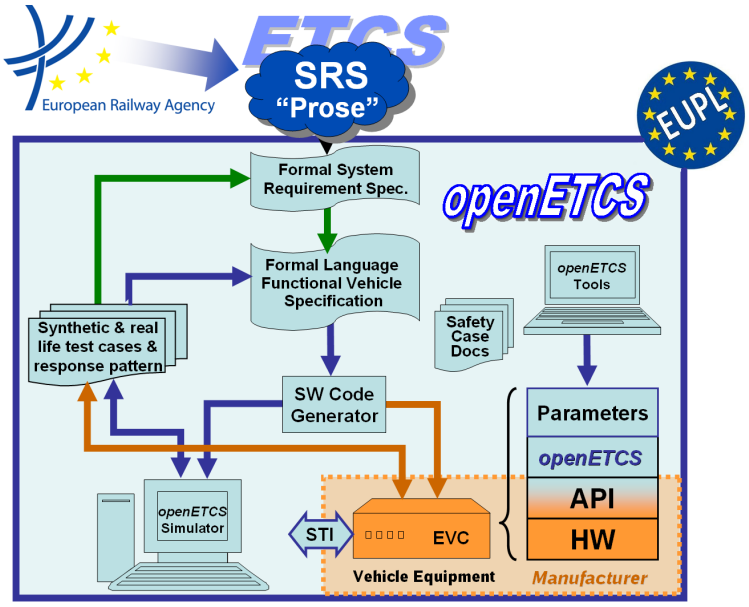
ITEA2 Project
Call 6 11025
2012 – 2015

Work-Package 1: “Management”

Project Quality Assurance Plan

Izaskun de la Torre

December 2, 2014



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Work-Package 1: “Management”

OETCS/WP1/D1.3.1
December 2, 2014

Project Quality Assurance Plan

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Description of work

Prepared for openETCS@ITEA2 Project

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Document History

Table 1. Documentation History

Version	Date	Chapters modified	Reason	Name
0.0.0	15.11.2012	All	First Steps on frame evaluation	Rico Kaseroni (DB) Peyman Farhangi (DB)
0.1.0	27.11.2012	All	First Steps on Content	Rico Kaseroni (DB) Jan Welte (TUBS) Peyman Farhangi (DB) Matthias Kuhn (DB)
0.1.1	29.11.2012	All	Optimaziation of document structure, Revision of Chapters according to EN 50128, Merging with project specific tasks	Stephan Jagusch (AEbt) Rico Kaseroni (DB) Cyril Cornu (All4tec)
0.2.0	30.11.2012	Baseline Requirements for certification	Extention of Chapter according to EN 50128	Jan Welte (TUBS) Rico Kaseroni (DB)
0.3.0	19.12.2012	All	Extention of Chapter 0, 1, 2, 3	All4tec, DB, SQS
0.4.0	11.01.2013	All	Extention to existing and further Chapters	All4tec, DB, SQS
0.6.0	28.01.2013	All	intellectual property (IP) Clean	Rico Kaseroni (DB) Cyril Cornu (All4tec)
0.6.1	29.01.2013	Scrum	Contribution	Bernd Hekele (DB)
0.7.0	01.02.2013	All	More Content	Rico Kaseroni (DB)
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0.9.1	07.02.2013	Scrum	Optimization	Bernd Hekele (DB)
0.9.2	07.02.2013	All	Restructuring	Rico Kaseroni (DB)
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0.9.4	12.02.2013	All	Optimization	Rico Kaseroni (DB)
0.9.4.5	15.02.2013	Chapter2	System Testing	Rico Kaseroni (DB)
0.9.4.6	15.02.2013	ALL	Optimization	Rico Kaseroni (DB)
0.9.5	22.02.2013	ALL	Restructuring & Optimization	Rico Kaseroni (DB)
0.9.5.1	01.03.2013	ALL	LaTeX conversion	Peter Mahlmann (DB)
0.9.5.2	04.03.2013	ALL	LaTeX Optimization	Rico Kaseroni (DB)
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Table 1 – continued from previous page

Version	Date	Chapters modified	Reason	Name
0.9.5.4	20.04.2013	ALL	New Content	Bernd Hekele (DB) Jan Welte (TUBS) Marielle Petit-Doche (Systerel) Stefan Rieger (TWT) Izaskun de la Torre (SQS)
0.10.0	26.08.2013	chapter 1.2 and 8.2	New Content	Bernd Hekele (DB) Stefan Rieger (TWT)
0.10.0	17.09.2013	chapter CAT1 and CAT2	Updated Content	Bernd Hekele (DB)
0.10.1	25.09.2013	Chapter 1	Terminology	Jan Welte (TUBS)
0.10.2	14.11.2013	Chapter 6.3, 7.1, 8.1	Updated Content	Izaskun de la Torre (SQS)
0.10.3	21.11.2013	Chapter 3.3, 5.2, 5.3, 6.2	Updated Content	Izaskun de la Torre (SQS)
0.10.4	30.01.2014	All	Fixed issues 4 and 11 of internal assessment	Izaskun de la Torre (SQS)
0.10.5	18.02.2014	All	Fixed issues 3, 10 and 12 of internal assessment	Izaskun de la Torre (SQS)
0.10.6	26.02.2014	5.2.1, 5.2.2, 11	Addition of new sections	Izaskun de la Torre (SQS)
0.10.7	11.03.2014	3.2.1, 11.2	An outline and new content	Izaskun de la Torre (SQS)
0.10.7	16.04.2014	Appendix E	Methods and Tools Update to cover Modeling needs	Bernd Hekele (DB)
0.10.7	08.05.2014	5.2.2.1 5.2.2.2	Add information about tools in the tool chain	Cécile Braunstein (Uni Bremen)
0.10.7	14.05.2014	3.2.2	Complete the openETCS tool chain lifecycle	Cécile Braunstein (Uni Bremen)

1 Introduction

1.1 Purpose

The purpose of the QA Plan is to define the processes, methods and tools that will be used to develop the OpenETCS project meeting ITEA requirements, following Open Source principles and practices and applying the SCRUM Methodology. Besides, two of the project outcomes, the OpenETCS software, the OpenETCS Tool Chain, will have to comply with CENELEC requirements [1].

Due to the nature of the OpenETCS project (Research and Development (R & D) EU project with a complex list of project outcomes and deliverables), the QA Plan is specifically designed to provide a complete, consistent and integrated view of the development process at both project and product level (i.e. the development life-cycle is described partially in two different deliverables, the QA plan should manage to provide an integrated view).

The QA Plan also describes the activities to monitor and manage quality in all aspects of the project:

- Defining and ensuring that all processes and products are compliant with the corresponding standard and requirements, according to the required system/software safety integrity level
- Identifying nonconformances
- Providing timely quality status feedback to management and affected personnel
- Ensuring noncompliance issues are addressed

Therefore, it describes the QA functions, responsibilities and specific monitoring and control activities.

1.2 Goals of the openETCS project

The main goals and deliverables of the OpenETCS project are:

A semi-formal reference specification for the ETCS requirements and architecture, completed by strictly formal models of sub-parts

The first goal of the project is to propose a semi-formal specification of the ETCS on-board unit (OBU) functionalities according to UNISIG SUBSET-026 [8], baseline 3.

