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Work-Package 3a: “Toolchain”

openETCS Toolchain WP Description of Work

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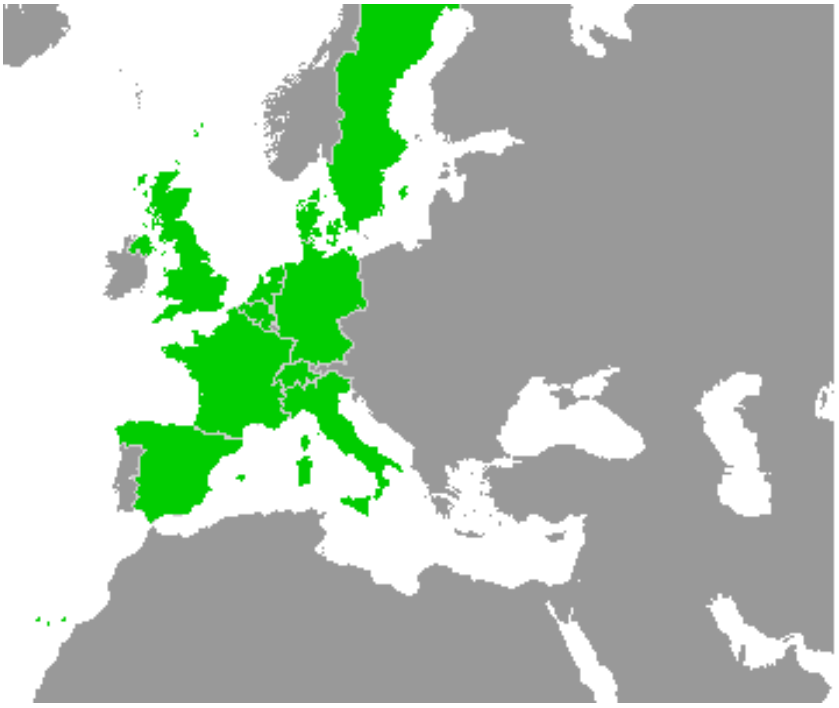

openETCS Toolchain WP Description of Work

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Description of work

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Abstract: This document contains the description of work planned for WP3a. This revision is necessary, as the workpackage from original ITEA proposal was split. This document will be the foundation for a revision of the ITEA proposal.

The revised DoW consists of four chapters for the four Tasks of WP3a.

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Introduction

This Work Package will provide the tool chain, based on formal methods, that is necessary to design, develop, verify and validate the ETCS system. This tool chain will encompass all description levels of the system design from holistic viewpoint to code generation. Specific attention shall be paid to the semantics and the traceability of each part of the chain. The formal specification will be used further for verification and code generation. Other uses of the formel specification are conceivable.

The tool chain must at least support the following tasks:

1. Support the writing of the formal ETCS system description, which may include a wide range of artefacts, from requirements to actual code (and everything inbetween). To achieve this, it will include elements like modeling languages, graphical or textual editors, version management, etc.
2. Support code generation.
3. Support actions like execution, debugging and simulation of some or all elements of the system description.
4. Support the generation of elements that support testing, like test cases, test data, test oracle, test procedure execution, etc.as needed.
5. Support the verification and validation of the various artefacts, including the formal ETCS specification against the textual ETCS specification.
6. Support tracing of artefacts across all tools and build steps, as needed.
7. Analysis of the system description, like transitions and cooperations between models.
8. Integrate the tools as needed to support the users as efficient as possible.

The tool chain definition will benefit from other R&D projects and off-the-shelves tools. The semantics of the modelling languages shall be carefully studied.

The first goal of this WP is to identify sets of consistent languages and tools enabling the design of the system. This will be done in close collaboration with WP2.

In order to be able to progress without depending too much on WP2 requirements and other deliverables, the subtasks shall make use of prototyping in order to gain knowledge regarding the possible modelling languages and tool platforms.

Compliance with standards as CENELEC or 50128 could have a significant impact in terms of workload. Moreover it should be included at the beginning of the tools development in the Development Plan or in a Safety or Quality Plan in close collaboration with WP4.

1 Core Tool Chain Analyses and Recommendations

The first task is the core tool chain analyses and recommendations. It is concerned with the languages themselves, the tools for authoring, as well as the methods used for formalising the specifications.

The core tools will be complemented by supporting tools, as outlined in Section 2. Specific attention shall be paid to the semantics and the traceability of each part of the chain.

