriction in use,
- Organization of the co-operation,
- Management of the subcontracting,
- Responsibility/liability of supplies/materials/software,
- Intellectual property and copyright strategies.

# 5. CONSORTIUM DESCRIPTION

## 5.1. PARTNERS DESCRIPTION & RELEVANCE, COMPLEMENTARITY

### 5.1.1 RELEVANCE OF THE INRIA TRISKELL TEAM-PROJECT TO THE PROPOSAL

INRIA, the French national institute for research in computer science and control, operating under the joint authority of the Ministries of Research and of Industry, is dedicated to fundamental and applied research in information and communication science and technology (ICST). Throughout its eight research centres located, INRIA has a workforce of 4 100 (3 150 of whom are scientists from INRIA or from INRIA's partner organizations such as CNRS (the French National Center for Scientific Research), universities and leading engineering schools). They work in about 200 project-teams. Many INRIA researchers are also professors who supervise around 1000 doctoral students, their theses work contributing to INRIA research projects. INRIA will be involved in the GEMOC project through its Triskell research team, a world leader in Model Driven Engineering research, located in the Irisa Joint Research Unit (JRU) in Rennes. In this context, INRIA represents also the following members of the Join Research Unit IRISA: CNRS, Université de Rennes 1, INSA de Rennes.

Triskell managed to become one of the top 5 world leading teams in Model Driven Engineering. For instance, during the last 4 years, we have published 14 papers at MODELS (surpassing every other team worldwide. Furthermore, of these 14 papers, 4 were selected for SoSyM as best papers of the conference (in 2007, 2008, and two in 2009). This was largely made possible thanks to our Kermeta environment, which is indeed clearly ahead of the competition, with unique features such as built-in Aspect Oriented Meta-Modeling and strong typing (including Model Typing).

### 5.1.2 Relevance of the I3S Aoste team to the proposal

The Aoste Team-project is a joint project between the I3S Laboratory (Informatique Signaux et Systèmes de Sophia Antipolis, UMR 7271 CNRS) and the INRIA Research center Sophia-Antipolis Méditerranée.
The main objective of Aoste is to reconcile formal and engineering models for the modeling and analysis of real-time and embedded systems. Such systems require sound mathematically based models (for safety-critical aspects) that can address the complexity and heterogeneity of the applications (mix of control and data flow), the execution platform (increasingly parallel with multi-core architectures) and the allocation of the former onto the latter, taking into account functional and non-functional aspects (timing constraints, power consumption). Aoste builds on the experience of its team members on synchronous reactive languages (SyncCharts, Safe State Machines of SCADE) and their extensions (GALS, polychronous languages). Aoste proposes both static and analysis methods to guarantee the correction of properties and assess the adequacy of the proposed models.
Over the last six years, we have set up to promote our work within the modeling community by taking the lead for the definition of the time model of the UML Profile for MARTE (Modeling and Analysis of Real-Time and Embedded systems), which has been formally adopted by the Object Management Group in November 2009. This time model gives a temporal and causal interpretation to models in general, and UML models in particular. This time model should be one the foundational element, in GEMOC, for the definition of the meta-language able to capture and compose MoCCs.

### 5.1.3 Relevance of the IRIT ACADIE team to the proposal

IRIT ACADIE (Assistance à la Certification d'Applications Distribuées et Embarquées – Distributed and Embedded Application Certification Assistance) has been involved in the integration of formal specification and verification and Model Driven Engineering technologies in the last 10 years. The results of this work, expressed as the eXecutable Domain Specific Modeling Language metamodeling pattern and the Coq4MDE formal specification of Model Driven Engineering key technological elements, has been applied in the FUI TOPCASED project for the development of model Validation and Verification tools such as model animators (in collaboration with ATOS Origin and the LIUPPA Movies team) and model checkers (in collaboration with the CNRS-LAAS-OLC, INRIA-VASY and INRIA-ESPRESSO teams). This work has been published both on formal engineering, model driven engineering and industrial transfer conferences. These activities are currently being extended in many projects such as FRAE QUARTEFT, ITEA OPEES and JTI ARTEMIS CESAR. These activities have always been conducted in close relationship with industrial partners like Airbus, ATOS, CNES, CONTINENTAL, C-S, EADS-Astrium and THALES providing a seamless transfer of formal specification and verification technologies to industrial end users through MDE.