The purpose of this semi-formal specification is:

- to enhance the understanding of the subset;
- to be able to be animated for testing and analysing purpose at system level;
- to provide information on the completeness and soundness of the SUBSET-026;
- to be used as a reference semi-formal specification for the implementation of an on-board unit (by the OpenETCS project team and by industrial actors);

The output is a model, at least semi-formal, which can be extended to many formal approaches (SCADE, Simulink, B tools, OpenETCS tool chain...) that can be given to all railway actors, and if possible associated to SRS documents in the ERA database.

Thus, strictly formal models can be designed from this semi-formal model which allows for formal proofs of sub-parts of SUBSET-026. This will allow improving the understanding of the system, and will provide elements for verification and validation using formal proof.

The final goal is that industrial actors work with this model instead of the natural language specification. The objective is to cover as much as possible of the functionality of the on-board unit described in SUBSET-026 and to show the capabilities of analyses of a complex system using formal approaches.

Definition the of safety case concept for the full model and application on a subset of the on-board unit

The safety strategy and the safety case concept required for the full validation of the product, compliant to the CENELEC standard shall be taken into account in all steps of the specification and design process. This will allow industrial actors to reuse the models and processes to develop certifiable products.

In particular the definition of the process shall take into account specification as well as verification and validation of the safety properties on the models. The outputs of WP4 (safety plan, safety case concept, verification plan and validation plan) will complete the description of the safety process.

Providing a tool chain and process/methodologies for developing an on-board software that can fulfil the CENELEC requirements for SIL4 software

The design process of the system and the associated tools of the tool chain shall be suitable to provide a certifiable product. For this purpose all steps of the process and the choice of the methods and tools shall be justified to ensure a safe approach to build an ETCS system.

The full safety process required to make OpenETCS *certifiable* according to CENELEC 50126, 50128 and 50129 shall be described in detail. The safety process will detail precisely which activities are required, why they are required, and the choices that are made to claim that a safe design process is guaranteed.

The use of formal methods, supported by tools, is highly recommended in this safety process for specification, design, verification and validation of the certifiable product.

The tool chain should include model editors, code generators, verification tools (including formal provers), validation tools (including test generators, simulators,..), document generation, version management, maintenance facilities, ...

Provide an executable software package generated from the specification of on-board ETCS

An executable software of the specification shall be provided, as well as a non vital implementation of the on-board unit for laboratory test, simulation and as reference. It will be a non-vital implementation, able to be executed in real-time and in interaction with other components.

1.3 Intended Audience

The QA Plan addresses all the stakeholders who are in the position to interact with OpenETCS project

Audience	Use	Role
OpenETCS Consortium Members	It provides information and access to the QA procedures and guidelines to be followed/applied during the different phases of the project development life-cycle. It provides a consistent and integrated view of the development process followed.	Consultation Reviewer Contributor or Committer
OpenETCS Quality Manager	It contains the quality targets to be achieved and the corresponding QA activities to be implemented and monitored.	Author
CENELEC Assessors	It shows the SQA strategy conceived and the one effectively implemented	To assess whether the project results comply to CENELEC standard
Open Source Community (Users, Adopters, Contributors, Committers)	Provision of information and access to the QA related procedures and guidelines implemented. Provision of information on the on-going projects Provision of guidelines on how to participate to any of the projects	For consultation and/or engagement
ITEA Representative	The QA Plan constitutes a Project Deliverable	For evaluation

Table 2. Intended Audience

1.4 Evolution

The first version of the document, prepared at the beginning of the project, will be updated regularly with the evolution of the OpenETCS project. The methods and tools to be applied during the development of the OpenETCS software products will be decided based upon the results of the research activities carried out during the project.

The QA Plan document will incorporate such decisions as they are taken with a proper justification of their appropriateness to meet the quality targets. The QA manager will guarantee the document is up to date.

The QA Plan document has been conceived as a reference document. This means that detailed descriptions of procedures, guidelines, methods and/or tools will not necessarily be included in the document but adequately referenced *(chapter 1.5)*. The authors of such documents and/or Wiki pages will be responsible for keeping them updated. The QA manager will monitor such activities and will guarantee changes are appropriately reflected in the QA Plan, when appropriate.

The QA Manager will maintain the QA Plan backlog [4] [Wiki].

Major revisions of the QA Plan will be accomplished by the Committers to the Management Project. Minor review process will be done with the participation of the external community, following procedure [11]

1.5 References, Guidelines and Standards

Standards				
Internal Code	Name	Version/ Edition/ Date	Repository	Responsible
[1]	EN 50128		-	CENELEC
[9]	ISO 9001		-	International Organization for Standardization
[7]	SUBSET-023	3.0.0	SSRS	UNISIG
[8]	SUBSET-026	3.3.0	SSRS	UNISIG

Table 3. Standards

References				
Internal Code	Name	Version/ Edition/ Date	Repository	Responsible
[23]	Full Project Proposal (FPP)	3.0	management	Klaus-Rüdiger Hase
[24]	Software Configuration Management Plan	0.1.0	governance	Jürgen Weiss
[17]	Project Co-operation Agreement	02e	management	Bernd Hekele
[16]	OpenECTS IP Policy	0.1	ecosystem	Bernd Hekele
[15]	OpenETCS Internal Assessment Plan	0.1	internal-assessment	Cyril Cornu
[21]	OpenETCS Validation & Verification Plan	01	validation	Marc Behrens Hardi Hungar
[4]	QA Plan Backlog	0.1.0	governance	Izaskun de la Torre
[5]	Traceability Matrix	0.1.0	governance	Izaskun de la Torre
	Safety Plan	0.10	validation	Jan Welte

Table 4. References

Procedures				
Internal Code	Name	Version/ Edition/ Date	Repository	Responsible
[11]	Review Process	0.2.1	governance	Ainhoa Gracia
[12]	Revision Process	0.2.1	governance	Ainhoa Gracia
[3]	Change/Problem Management Process	0.1.0	governance	Izaskun de la Torre
[14]	Grieving Handling Process		governance	Bernd Hekele
[19]	Committer Approvement Process	2012-11-14	ecosystem	Jonas Helming
[20]	openETCS Development Process	2012-11-14	ecosystem	Jonas Helming
[6]	Training Process	0.1.0	governance	Izaskun de la Torre
[10]	Document Control Process	0.1.0	governance	Ainhoa Gracia

Table 5. Procedures

Guidelines				
Internal Code	Name	Version/ Edition/ Date	Repository	Responsible
[13]	Contribution guidelines	01	ecosystem	Bernd Hekele
[18]	Committer Election Guideline	2013-02-06	ecosystem	Jonas Helming
[22]	openETCS Publishing Guideline (see also Sct. 10)	2013-07-15	Dissemination	Stefan Rieger
[27]	Expert Election Guideline		governance	*To be defined*

Table 6. Guidelines

Templates				
Internal Code	Name	Version/ Edition/ Date	Repository	Responsible
[25]	Competence Matrix Template	0.1.0	governance	Jan Welte
[26]	Expert database Template		governance	*To be defined*

Table 7. Templates

1.6 openETCS Terminology

The openETCS project deals with topics from different domains like railway vehicles, signaling systems, formal methods and tool development. As every of these domains has their specific

terminology, the identification of all relevant terms and abbreviations is an important part of the openETCS development process. Respectively a terminology process has been defined which collects, defines, analyses and distributes the relevant terminology for all parts of the openETCS project.