1.1 Identify and define the potential modelling languages

The goal of this task is to identify the modelling languages that could fit to requirements associated to specific need of ETCS design. Those needs may come from specificities of ETCS and also from railway norms, and they will be defined by tasks of WP2 (in particular D2.3.1 - Set of requirements on modeling and D2.2.1 - Process definition). Depending on recommendations of WP2, several languages may be necessary to handle the different levels of abstraction of the whole design process. For each candidate, a small subset of the ERTMS specification will be modelled. The languages may have to be adapted in the process. The identification and definition will distinguish between wide-spectrum modelling languages suitable for a wide variety of modelling domains such as UML, SysML, B, and domain-specific languages (DSL) designed and optimised for application in a specific application domain only. For wide-spectrum languages their metamodels[1] will be analysed with respect to their expressive power and resulting adequateness for designing ERTMS models. For DSL candidates the associated meta-metamodels[2] will be analysed with respect to their capabilities to support language extensions that may become necessary for novel releases of the ERTMS specification the in the future. Since no language is universal, and thus not able to address all aspects of design needs, the proposed approach is lucky to involve several modelling languages supporting different viewpoints and working at different levels of abstractions. With this kind of approach, we will need to check the compatibility of the semantics of the modeling languages that address overlapping viewpoints. There are two problems here. First, when dealing with an heterogeneous specification, we need a common semantical basis to check the compatibility of the models. More pragmatically, when we deal with two models (expressed in a different language) that describe the same part of the system, we need to show that they are consistent with each other. Candidate languages will be subsequently evaluated against the requirements from WP2. If a suitable language is identified, but no partner steps up to model the prototype, it will not be considered.

Given that different levels of abstraction have to be addressed in the design phase, several languages may be necessary to handle all design phases. Here, the semantics of the languages is the key point; it shall be accurately adapted to the level of description required in each phase of the design.

Input:	WP2: List of suitable languages (based on State of the Art Analysis)	Oct-12
Input:	WP2: Small subset of ERTMS requirements that is representative	Oct-12
Input:	Those WP2 Requirements that are sufficient to evaluate a target language	Jan-13
Output:	Formal Model representing the sample spec, one for each candidate	Mar-13
Output:	Documentation of the changes to each language used (if any)	Mar-13
Output:	Evaluation of the models against the WP2 requirements	Apr-13
Output:	Decision on the final language choice(s)	May-13

1.2 Identify and compare existing modelling tools

[1] Recall that metamodels specify the syntax and static semantics of a modelling formalism.

[2] Recall that the meta-metamodel specifies the capabilities to define language elements and their static semantics in a DSL.

Corresponding to Section 1.1, the objective of this subtask is the identification of the core modelling tools (analysis and other supporting tools will be the subject of Section 2), based on the analysis from WP2, by using it for the prototyping described in Section 1.1.

The experience with the tools will be recorded, and the tools will be evaluated against the requirements from WP2.

Input:	WP2: List of suitable tools (based on State of the Art Analysis)	Oct-12
Input:	Those WP2 Requirements that are sufficient to evaluate the tool	Jan-13
Output:	Experience report for each candidate tool	Mar-13
Output:	Documentation of the changes to each tool (if any)	Mar-13
Output:	Evaluation of the tools against the WP2 requirements	Apr-13
Output:	Decision on the final tool choice(s)	May-13

1.3 Identify the tool platform

There is a distinction between tools (Section 1.2) and tool platform: The tools are the core that processes the languages, and typically also have an editor. The tool platform is language independent, but provides mechanisms to integrate various tools. For example, Eclipse is a tool platform. The Java Development Tools (JDT) are an extension to Eclipse that allows working with the Java programming language.

As the toolchain will consist of many tools that must work together seamlessly, it should be analysed independently from the tools. A tool will typically suggest a certain tool platform. The aim of this task is the identification of a tool platform for each candidate tool from Section 1.2. In particular, the platform should provide an suitable to interface (e.g. XML or JSON definition) to facilitate data exchanges between the various tools of the toolchain.

Several levels of interoperability can be supported by the toolchain. For instance, in Eclipse, the most basic level provides support for plugins (OSGi); that is the ability to have several tools inside a common platform. In the project, we will also need support for interoperability at the data level, which can be found in the Eclipse world with the Modeling Framework; that is the ability to have tools that converse/interact using a standardized (low-level) syntax. Finally, we could also require interoperability at a "semantical" level—for example with support for linking objects in different modeling languages—or ask for more basic services, such as serialization and versioning. We believe that, for the project, we at least need interoperability at the data level.