### 5.1.4 Relevance of the ENSTA-Bretagne to the proposal

ENSTA-Bretagne is an academic partner involved in several projects related to MDE technologies; applied to process modelling, hardware/software co-design, requirements modelling, and validation. ENSTA-Bretagne expertise in hardware/software co-design has been reinforced during the national research ANR project MOPCOM-SOC/SOPC. One of the results brought in this project is the Cometa metamodel.. This metamodel is used through a dedicated tool-assisted methodology based on UML/MARTE. This Cometa metamodel is also used in the European ARTEMIS iFEST project as pivot formalism between several tools related to the co-design domain. In this context, the model of computation, described in

Cometa, is promoted to structure the application modeling. ENSTA-Bretagne will contribute to GEMOC in the areas of metamodeling related to the communication in the model of computation. ENSTA-Bretagne will make use of GEMOC results in courses included in a postgraduate training on embedded system modelling and validation, down to concrete robotic applications developed with other teams of the ENSTA-Bretagne, like oceanographic submarine observatories and an autonomous submarine.

ENSTA-Bretagne will contribute to GEMOC dissemination through scientific articles at conferences and workshops. MDD4DRES summer school, co-organized by ENSTA-Bretagne, will be also excellent for such dissemination, gathering an industrial and academics international audience.

### 5.1.5 RELEVANCE OF THE THALES TRT COMPANY TO THE PROPOSAL

Thales is a world leader for mission critical information systems, with activities in 3 core businesses: aerospace, defense, and security. It employs 68000 people worldwide, and is present in 50 countries.

Thales research activities are lead in the form of surveys, gathering business and R&T teams around common goals related to experiments, validation and technological migration. This original pattern avoids the pitfalls of the classical linear model Research-Transfer-Development. In the continuity of its research activity, Thales Research and Technology plays a central role in the definition of the processes and methodologies applied by the various business units to develop real-time embedded systems. Thales has a great expertise in the issues posed by the GEMOC project. Thales will insure the consistency of the experiments as well as the dissemination of the results of the project in the entire group.

In the one hand, applications provide more and more functionalities, and are more and more complex. In the other hand, current tools do not handle such complexity and thus cannot achieve the necessary decreasing of costs and time-to-market. To handle those issues, it is necessary to develop tool chains allowing the design and analysis of real-time embedded systems, supporting automation and rationalization, and providing guidance to developers. According to our experience, model based approaches are good candidates to provide such features and help to diminish costs related to execution infrastructures. Indeed, modeling support the capture of all relevant features of real-time systems design and analysis. Besides, the simulation of heterogeneous models provides relevant information to system analysts. Then, execution of heterogeneous models, mixing several models of computation and communication, constitutes a great challenge.

In the past, Thales Research and Technology has developed a strong modeling expertise through its contribution to several research projects related to UML modeling and Model based Engineering: CARROLL, MOVIDA, RT-SIMEX, etc. Thales R&T has also been an active actor in the definition of the UML profile for MARTE standardized by the Object Management Group (OMG) as well as the definition of ALF and fUML. This expertise has resulted in deployment of several modeling technologies in the group.

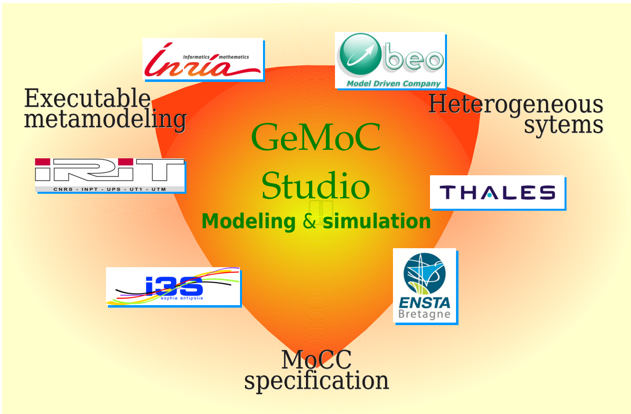
### 5.1.6 RELEVANCE OF THE OBEO COMPANY TO THE PROPOSAL