1.6.1 Terminology Process

The openETCS terminology process is based on the main openETCS development environement mainly github and Latex. In addition the iglos (https://www.iglos.de/iglos/) environment is used to model and manage terminology relations. The overall process contains the following steps:

1. Term proposals with definition, source and relation proposals via https://github.com/openETCS/glossary/issues or through extraction from project documents
2. Inclusion of term, definition, source and relation proposals into iglos, to manage the terminology work and allow analysis of the terminology (e.g. for consistency)
3. Export of terms and abbreviations and their information as definitions, sources and relations from iglos using a csv-file
4. Transformation of the csv-file into a latex glossary (https://github.com/openETCS/glossary/blob/master/Latex_Glossary/openETCS-Latex-Glossary.tex)for all project documents
5. All glossary files and their documentation is provided in the github glossary repository and continuously updates

Depending on the needs further extractions from the iglos database can be created providing terminology for specific openETCS activities.

The glossary and the list of abbreviations respectively acronyms is then added to any latex document by using the glossaries package. The latex commands to do this can be found in the *User Manual for glossaries.sty v3.07* or in the short description in the glossary wiki at https://github.com/openETCS/glossary.

The following subsections list the important glossary terms and the abbreviations used in this document.

1.6.2 Glossary

1.6.3 Abbreviations

2 Project Organization

OpenETCS is a cooperative European-ITEA project. The project plan (objectives, work plan schedule, role of the partners, project organization) is described in the [23] FPP document, which is updated regularly (at least yearly). The project is accomplished according to the Project Co-operation Agreement (PCA) [17] signed by the partners.

The organization of the project has to meet the following constraints and challenges to succeed:

1. As an ITEA project, the project has to meet requirements imposed by the ITEA Office that affect both the organization and the outcomes of the project.
2. As an ITEA project, the effective involvement of the partners is sometimes hampered by external constraints (i.e. local financing, local approvals) so mechanisms to guarantee the "required competence" is available when needed are to be implemented. Besides, OpenETCS operates in a regulated environment where demonstrating the competence of the personnel assigned to the different activities is required.
3. Some of the results (software & tool chain) have to be certifiable; CENELEC SIL4 requirement [1] have to be followed and the corresponding evidence provided.
4. As an open source project, Open Source principles will be respected; high degrees of engagement from the community are intended.
5. As it is the intention to apply SCRUM, the appropriate responsibilities and mechanisms have to be implemented

The following chapters shows the mechanisms implemented at organizational level to guarantee the above mentioned objectives are achieved.

2.1 openETCS project organisation

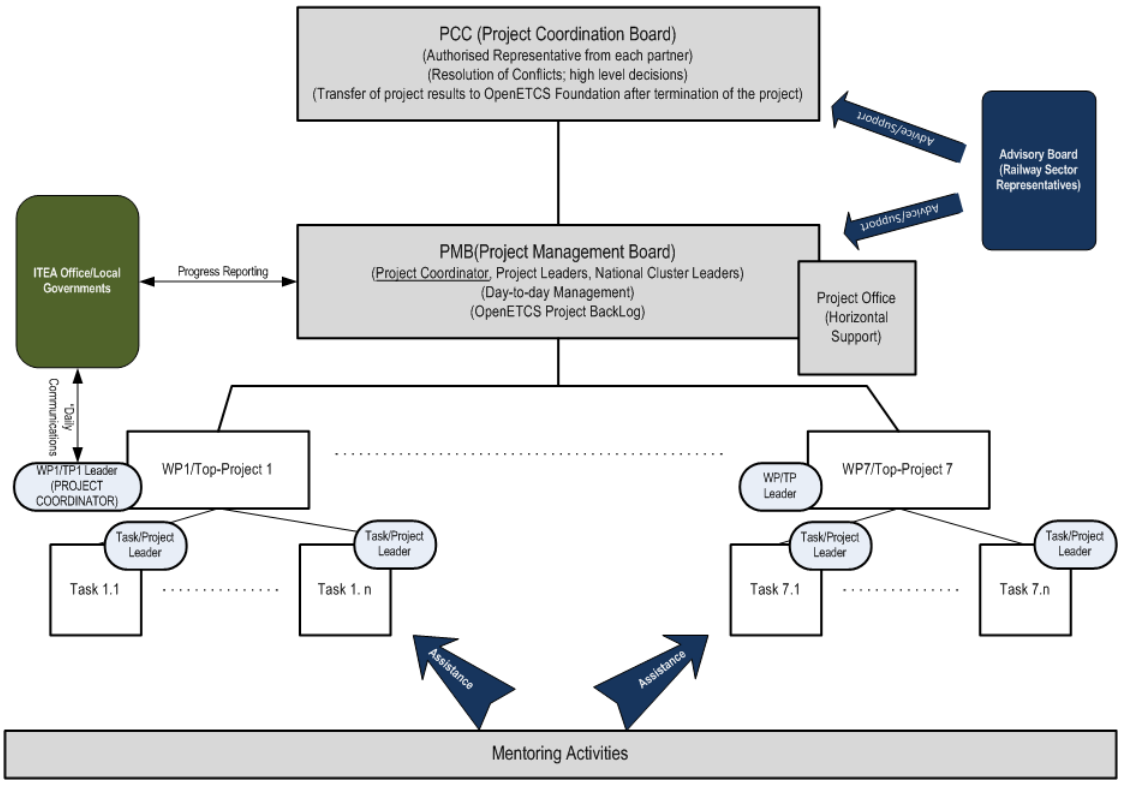

Figure 1. OpenETCS Project Structure

2.1.1 Compliance with ITEA Requirements

ITEA rules are documented in the ITEA2 Frame Agreement.

Compliance to ITEA Requirements is achieved by means of:

- The appointment of a Project Coordinator (DB, WP1, supported by the Project Office) who leads the project and is responsible for the communications with the ITEA representatives.
- The appointment of a Local Coordinator per country, National Cluster Leader, who reports to the corresponding National Authorities of the progress of the local partners
- A signed PCA where cooperation rules and principles and working structures are agreed by all the partners.
- An OpenETCS Foundation NV which guarantees sustainability of the project results once the project is finished.

2.1.2 Compliance with Open Source Principles

Compliance to the Open Source Principles and related objectives is achieved by means of:

- An OpenETCS IP Policy and Procedures [16]
- An OpenETCS Development Process [20] [Wiki] based in the Eclipse Development Process [2], designed to promote dynamism in the development and openness. All the guidelines are maintained and available at the OpenETCS Ecosystem project [Wiki]:

  - The OpenETCS project is conceived as a project of projects organized in a hierarchical manner, where the WorkPackages, as defined within the WorkProgramme [23], are considered Top-Level Projects with their own charter. The so-called Tasks are projects, sub-projects of the corresponding Top-Level Project.
  - Anyhow, new projects can be launched, if needed and approved; existing projects can be archived, if they become inactive. Therefore the final structure of the OpenETCS project will very much depend on its evolution.
  - The list of OpenETCS projects with information on their status is available in [governance]
  - Any project (independently to its position in the hierarchy, and type) has its project leader, scope and maintains its own resources. The project leader is not only responsible to guarantee progress towards the scope of the project but to promote that the most appropriate community is engaged in the project life-cycle with openness and transparency. This community includes committers, contributors, users and adopters.
  - Every Top-project/Work Package (WP) has its own repository under the responsibility of the Top-Project/WP Leader.
  - The PMB (Project Management Board) is responsible for maintaining and assuring the implementation of the OpenETCS Development Process and for ensuring the required “coordination" among the projects.
  - The Mentoring board is responsible for mentoring projects and advising.
  - The Project Office is responsible for the administrative tasks around the OpenETCS Development Process and maintains the OpenETCS Ecosystem project

- The tools to support the OpenETCS Development Process are open source tools. A relation of the tools approved by the consortium is in WP7.
- The engagement of the OpenETCS Advisory Group will not only provide valuable technical insights but visibility of the project within the railway community.