Input:	List of target platforms, based on the tools being evaluated (1.2)	Oct-12
	Those WP2 Requirements that are sufficient to evaluate a target language	Dec-12
Output:	Evaluation of each tool platform against WP2 requirements, independent of target tool	Feb-13
Output:	Evaluation of tool platform in the context of specific target tools	Mar-13
Output:	Selection of Tool Platform (and reasoning)	Apr-13

2 Supporting Tools Analyses and Recommendations

The languages and tools of the core chain have to be complemented to support a number of activities that are crucial for the project. The purpose of this task is to compose a list of tools

which may be used in performing or supporting activities, analyse their suitability and propose a selection for inclusion in the openETCS tool basis. This has to be coordinated with

- the core tool chain selection (suitable tools should be available),
- the definition of the overall development process, as that defines the steps to be performed and
- the safety analyses to conclude if the proposed tools are suitable to respond to standard criteria for certifiable tool chain.

The flow of information in the coordination is bidirectional, e.g. the process steps should ideally be taylored towards realizability with good support by available tools. Techniques complementing the tool-supported steps must be included in the process description.

The following activites have to be take in account:

- Model Transformation and code generation
- Requirement traceability
- Validation and verification
- Safety analyses Tools

2.1 Model Transformation and Code Generation

Analyse model transformation techniques and tools in order to refine the specification from one description level to another.

Analyse the code generation strategy.

Input:	WP2 Requirements	Jan-13
Input:	WP3-a Decision on the final language choice	Apr-13
Output:	Model Transformation Strategy	Sept-13
Output:	Code Generation Strategy	Sept-13

2.2 Requirement traceability

Requirements elicitation is the first step of the process, but we can decide that requirements are already elicitate in the subset-026, or selected in WP2. However, how to manage the requirements traceability and how to deal with coverage and traceability of the requirements on models. Thus this activity is a main challenge in developping critical and complex systems.

Input:	WP2 Requirements	Jan-13
Input:	WP3-a Decision on the final language choice	Apr-13
Input:	WP2 Designer Wishes and Requirements	Apr-13
Output:	Captured and organised designer requirements	Sept-13

2.3 Validation and Verification Tools

In the development of a safety-critical rail system like the ETCS OBU, several kinds of verification and validation activities have to be performed. One the one hand, the relevant standards require the verification of the *safety aspect* of every major design step. They also list constraints on methods (and tools) which may be used for these purposes. On the other hand, any viable development process for a complex real-time system like the OBU needs early validation of design artifacts. This concerns for instance functionality and real-time properties beyond the safety-related issues. The formalisation of design artifacts which comes with a model-based process offers the possibility to employ tools to a substantial degree for these activities.

Validation and Verification activities have different goals and methods :

Validation aims to prove that the build software fulfills the user needs, in particular with respect to safety and quality requirements.

Verification aims to prove that the build software fulfills the requirements of that phase with respect to completeness, correctness and consistency.

The choice of VnV methods depends on the kinds of properties which are treated.

Functional Properties. First, we have to show that all of the components of the system behave as they are intended. This includes at least proving that low-level requirements meet high-level requirements at each stage of specification, and in turn that the code meet these low-level specifications.

One possibility is to use a completely certified toolchain up to code generation, some formal methods have shown their effectiveness in many industrial cases. Failing that (*i.e.* if not all the code is generated and/or if the generation cannot be trusted), we will need to have formal specifications and to verify the code against them. Hoare logic-based tools seem like a good approach in this case, as well as of course test cases generation according to a suitable coverage criterion.

Secondly, we have to show that the high level requirements have been completely specified. This is usually achieved by coverage technics.

Non-Functional Properties. Such properties include all aspects that are related to the nominal behavior of the components. In particular, this concerns the following points:

- Schedulability and Worst Case Execution Time (WCET)
- Data dependencies between outputs and inputs
- Modelling and process requirements for SIL4 systems

Schedulability can be done on the models, based on hypotheses for the WCET of single tasks, but verifying these hypotheses require a full knowledge of the code, the underlying hardware, and the compilation toolchain.

Data dependencies can also be assessed on the models, but as in the previous subsection, some verification on the code itself might be required. Static analyzers should be able to handle that.

Traceability items can help to check that proces requirements are satisfied, code reviews allowed to verify modelling requirements.

Safety properties. This must ensure that components are always able to perform their work. It includes in particular:

- Absence of runtime error (again if the code generation does not guarantee it by construction. Static analysis can be employed there also).
- Fault tolerance against unexpected input (safety analyses can raise this unexpected input).
- High-level safety requirements (formal raisonning, test or simulation can show safety requirements are satified).