Obeo is a leading company for model driven software development based on Eclipse. Obeo offers products and services both to industrialize new development and to understand/update legacy systems. The company was created in 2005 and has now more than 45 employees in three offices (Nantes, Paris and Toulouse). It has several large companies as customers like Thales, Airbus, CEA, Alstom, Unédic, etc.

Involved in the Open Source community, Obeo is an Eclipse-based company. It is the only french member of the Eclipse Foundation Strategic Member committee. It lead several modeling project such as: Acceleo (EMF code generator), ATL (EMF model transformation), EMF compare (model comparison), EEF (EMF model property editions). Moreover, Obeo is developing a nascent Eclipse-based technology, Obeo Designer, which devises a modeling environment for alleviating domain specific modeling language definitions and uses. Hence, Obeo will bring to the project this dual experience: modeling and Eclipse.
The Obeo strategy is based on academic and industrial collaborations. Hence, Obeo is participating to several R&D projects such as Movida, RT-Simex, Edona, Verde, Imofis. Besides, Obeo is leading the Opees project. It will thus bring to the project this experience to ensure long-term availability of innovative engineering technologies resulting of GEMOC.

### 5.1.7 COMPLEMENTARITY OF THE PARTNERS WITHIN THE CONSORTIUM

GEMOC relies on three majors concepts (cf. Figure below): Executable metamodeling, Heterogeneous systems and MoCC specification. These three concepts are mandatory to enable the composition and simulation of heterogeneous models in the GEMOC studio. While each involved partner brings a piece of the triangle to ensure the success of the project, we all share experiences about modeling and simulation through many projects like TopCased, RT-Simex, MARTE, Mopcom-SoC/SoPC and OPEES.




Concerning the executable metamodeling knowledge, both IRIT (ACADIE Team) and INRIA (Triskell team) will bring their experiences about the design of the "eXecutable DSML" metamodeling pattern. INRIA will also contribute the KERMETA meta-programming language. Note that the INRIA Triskell team also provides deep knowledge about model manipulation (transformation, merge, typing, etc.).

For knowledge about the MoCC specification, ENSTA Bretagne will provide feedback on its definition of the COMETA communication modeling language and I3S (AOSTE team) will bring its skills about the formal manipulation of logical time via MARTE and CCSL. The formal aspect of the GEMOC project will be developed by IRIT and I3S based on their experiments on set-based formal specification of model and metamodel technologies and its implementation using proof assistants.

Finally, three partners cover the heterogeneous system aspect. First Thales has long experiment in modeling industrial heterogeneous real-time and embedded systems. Second, ENSTA Bretagne participates to the iFest project, which deal with hardware software codesign. Finally, Obeo will provide its expertise on viewpoint modeling and merging, where heterogeneous representations can be integrated.

Also, it is important to notice that each partner have experiences on Eclipse technology, especially Obeo that conducted relevant experiences on open-source dissemination with Acceleo, EEF and EMF Compare. All GEMOC's partners also participated in preliminary studies as part of the "Action Spécifique" (CNRS GDR GPL) on heterogeneity in software engineering (lead by the Triskell and Aoste teams), and are participating in setting up the Eclipse Polarsys Platform as outcome of the OPEES project (lead by Obeo).

## 5.2. QUALIFICATION OF THE PROJECT COORDINATOR

**Benoit Combemale** (MCF, University of Rennes 1) is appointed to be the coordinator for the GEMOC project. He received his PhD in computer science from the University of Toulouse, France in 2008. He first worked at Inria before joining the University of Rennes 1 in 2009. He is now associate professor of Computer Science at the University of Rennes 1, specializing in software engineering, and a member of both the IRISA and Inria Labs. His research interests include model-driven engineering (MDE), software language engineering (SLE) and Validation & Verification (V&V). He also teaches object-oriented programming and modeling, MDE and V&V in different universities and engineering schools.