2.1.3 Compliance with SCRUM Requirements

Agile Project Management ha been introduced to software projects in the 90-ties and is now a de-fact industry standard well documented in publications.

Compliance to SCRUM Requirements is achieved by means of

- Each Work Package/Top-Project Leader is the SCRUM Product Owner of the corresponding WP/Top-Project results and maintains the corresponding backlog
- Each Project/Task Leader is the SCRUM Product Owner of the corresponding Tasks results and maintains the corresponding backlog
- The Project Coordinator is the SCRUM Product Owner of the project results and maintains the project results backlog.
- Weekly meetings are maintained to find and report on impediments, assess progress, promote cross-collaboration, plan next steps and therefore, maintain the corresponding backlog.
  - Weekly Scrum meetings are per definition open meetings, e.g., everybody from the teams can participate and contribute to the meeting.

  - The weekly meetings are strictly time-boxed.
  - At WP/Project level, the registered committers, contributors, users and adopters are invited to participate
  - At Open ETCS project level, the components of the PMB(Project Management Board) are invited.

- The work-packages resp. tasks need to organize there scrum teams according to practical needs.
- Teams are typically distributed in geography and in organisation (i.e., participating companies).
- Scrum teams typically have to provide several development roles (according to CENELEC and according to Eclipse). Guidance on the possible mixtrues of CENELEC roles into a Scrum team is documented in the appendices section of this guideline.
- To be able to be successful in Agile Development we need to set special focus to the role of the "User" of a product.
  - In general, the user of a product in openETCS should representratives of the project openETCS consuming the result of a scrum team.
  - The workpackage leader of the WP using an outcome of the team is the first candidate.
  - Representatives of partners making use of the openETCS result in long term are also natural users of a team result.
  - Partners in the openETCS project need to agree on the Users before the task when planning the interfaces.
- Each team has to select a scrum master. Scrum training is mandatory.
- A SCRUM master (WP1) is responsible for supporting the teams.

SCRUM PROCESS

Scrum process starts with a Product Backlog, this product backlog contains an ordered list of requirements that is maintained for a product. The product backlog items (PBIs) are ordered by the Product Owner based on considerations like risk, business value, date needed, etc. The product Owner is the responsible of the product backlog and the priorizations of PBIs.

After definition of Product Backlog the next task is to create the spring planning meeting, this meeting is organized at the beginning of the sprint cycle. The objective of this meeting is to define the PBIs to be done in following sprint. The Sprint is the time period in which development occurs on a set of backlog items that the team has committed to (also commonly referred to as iteration). The result of PBIs selected for implement in one spring is called the sprint backlog. The sprint backlog is the list of work the Development Team must address during the next sprint. The list is derived by selecting product backlog items from the top of the product backlog until the Development Team feels it has enough work to fill the sprint.

Each day during the sprint, a project team communication meeting occurs. This is called a daily scrum meeting and has specific guidelines. The scrum meeting is organized by the scrum master and the participants respond to three questions: What have you done since yesterday? What are you planning to do today? And Any impediments/stumbling blocks?.

At the end of the spring, the result of the PBIs implemented is called the increment (or potentially shippable increment), this is the sum of all the Product Backlog items completed during a sprint and all previous sprints. The increment must be in a usable condition regardless of whether the Product Owner decides to actually release it.

At the end of spring cycle or iteration, two meetings are held; the spring review meeting and spring retrospective. The approximate duration of the spring review meeting will be no more than 4 hours and will be moderate by the scrum master in this meeting two main activities will be take, one is to review the work completed and the planned work that wasn´t and the other is to presented to the Product owner the work done (demo). The other meeting after iteration is the spring retrospective, it will be managed by the scrum master and the main objective of this meeting is to use as process continuous improvements. Two main questions are asked to all participants in this meeting; what went well during the sprint? What could be improved in the next sprint?

OPENETCS SCRUM PROCESS

In OpenETCS there are 3 types of SCRUM process:

- The first level is the OpenETCS Project level, where Project Coordinator is the Product Owner. In this level the SCRUM meetings are organized every Friday.
- The second level is the Work Package level, where Work Package Leader is the Product Owner. In this level SCRUM meeting depends on WP, but at least two SCRUM meetings are organized every week.
- The last level is the Task level, where the Task Leader is the Product Owner. In this level SCRUM meeting period is variable and depends on the task.

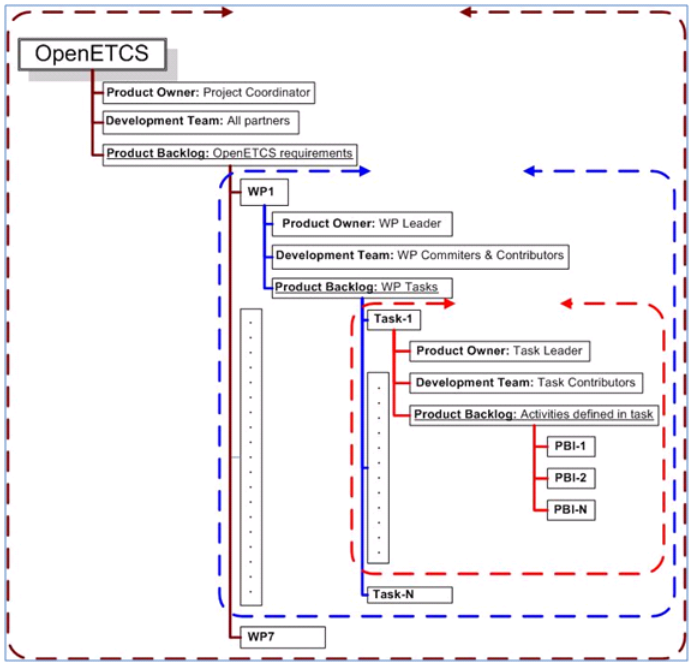

Figure 2. OpenETCS Project Structure

The Scrum Team consists of a Product Owner, the Development Team, and a Scrum Master where the Scrum Master is selected by the Team.

The flow below shows how the openETCS process is.

2.1.4 Compliance with software management and organisation according to EN50128:2011

In principle, two of the OpenETCS project results (Software and Tool Chain) are to be CENELEC safety integrity level (SIL) 4 certifiable. These are two of the results from WP3 and WP7. The following mechanisms, at organizational level, will help the corresponding project leader to provide evidence of compliance with chapters 5.1 and 5.2. Anyhow, evidence that requirements imposed are met will have to be provided for each of the two software projects on a project by project basis.