Input:	WP2 Requirements	Jan-13
Input	WP3b formalized API	Mar-13
Input:	Those sufficient elements of WP4 VnV Plan to evaluate tools	Jan-13
Output:	VnV tool choice	Apr-13
Output	Test automation tool choice with experience report	Apr-3

2.4 Safety analyses Tools

The purpose of this subtask is to propose a list of tools to support safety analyses activities. This task is to coordinate with the requirements issues of WP2 and the needs of WP4 in regards of safety cases definition.

Examples of interresting tools deals with fault-trees and FMEA generation, that can be based on formal methods (automata, pre-post condition logics,...)

Input:	WP2 Requirements	Jan-13
Input:	Those sufficient elements of WP4 Safety case to evaluate tools	Jan-13
Output:	safety analyses tools choices	Apr-13

3 Define and Develop Tool Chain

This subtask defines and develops the tool chain and the infrastructure enabling its evolution and maintenance. First of all, a "make or reuse" decision about the components of the tool chain has to be made. Then a common development infrastructure has to be defined or chosen in order to integrate all the tools (Eclipse like infrastructure). Finally, the subtask achieves the development and the integration of the tools.

3.1 Overall Tool Architecture

Once language, tools and tool platform have been identified, the architecture can be defined using that as the foundation. The architecture also contains the specification of tool interaction

mechanisms (model changes might trigger code generators, model or code changes might trigger regression tests etc.)

Note that this may not be that much work: A tool platform like Eclipse essentially defines the overall architecture already. Further, using an agile approach, it is perfectly acceptable if the system changes over time (i.e. APIs change, etc.), as long as the proper mechanisms are in place, like automated testing.

3.2 Development Infrastructure

To allow robust distributed development, care must be taken in setting up a functioning infrastructure. This includes

- a continuous automated build system,
- mechanisms to upgrade tools in the platform,
- mechanisms to add tools to the chain at a later stage,
- tool chain documentation system.

The effort for this must not be underestimated.

3.3 Decomposition and Distribution of work

Another major task is the robust decomposition of the tool chain and its distribution and tracking of the various components. Specifically, robust integration tests and version management for the tool chain are crucial[3].

3.4 Inputs and Outputs for Section 3

Input:	WP3a, Section 1: Formal Model representing the sample spec, one for each candidate	Mar-13
Input:	WP3a, Section 1: Decision on the final language choice(s)	May-13
Input:	WP3a, Section 1: Experience report for each candidate tool in the core tool chain	Mar-13
Input:	WP3a, Section 1: Decision on the final tool choice(s)	May-13
Input:	WP3a, Section 1: Selection of Tool Platform (and reasoning)	Apr-13
Input:	WP3a, Section 1: Decision on the final (development) method	Apr-13
Input:	WP3a, Section 2: Verification and test tool choice(s)	Apr-13
Input:	WP3a, Section 2: Captured and organised designer requirements	Sept-13
Output:	Specification of tool interoperability mechanisms	May-13
Output:	Specification of core and support tool chain architecture and its embedding into the platform	June-13
Output:	Infrastructure evolution strategy	Aug-13
Output:	Tool chain qualification test suite	Aug-13

[3]The related activities are often called *tool qualification*.

4 Develop Open Source Ecosystem

The goal of this task is the development of an open-source ecosystem for the toolchain under development and all its components as well as for the implementation of the ETCS system. This ecosystem defines the license model to be used, the project infrastructure, usage and contributions of existing open-source projects and the process to coordinate the development efforts from different partners. Additionally as part of this task, suggestions and guidelines for the projects infrastructure are developed. The goal of the ecosystem is to facilitate the collaboration of the industrial partners and enable long-term maintenance of the outcome of the development. For the ecosystem, well-established open source ecosystems, such as the Eclipse ecosystem shall be used as templates.

As the development of an ecosystem needs to react on the on-going project and adapt to needs, the ecosystem has to evolve over the project duration. As a first output, this taks will produce initial proposals for the license model, the process, as well as the infrastructure. Subsequently, these proposals can be adapted based on the feedback from all project partners.

As the license model and the open source process have high impact on the overall project, the task will only propose solutions. These solutions are based on requirements given by WP1. Final decisions in this area have to be made by WP1.

Input:	Feedback from project partners (All WPS)	continuosly
Input:	WP1: Requirements for the open source ecosystm	continuosly
Input:	WP1: Legal decisions	continuosly
Output:	Initial proposal for license model	Aug-13
Output:	Initial proposal for open source development process	Aug-13
Output:	Initial proposal for infrastructure and tools	Aug-13
Output:	Adaptation of license model	continuosly
Output:	Adaptation of open source development process	continuosly
Output:	Adaptation of infrastructure and tools	continuosly