## 5.3. QUALIFICATION AND CONTRIBUTION OF EACH PARTNER

| **ENSTA Bretagne** | Nom | Prénom | Emploi actuel | Discipline | h.m | Rôle/Responsabilité |
|---|---|---|---|---|---|---|
| Coordinator | Le Lann | Jean-Christophe | Associate Professor | Informatique | 15 | *WP2 leader and ENSTA-B coordinator* |
| Other members | Champeau | *Joel* | *Associate Professor* | Informatique | 15 | |

| **I3S** | Nom | Prénom | Emploi actuel | Discipline | h.m | Rôle/Responsabilité |
|---|---|---|---|---|---|---|
| Coordinator | DeAntoni | Julien | MCF (UNS) | Informatique | 15 | *Leader of WP3 (coordinator).* |
| Other members | Mallet | Frédéric | *MCF/HDR (UNS)* | Informatique | 9 | |

| **INRIA** | Nom | Prénom | Emploi actuel | Discipline | h.m | Rôle/Responsabilité |
|---|---|---|---|---|---|---|
| Coordinator | Combemale | Benoit | MCF (UR1) | Informatique | 12 | *Project coordinator and leader of WP0 (coordinator).* |
| Other members | Vojtisek | Didier | Ing. Recherche (INRIA) | Informatique | 16 | *Leader of WP4 (coordinator),* Development leader of the GEMOC Studio |
| | Barais | Olivier | MCF (UR1) | Informatique | 4 | Architecture leader of the GEMOC Studio |
| | Baudry | Benoit | CR1 (Inria) | Informatique | 4 | *Inria coordinator.* Evolving in WP1, WP2 and WP3. |

| **IRIT** | Nom | Prénom | Emploi actuel | Discipline | h.m | Rôle/Responsabilité |
|---|---|---|---|---|---|---|
| Coordinator | Crégut | Xavier | MCF (INPT) | Informatique | 10 | *IRIT coordinator and leader of WP1.* Metamodeling technologies leader, WP2, WP4 |
| Other members | Thirioux | Xavier | *MCF (INPT)* | Informatique | 6 | Proof assistant specialist, WP3, WP1, WP2. |
| | Pantel | Marc | MCF (INPT) | Informatique | 8 | WP5 (Airbus Fly By Wire FCGU use case), WP1, WP2, WP3 |

| **OBEO** | Nom | Prénom | Emploi actuel | Discipline | h.m | Rôle/Responsabilité |
|---|---|---|---|---|---|---|
| Coordinator | Brun | Cédric | R&D engineer | Informatique | 6 | *Obeo coordinator.* |
| Other members | Bats | Mélanie | R&D engineer | Informatique | 24 | Animator engine architect and developer on WP4 and use case experimentations on WP5 |

| THALES | Nom | Prénom | Emploi actuel | Discipline | h.m | Rôle/Responsabilité |
|---|---|---|---|---|---|---|
| Coordinator | LeNoir | Jérôme | R&D Project leader | Informatique | 13 | *Thales coordinator.* Contributions to the WP0 and WP5. |
| Other members | Koudri | Ali | *Research engineer* | Informatique | 23 | *Leader of WP5.* Contributions to the WP2 to WP5 tasks |

# 6. SCIENTIFIC JUSTIFICATION OF REQUESTED RESSOURCES

## 6.1. PARTNER 1: INRIA

- *Staff*

To achieve the objectives of the tasks in which INRIA will be involved the following permanents will be associated to the project (40 Men-Months):

- ***Dr. Benoit Combemale*** (MCF UR1): ~22% *(8MM: 4 WP0, 1 WP1, 2 WP3, 2 WP4)*
- ***Dr. Benoit Baudry*** (CR INRIA, HDR): ~22% *(8MM: 1 WP1, 2 WP2, 3 WP4, 2 WP5)*
- ***Dr. Olivier Barais*** (MCF UR1): ~11% *(4MM: 2 WP1, 2 WP4)*
- ***Ing. Didier Vojtisek*** (Ing. Recherche INRIA, SED): ~45% *(16MM: 2 WP1, 2 WP2, 11 WP4, 1 WP5)*