- Every partner in the consortium is ISO9001 Certified or will be in the position to provide evidence of a quality management process is accordance to ISO9001
- Every partner maintains an updated CV of the staff/experts involved in OpenETCS
- A Required Competence Matrix (RCM) per role and project will be maintained *(Chapter 4)*.
- A database with the participants per role and task/project will be maintained by the task/project leader.
- Overall, the independence required to develop certifiable results is promoted by the Work Programme which is structured into the following “independent" WorkPackages/Top-Projects, each lead by a different organization.
  - WP2, focused on Requirements Specification is led by SNCF.
  - WP3, focused on the Software Implementation taking as input WP2 and WP7 results is led by Alstom France.
  - WP4 focused on Verification and Validation (V & V) structure, is led by DLR
  - WP5 focused on demonstrating applicability/validity of WP3 and WP7 results is led by ERSA
  - WP7 focused on the development of the Tool Chain is led by DLR taking as input WP2 and WP4 inputs
  - For the purpose of validating/adapting technical approaches, tools and concepts before they are taken into consideration, three Use Cases will be engaged.
  - The Open Development Process facilitates the creation of the necessary projects required to achieve the OpenETCS project results.
- For each assessable result, CENELEC required software roles will be covered by experts from different WPs. Incompatibilities can be controlled and monitored as active participation to the different projects has to be granted, accepted and is appropriately registered *(Chapter 2.2)*. Evidence of competence can be provided by comparing the CV of each expert with the RCM for the role assigned.
- For each assessable result, if possible, the role of the assessor will be selected from the external community of the project. Meanwhile, an internal independent assessor will be appointed. The role and profile of this assessor is detailed in OpenETCS/internal-assessment [15] [wiki pages]

One of the mechanisms to guarantee the availability of competence staff when needed will be the design and implementation of a training programme. The training programme will be managed by the Project Office. The identification of needs will be performed by the project leaders, the PMB and the Quality Manager. The training process is detailed in [governance]

2.2 Committers assignment and responsibilities

Each Top-Project/WP leader is responsible for establishing and publishing the specific required competence matrix for the Top-Project/WP *(Chapter 4)*. This matrix will be updated in response to the demands imposed by the evolution of the project. The competence matrix template [25]is provided in [governance]

Each Top-Project/WP leader is responsible for developing the most appropriate communities of users, adopters, contributors and committers as required by the Top-Project/WP. A database will be maintained and assessed periodically by the Top-Project/WP Leader. This database will contain the coordinates of the expert, his/her role in the project and a basic explanation of adequacy. The expert database template is provided in governance.

The required core competences as well as the expected contribution of each of the identified communities are described in Chapter 4.

Only committers have write-access to the project resources. Becoming a committer requires of the acceptance of the project leader and of the rest of the project committers. Guidelines on how to become a committer can be found in [ecosystem wiki pages].

- It is the responsibility of the Project Leader to make sure the required competence to develop a task is covered by the engaged committers.
- It is the responsibility of the Open ETCS Project Leader to guarantee the required competence for the project is covered by the effective committers.

Contributors have read-access to the project resources, and acceptance is not required. Guidelines on how to become a contributor can be found in [ecosystem wiki pages].

An expert can contribute to different projects with different roles. The data from different project will be integrated and analysed to detect potential incompatibilities, if applicable. This activity will be done by the QA Manager. The guideline on how to select expert is detailed in governance.

2.3 Project QA Management

QA activities will be under the responsibility of the QA Manager, who reports to the Project Coordinator.

The QA Manager will be responsible for the identification, supervision and control of all the processes, methods and tools required to meet the quality targets of the project. It is also the responsibility of the QA manager to provide the necessary evidence that such activities have been developed.

The activities of the QA Manager will be:

- To maintain the QA Plan and associated procedures and guidelines.
- To maintain, implement and publish a QA Plan Backlog
- To participate in the OpenETCS Ecosystem project in cooperation with the Project Office

- To perform periodical audits of the maturity of the different on-going projects; propose improvement actions, if necessary.
- To participate in the review processes of the different work products.
- To collaborate with the Project Office in the identification of gaps and in the development of the corresponding Training Programme.
- To perform quantitative and qualitative analysis at process and product levels. To maintain a set of metrics for all the processes.
- To produce and publish the corresponding quality reports.

3 Life Cycle

The openETCs project itself is a R & D project running over 3 years which has the goal to deliver products such as the on-board specification model and the corresponding tool chain to generate source code based on this model. While the project life cycle is limited through the project time span, the products shall be used and also developed further after the end of the openETCS project. Respectively, the project only presents the firth development part of the product life cycle.

3.1 Project Life Cycle

The project Life Cycle is implemented through a set of WPs broken down into Tasks. In response of the nature of the project, these WPs are grouped into three purpose driven categories. The first category (WP2, WP4) addresses the specification of the work to be developed and the validation of the results to be obtained; the second category (WP3, WP7, WP5) addresses the development itself and the demonstration of the software and the tools chain developed and the third category (WP1, WP6) addresses the project management, the quality assurance and the dissemination of the project. This structure permits both the development and the integration of conceptual (R & D) and implementation activities to achieve innovative, validated and fit-for-purpose results. The detailed description of the Work Package description and overview plan is covered by [FPP].

3.2 Product Life Cycle

As the OpenETCS project products shall be part of the train development the reference for their life cycles are the CENELEC standard phases defined in the EN50126. But as the products are in general R & D results, their life cycles do not include any certification or acceptance activities at the moment. The main OpenETCS products are the OpenETCS Software model and the OpenETCS tools chain development, which have their own life cycles. For both parts the main development, verification and validation activities are done during the OpenETCS project. For the software only the demonstrator implementation is part of the OpenETCS project, while any kind of implementation on a target hardware is out of the project. For the OpenETCS tools chain the basic implementation is part of the project, but all further steps from qualification on are out of the project. In general long time maintenance is a key concept of these products but it can not be established in the project time span.

3.2.1 Life Cycle of the OpenETCS Software

The software development life-cycle of the OpenETCS project should be complied with CEN50128. Requirements imposed by the standard are analyzed and shown in detail in D2.2, while the software development life cycle applied in this project is described in Deliverable 2.3 and D2.4. The Test and Validation activities are presented in D4.2. The integration, the assessment and any maintenance is only defined in relation to the demonstrator implementation as no further phase can are planed in depth at this point.

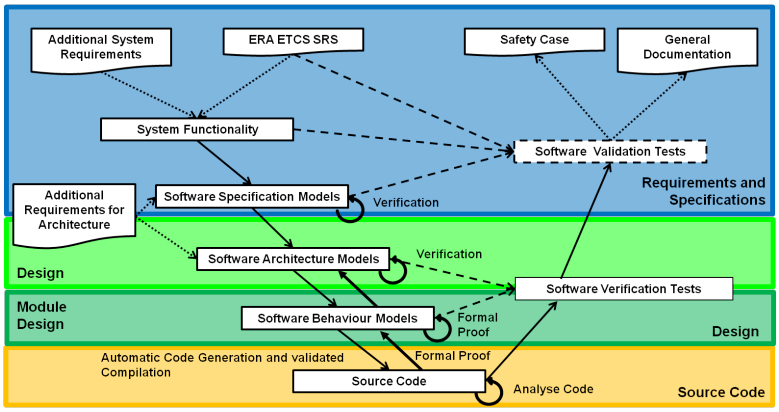

Figure 3. Overall openETCS development Process

IT: necessary to cover the activities (be sure that are compliant with the Plans), the input and output of each activity and its criteria, entity in charge of each activity and quality activities

Check the coherence in all the deliverables where the openETCS life cycle is explained. There are some incoherences between them related to the phases. Analyse during telco what the final version will be.

D4.2.3

Table 8. Phases openETCS software development process

Phase	Name	Description	Main Tool component
P1	Software Requirement Phase	Requirement input documents converted to a ReqIF format and informally analyses. The analysis specifies relationships between requirements and revises parts of the requirements to obtain a detail and atomic abstraction level usable for moralization. To support thus the requirements are categorized and grouped.	ProR
P2	Software Architecture Modeling Phase	Building a SysML based on the informal analysis using the categorization of requirements. The architecture model focuses on functional blocks and data flows.	SysML Papyrus
P3	Software Behavior Modeling Phase	Building the SCADE model for the separated basic functional blocks. The SCADE model describes the detailed behavior for the function using the data flows.	SCADE Suite
P4	Code Generation Phase	Based on the SCADE Behavior Model C code will be automatically generated. This C code is than compiled to executable code which runs on the EVC.	SCADE Suite + C Code compiler
P5	Formal Validation phase	Using test models and model checking techniques, to validate the correct model behavior.	Various tools

D2.3, V&V Plan, WP7 Development Plan

System Phase: SSRS

Inputs

- System Requirement Specification SUBSET-026 3.3.0
- Functional Interface Specification SUBSET-034-3.0.0

Outputs

- Sub-System Requirement Specification (SSRS)
- Application Programming Interface
- Sub-System Hazard Analyses (SSHA)

Tasks

-

System Phase: Sub-System Model

semi-formal model of the sub-system

strictly formal models

Inputs

-

Outputs

- sub-system architecture
- semi-formal model of the sub-system

Tasks

- Design a model to describe sub-system architecture, main functions and to allocate sub-system requirements
- completed it with a formal model to focus on a subset of functions or properties

Software Phase: Software Requirements

Inputs

-

Outputs

-

Tasks

-

Software Phase: Software Model

semi-formal model

strictly formal model

Inputs

•

Outputs

- Software Architecture and Design Specification
- formal model of the software

Tasks

•

Software Phase: Code

Inputs

•

Outputs

•

Tasks

•

Software Phase: V&V Source Code

Inputs

•

Outputs

- SW Code Generation Verification Report

Tasks

•

Software Phase: V&V Sw model

Inputs

•

Outputs

- SW Architecture, Design and Modelling Verification Report

Tasks

•

Software Phase: V &V Software Requirements

Inputs

•

Outputs

• SW Requirements Verification Report

Tasks

•

System Phase: V&V Subsystem models

Inputs

•

Outputs

•

Tasks

•

System Phase: V&V SSRS

Inputs

•

Outputs

• SSRS verification report

Tasks

•

3.2.2 Life Cycle of the OpenETCS Tools chain

The development of the Tool Chain has to comply with EN50128. Requirements imposed by the standard are analyzed and shown in detail in D2.2. The tools chain development life cycle is described in the document WP7-ToolChainDevelpmentPlan. As the tools chain is a combination and improvement of already existing tools, which have a specific life-cycle, the tools chain life cycle mainly consists of integration and maintenance activities.

The tool chain lifecycle is depicted figure 4

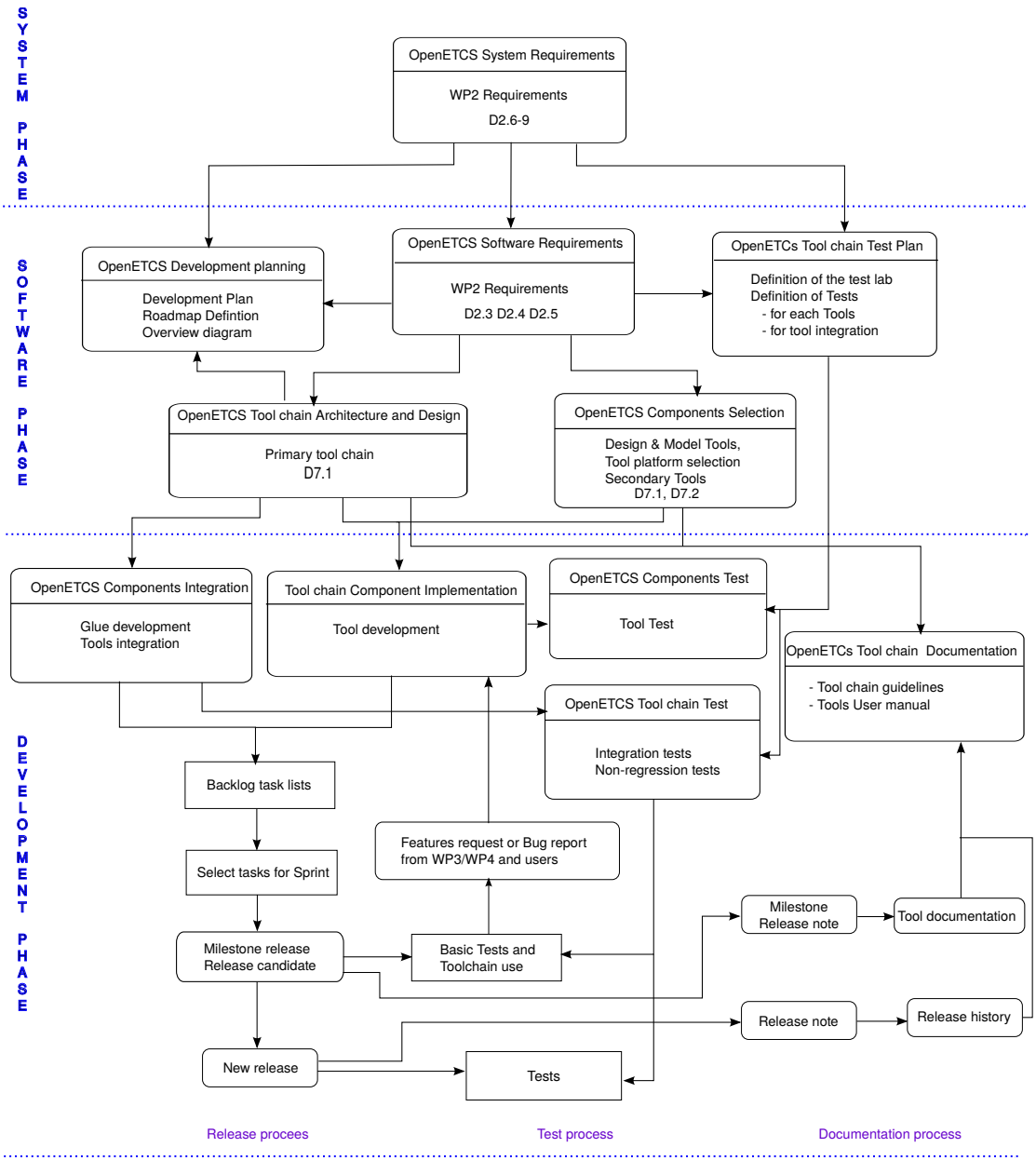

Figure 4. The OpenETCS tool chain life cycle

At following, a more detailed overview of the toolchain life cycle is provided. Each life cycle stage includes its input, output and the activities to be done.