We ask for the funding of a post-doctoral researcher for 24MM to complete the tasks assigned in the project. The candidate will apply from January 2013 and will be located at the INRIA Rennes Bretagne-Atlantique Center. S/he will benefit of the technical support of the INRIA SED (*Service d'Expérimentation et de Développement*). This post-doctoral researcher will play a key role in achieving the scientific and technical work of GEMOC, especially in WP4. The post-doctoral researcher will be assigned as following: 9 in WP1, 6 in WP3, 8 in WP4 and 1 in WP5.

INRIA also ask for the funding of a software engineer for 18MM to help in the technical work of GEMOC (especially in WP4), and in the lead and animation of the project. S/he will also assume the integration task of the Eclipse plugins developed in the project to build the GEMOC Studio. Finally, s/he will also evolve in the competitive context of INRIA and its development team for the transfer and the dissemination of the resulting GEMOC studio.

The candidates will have good and general competences in software engineering, good knowledge in Java and Eclipse–based development, good animation and communication skills (both in French and in English). The definition of these positions is still in progress and will be disseminated by the way of the INRIA and IRISA programs.

Thus, INRIA will involve 36 Men-Months of permanent resources and 42 Men-Months of non-permanent resources: ~2.2 people all along the project.

- *Travel*

Travels will be motivated by the following reasons:

- Technical meetings (2 or 3 days) will be arranged with the partners in order to coordinate the project execution and progress on the execution of the WPs. There will be four meetings per year in France for two persons, one will be held locally so we ask for the funding of the trip for the three other ones. The total cost for this item is 13,5k€: 3 travels x 2 persons x 3 years x 750€ (including travel and accommodation).
- Four travels for one person across Europe (x5) and the United States of America (x2) for scientific and industrial dissemination purpose. The total cost for this item is 18.5k€: 2.5k€ for a European mission, and 3k€ for an international mission (including travel, accommodation and conference registration fees).

- For the specific dissemination purpose, INRIA as a project leader needs 2 national travels x 1k€ in exhibitions (including travel, accommodation, and exhibition space).

**The total cost for traveling inside and outside the project is 34k€.**

- *Other expenses*

INRIA intends to buy two computers bearing wasteful development tasks for the two non-permanent staff recruited for the project. The cost of these computers and its accessories (e.g., screen and bag) is 2 x 2.5k€. We also ask for the funding of a laptop for demonstration purpose. The cost of this laptop is 2000€.
Moreover INRIA will organize the two-day intermediary meetings in Brittany (total cost for this item is 4k€: 2k€ x 1 meeting x 2 first years), as well as the kick-off meeting and the two-day final workshop in Brittany (total cost for this item is 6k€: 3k€ x 2). **The total cost is 11k€.**

### 6.2. PARTNER 2: I3S

- *Staff*

To achieve the objectives of the tasks in which I3S will be involved the following permanents will be associated to the project (36 Men-Months):

- ***Julien De Antoni*** (MCF UNS) 42% *(15MM: 1 WP0, 2 WP1, 4 WP2, 4 WP3, 3 WP4, 1 WP5)*
- ***Frédéric Mallet*** (MCF UNS, HDR): 25% *(9MM: 3 WP0, 3 WP2, 2 WP3, 1 WP4)*

To address the research work on the definition of a timed model for concurrent entities (WP2) and the formalization of the composition between concurrent MoCCs (WP3), we request the funding of a PhD student (36MM) that will have to work closely with IRIT. The main scientific challenge is to combine declarative polychronous constraint-based specifications (as in CCSL) with state-based specifications (COMETA), while still preserving good properties of our models.
Thus, I3S will involve 24 Men-Months of permanent resources and 36 Men-Months of non-permanent resources: ~1.67 persons all along the project.