OpenETCS Software Requirements

Inputs

- D2.6-9

Outputs

- D2.3
- D2.4
- D2.5

Tasks

- Specific requirements for the selection and the development of tools and the tool chain development.

OpenETCS Development Planning

Inputs

- D2.6-9
- D2.3-5

Outputs

- Development Plan
- Roadmap definition
- Overview Diagram
- Release process

Tasks

- Elaborate guidelines to develop the tool chain in an agile development.

OpenETCS Tool chain Test Plan

Inputs

- D2.6-9
- D2.3-5

Outputs

- Test Lab definition
- Integration tests
- Performance tests

Tasks

- Elaborate test plans of the tool chain.

OpenETCS Tool chain Architecture and Design

Inputs

- D2.3
- D2.4
- D2.5

Outputs

- D7.1 Report on all aspects of secondary toolin
- tool chain Design Specification

Tasks

- Selection of the tool chain design.
- Definition of how the tool chain is implemented.

OpenETCS Components Selections

Inputs

- D2.3
- D2.4
- D2.5
- Feature requests

Outputs

- Primary Tools: Evaluation of the models and tools against the WP2 requirements
- Primary Tool platform Evaluation: Evaluation of the tool platform against the WP2 requirements
- D7.1 Report on the Final Choice of the Primary Toolchain
- Secondary Tools Evaluations
  - O7-2-1 Management
  - O7-2-1 Safety
  - O7-2-1 VnV
  - O7-2-1 Transformation
  - D7.2 Report on all aspects of secondary tooling

Tasks

- Evaluation and selection of tools according to the different development phases.
- Selection of the tool platform for the tool integration.
- Evaluation and selection of tools to answer features requests.

Tool chain Components Implementation

Inputs

- D7.1
- D7.2

Outputs

- Tools
- Tools User Manual

Tasks

- Implementation of the tools to be integrated into the tool chain

Tool chain Components Integration

Inputs

- D7.1
- D7.2

Outputs

- Tool chain Releases
- D7.4

- Release note
- Tool chain Guideline

Tasks

- Integrate tools.
- Develop glue to make tools talk to each other.
- Define how to use the tool chain.

OpenETCS Component Tests

Inputs

- Test Plan
- Tools
- D7.2

Outputs

- Tools Test report

Tasks

- Definition of how to test the tool chain
- Execution of the tools test cases

OpenETCS Tool chain Test

Inputs

- Test plan
- Test lab
- Tools
- Tool chain releases
- D7.2

Outputs

- Tool chain Test report
- Bug report
- Feature request

Tasks

- Integration tests
- Functional tests
- Data artifacts integrity tests
- Non-regression tests
- Performance Test

Tool chain Maintenance

Inputs

- Bug report

- Feature request

Outputs

- New Tool Selection
- Bug fixes

Tasks

- Report bug in tools or in the tool chain
- Report missing or wishing feature for the tool chain

OpenETCS Tool Chain Documentation

Inputs

- Tool chain release
- Release notes
- Tools selection

Outputs

- Tool chain guidelines
- Tool chain users documentation
- Tool chain developer documentation

Tasks

- Document the development process
- Document the use of the tool chain
- Define the tool chain guidelines and best practice
- Report missing or wishing feature for the tool chain

3.3 QA Management

The Software quality assurance will assure that any deviations during the project and product life-cycle from plans and standards are detected, recorded, evaluated, tracked, and resolved.

Software quality assurance will work with the Configuration Management process to assure that proper controls are in place and applied to life cycle data.

The monitoring activities of the Life Cycle control involve a development of criteria for inputs and outputs of the different life cycle phases, reviews and documentation audits to determine if the overall Life Cycle process is correctly followed. As well as assuring the compliance with the CENELEC standard.

The QA Manager will be responsible for:

- Conducting an internal formal audit every month to:
  - assure that the transition criteria to successfully assist in entry from one life-cycle phase to another, is quantifiable, flexible, well documented, and present for every life-cycle phase

  - assure that the different criteria for moving from one step to the next are satisfied (assure transition criteria are adhered to throughout the life-cycle).
  - assure each of the life-cycle phases outputs are verified, assured, and configured as part of the integral processes (sw verification process, configuration management process, sw quality assurance process, change/problem management process, review and revision processes, ...)
  - Verify the correct aplication of the integral processes inside life cycle
  - ensure that the output deliverables of a phase are consistent and meet all requirements established in the input deliverables
  - assure that the as-delivered products matches the as-built and as-verified product
  - Verify life cycle and assure that every objective and requirement of the CENELEC Standard is fulfilled

- Producing and publishing the corresponding quality reports

In order to do the formal review correctly it will be use the Life Cycle Control and Monitoring Activities formal audit checklist. This Checklist template is provided in [governance].

4 Roles

4.1 OpenETCS Roles

In view of the nature of the project, roles are grouped into three independent categories:

- CAT1: Open Source Development Process Roles
- CAT2: SCRUM Roles
- CAT3: CENELEC Roles

Therefore, any participant will always adopt a role within CAT1, a role within CAT2 and if he/she is involved in the development of a CENELEC assessable product, a third role in CAT3.

As already mentioned, OpenETCS is a project of projects. An expert can participate to different projects with different roles. Therefore an expert will have a CAT1, CAT2 and/or CAT3 role per project.

In the Appendices A, B, C and D, the responsibilities and the core competences required by each role are detailed. It is the responsibility of the QA Manager to keep them updated

In the case of CAT 1 roles, specific technical competence will be required depending on the scope of the project. For this reason a new column has been added. In this column, specific technical competences for each project and role are to be included. It is the responsibility of each project leader to provide this information.

According to the open development process followed by Open ETCS, the QA process is also a project. For this reason the QA Manager will have to meet the competences of a Project Leader and the specific competences imposed by CENELEC and the OpenETCS project to the Quality

Manager activities. When needed, specific responsibilities imposed by a project to a role will be detailed too.

As project results affected by CENELEC are already identified, both core and specific required competence per CAT 3 role are included in Appendices C and D.

4.2 Roles within the Development process of the openETCS Software

The responsibilities and competences for every role specific to the openETCS Software development are listed in Appendix C. The independence of different roles is the core concept of the quality assurance strategy required be CENELEC standard. As openETCS is a collective project by various independent partners, the project organization already ensures full independence between the roles administrated by experts from different partners.

4.3 Roles within the Development process of the openETCS Tools Chain

See Appendix D

4.4 QA Activities

The QA Manager will be in charge of:

- Maintaining the Requirements Competence Matrices updated in response to the evolution of the OpenETCS project
- Performing periodical audits of the participants' database per project; trace database with the RCM (Required Competence Matrix) for such project
- Identify training needs and provide the required support to the Project Office in the definition and organization of the corresponding training activities.
- In the case of CENELEC related project, provide the necessary evidence of competence and independence between roles. If this is not possible, propose the necessary solutions and support the projects in its implementation

5 Methods, measures and tools for quality assurance (product + open ETCS software + Tools chain)

Selection of methods and tools used in each phase of the OpenETCS process is a part of the WP7 activities. This selection is based on the state of art established by WP2 (D2.1 and D2.2), the set of requirements defined by WP2 (D2.6-9) and the process definition (D2.3, D2.4, D4.1, D4.2.3).