- *Travel*

Travels will be motivated by the following reasons:

- Technical meetings (2 or 3 days) will be arranged with the partners in order to coordinate the project execution and progress on the execution of the WPs. There will be four meetings per year in France (or on site) for two persons, one will be held locally so we ask for the funding of the trip for the three other ones. The total cost for this item is 13,5k€: 3 travels x 2 persons x 3 years x 750€ (including travel and accommodation).
- Four travels for one person across Europe (x3) and the United States of America (x 1) for scientific and industrial dissemination purpose. The total cost for this item is 10.5k€: 2.5k€ for a European mission, and 3k€ for an international mission (including travel, accommodation and conference registration fees).

**The total cost for traveling and meeting/workshop organization is 24k€.**

- *Other expenses*

I3S intends to buy two computers bearing wasteful development tasks for the two non-permanent staff recruited for the project. The cost of these computers and its accessories (e.g., screen and bag) is 2 x 2.5k€. We also ask for the funding of a laptop for demonstration purpose. The cost of this laptop is 1.5€. **The total cost for other expenses is 6.5k€.**

### 6.3. PARTNER 3: IRIT

- *Staff*

To achieve the objectives of the tasks in which IRIT will be involved, the following permanents will be associated to the project (36 Men-Months):

- ***Xavier Crégut*** (MCF INPT): ~28% *(10 Men-Months: 1 WP0, 6 WP1, 1 WP2, 2 WP4)*
- ***Xavier Thirioux*** (MCF INPT): ~17% *(6 Men-Months: 1 WP0, 5 WP3)*
- ***Marc Pantel*** (MCF INPT): ~22% *(8 Men-Months: 3 WP1, 1 WP3, 4 WP5)*

To address the research work on the design of a methodology for xDSMLs and MoCCs specification and its relation for a formal embedding of the MoCCs interactions, we request the funding of post-doctoral students (24MM) that will have to work closely with INRIA. The main scientific challenges are: first to combine xDSMLs specification using Kermeta metaprogramming technologies and the xDSML metamodeling pattern (WP1), with the MoCCs specification based on the integration of CCSL and Cometa (WP2), and to provide a formal specification and implementation for the interaction between the various MoCCs. These students will also participate in the validation of the proposed approach in the WP4 and W P5 use cases.

Thus, IRIT will involve 24 Men-Months of permanent resources and 24 Men-Months of non-permanent resources: 1.33 full-time persons all along the project.

- *Travel*

Travels will be motivated by the following reasons:

- Technical meetings (2 or 3 days) will be arranged with the partners in order to coordinate the project execution and progress on the execution of the WPs. There will be four meetings per year in France for two persons, one will be held locally so we ask for the funding of the trip for the three other ones. The total cost for this item is 13,5k€: 3 travels x 2 persons x 3 years x 750€ (including travel and accommodation).
- Four travels for one person across Europe (x3) and the United States of America (x 1) for scientific and industrial dissemination purpose. The total cost for this item is 10.5k€: 2.5k€ for a European mission, and 3k€ for an international mission (including travel, accommodation and conference registration fees) per year.

IRIT will also organize a two-day meeting in Toulouse each year. The total cost for this item is 2k€. **The total cost for traveling and meeting/workshop organization is 26k€.**

- *Other expenses*

IRIT intends to buy one computer (workstations or laptops) for the staff involved for the project. The cost of these computers and its accessories (e.g., screen and bag) is 2.5k€.
**The total cost for other expenses is 2.5k€.**

### 6.4. PARTNER 4: ENSTA-BRETAGNE

- *Staff*

To achieve the objectives of the tasks in which ENSTA-Bretagne will be involved the following permanents will be associated to the project (30 Men-Months):

- ***Joel Champeau*** (Associate Professor) ~40% (15 Men-Months)
- ***Jean Christophe Le Lann*** (Associate Professor) ~40% (15 Men-Months)

We ask for the funding of a post-doctoral position to achieve the tasks assigned in the project (30MM) mainly in WPs 1, 2 and 4. The candidate will apply from January 2012 and will be

located in ENSTA-Bretagne. S/he will benefit assisted by our permanents. The main scientific challenge is to combine declarative polychronous constraint-based specifications (as in CCSL) with state-based specifications (COMETA), while still preserving good properties of our models. The candidate will have also good and general competences in software engineering, good knowledge in Java and in Eclipse Modeling.
Thus, ENSTA-B will involve 30 Men-Months of permanent resources and 30 Men-Months of non-permanent resources: ~1.7 persons all along the project.

- *Travel*
  - Technical meetings (2 or 3 days) will be arranged with the partners in order to coordinate the project execution and progress on the execution of the WPs. There will be four meetings per year in France for two persons, one will be held locally so we ask for the funding of the trip for the three other ones. The total cost for this item is 13,5k€: 3 travels x 2 persons x 3 years x 750€ (including travel and accommodation).
  - Four travels for one person across Europe (x3) and the United States of America (x 1) for scientific and industrial dissemination purpose. The total cost for this item is 10.5k€: 2.5k€ for a European mission, and 3k€ for an international mission (including travel, accommodation and conference registration fees) per year.

**The total cost for traveling and meeting/workshop organization is 24k€.**

- *Other expenses*

ENSTA-B intends to buy one computer (workstations or laptops) for the staff involved for the project. The cost of these computers and its accessories (e.g., screen and bag) is **2k€**.

### 6.5. PARTNER 5: OBEO

- *Staff*

To achieve the objectives of the tasks in which Obeo will be involved the following permanents will be associated to the project (30 Men-Months):

  - ***Cédric Brun*** (R&D engineer) ~20% (6MM: 2 WP0, 1 WP1, 1 WP2, 1 WP4, 1 WP5)
  - ***Mélanie Bats*** (R&D engineer) ~80% (24MM: 1 WP1, 12 WP4, 12 WP5)

Thus, Obeo will involve 30 Men-Months of permanent resources.

- *Travel*

Travels will be motivated by the following reasons:

  - Technical meetings (2 or 3 days) will be arranged with the partners in order to coordinate the project execution and progress on the execution of the WPs. There will be four meetings per year in France for one person. The total cost for this item is 9k€: 4 travels x 1 persons x 3 years x 750€ (including travel and accommodation).
  - Four travels for one person across Europe (x3) and the United States of America (x 1) for scientific and industrial dissemination purpose. The total cost for this item is 6k€: 1.5k€ * 4 international missions (including travel, accommodation and conference registration fees).

**The total cost for traveling and meeting/workshop organization is 15k€.**

- *Other expenses*

Obeo intends to buy one laptops for development. The cost of these computers and its accessories is 1.6k€. We also ask for the funding of a laptop for demonstration purpose on the WP5. The cost of this laptop is 1000€. **The total cost is 2.6k€.**

### 6.6. Partner 6: Thales

- *Staff*

The personal will work on the project will be only permanent personals (36MM).

- *Travel*

- Technical meeting will be organised with all partners in aim to coordinate the realisation of the project. We plan a budget for 2 meetings per year for 1 or 2 Thales persons (1 meeting out-side of Île-de-France and 1 meeting in Île-de-France), mean 4 200 € (3 years * 2 persons * 650 € + 3 * years * 2 persons * 50 €).
- Other technical meetings with partners on identified work. We estimate a corresponding budget of 4 meeting per year mainly in Île-de-France with one meeting outside Île-de-France, mean 4 200 € (3 year * 2 persons * 650€ + 3 years * 3 meetings * 2 persons * 50€)
- Finally, 3 missions in the context of dissemination are planned in France 1 950 € (3 missions * 650 €) and an international for a budget of 5 000 € (2 persons * 2 500 €).

We also ask for the funding of the receptions expenses for an annual meeting in Palaiseau with all partners for a total budget of 900€ (3 year * 300 €).
**The total cost for other expenses is 16 250€.**

- *Other expenses*

Other expenses are for development kit for the industrial use-case (**3k€**).

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