Results of the selection of methods and tools are given in the D7.1 and D7.2 deliverables. Conformance of the methods and tools are going to be discussed in D7.3.

The following table give details of all this deliverables.

Deliverable	Content of Relevance for this Chapter
D2.1: Report on existing methodologies	State of the art on methods and tools
D2.2: Report on CENELEC Standard	CENELEC requirements to be fulfilled and the approach followed by the project to provide evidence
D2.3: Process definition	OpenETCS process definition
D2.4: Report on Methods definition	Description of methods and tools to use to follow the OpenETCS process
D2.6-9: Set of requirements for the OpenETCS project	Definition of the requirements that the selected methods and tools shall follow
D4.1: Report on V & V Plan & Methodology	Detailed description of the V & V process and how are used the methods and tools to cover V & V artifacts
D4.2.3: Safety Plan	Detailed requirements on methods and tools to be used during the process to obtain a SIL4 developement of on-board unit
D7.1: Report on the final choice(s) for the primary tool chain (means of description, tool and platform)	Selected methods and tools to be used during the specification and design part of the OpenETCS process
D7.2: Report on all aspects of secondary tooling (results of T7.2)	Selected methods and tools to complete the OpenETCS process (V & V, safety analyses,..)
D7.3: Tool chain qualification process description	This report describe how the selected methods and tools fit the qualification requirements according CENELEC standard

Table 9. Referenced deliverables

5.1 Methods, measures and tools for quality assurance OpenETCS Application Software

It is assumed that the OpenETCS application software will be SIL4 compliant. Therefore, the methods, techniques and tools shall be suitable to SIL 4.

The selected methods and measures are included in Appendix E

5.2 Methods, measures and tools for quality assurance openETCS Tools chain

The Tool Chain will be composed of a set of tools with different levels of interaction. The openETCS tool chain consists on a series of supporting tools that helps in the development of the whole project. Such tools include, but are not limited to, development and design tools, language translators, testing and debugging tools, and configuration management tools. Support tools are further classified according to their influence on the system:

- On-line support tools are tools that can directly influence the safety-related system during its run time
- Off-line support tools are tools that support a phase of the software development lifecycle and that cannot directly influence the safety-related system during its run-time

Following CENELEC criteria, each tool belongs to one of the following classes: T1, T2 and T3. Class 3 and Class 2 Tools are obliged to follow specific development methods, techniques and tools.

5.2.1 Selected Tools

Nowdays, by looking different aspects of the possible tools for the toochain like the strengths, weaknesses, opportunities, features and threats, the selection of the below tools is done.

- Eclipse (eclipse Kepler SR1 IDE): tool platform (Eclipse with the modeling framework (EMF))
- Papyrus/SysML to cover the highest level of the OpenETCS V cycle
- ProR: requirement manager
- SCADE: Low level description and code generation
- EFS to support V&V activities.
- Git: configuration management

Decision has been made to start WP3 and WP4 activities based on SysML/Scade basis, which are involved in the toolchain. However, work to define an alternative fully open source chain to provide SIL4 software is encouraged. On going work is thus provided around SysML/ Classical B.

5.2.2 Metrics Covered by tools

T1 Tools	
Name	Metrics
ProR	requirements management
Git	Software Configuration Management

Table 10. T1 Tools

T2 Tools	
Name	Metrics

Table 11. T2 Tools

T3 Tools	
Name	Metrics
Papyrus	System level description
SCADE	Software level description

Table 12. T3 Tools

IT: analyse with VnV actors the tools classifications taking into account the feedback of issue 87 of governance

5.3 Quality Control and Monitoring Activities

The monitoring activities of the selected Tools, Methods and Techniques implicates a development of criteria, reviews and audits to determine if the overall tools and methods & Techniques selection and implementation is correctly develop and maintain. As well as assuring the compliance with the CENELEC standard.

The Quality Assurance Manager should do the following monitoring activity:

- Conduct an internal formal audit to confirm the methods and tools are ready to use. This audit consists in:
  - Assessing the accept criteria of the tools and methods
  - Assessing the fulfilment of the expectations of the tools and methods
  - Assesing the set of selected methods and tools fulfill CENELEC standard (Benchmarking methods, techniques and tools against CENELEC standard.)
  - Verifying every tool availability and operability
  - Verifying new tool version control
  - Verifying the evaluation of the selected tools, methods and techniques
- Conduct an internal formal audit every month to confirm the methods and tools chain are appropiately implemented.
  - Verifying the correct use of each tool in each WP and Phase
  - Verifying the correct use of each technic and metric in the project

In order to do the formal review correctly it will be use the Tool, Method and Technic Monitoring Activities formal audit checklist. This Checklist template is provided in [governance].

6 Documentation

The documentation structure of the OpenETCS project is composed of:

- Deliverables, which constitute the official outcomes of the different Top-Projects/WPs
  - The relation and scope of the deliverables to be produced along OpenETCS can be found in the FPP [23].
  - The updated status of development of each Deliverable can be found in [State-of-Deliverables Wiki].

  - The approved and therefore valid version of each Deliverables can be found in the repository of the Top-Project/WP it belongs to.

- Contractual documents, with the Commission and among the project partners
  - The status of development of each contractual document can be found under the repository of Management (WP1).
  - The last approved and therefore valid version of each contractual document can be found under the repository of Management (WP1).
- Periodic Progress Reports, to show progress to ITEA and EC representatives.
  - The state of each Periodic Report can be found under repository of Management (WP1).
  - The last approved and therefore valid version of each Periodic Progress Report can be found under the repository of Management (WP1).
- Supporting Documents, in the form of Templates and Procedures
  - The procedures and templates applicable to a specific Top-Project/WP can be found in the repository of the corresponding TP/WP.
  - The procedures and templates applicable to the whole project can be found in the repository of Governance.
- Internal Reports, in the form of Meeting Minutes
  - The minutes of the weekly scrum meetings are found in the repository of Governance.

The nomenclature used for the naming of the different documents is provided in [governance Wiki].

For each TP/WP the relation of existing documents is provided in the form of a list [Wiki]. This list includes a direct access to the valid version of each document.

6.1 Documentation Structure within the development process of the openETCS Software

As a SIL4 software, the documentation structure has to comply with CENELEC requirements. The following table shows the document structure required by CENELEC for a SIL 4 development and the corresponding documents produced in the OpenETCS project.

Table 13. Documentation Structure

Documentation Structure within the development process of the openETCS Software			
Phase	**SIL4**	**Document**	**Responsible**
Planning	Highly Recommended (HR)	Software Quality Assurance Plan (D1.3.1) Software Quality Assurance Verification Report Software Configuration Management Plan (SCMP) Software Verification and Validation Plan (D4.1) Hazard and Risk Analysis Methodology (D4.2.3) Dissemination Plan (D6.1)	Izaskun de la Torre Todo Peer Jacobsen Hardi Hungar Jan Welte Stefan Rieger
Continued on next page			

Table 13 – continued from previous page

Documentation Structure within the development process of the openETCS Software			
Phase	**SIL4**	**Document**	**Responsible**
Software Requirements	HR	Software Requirements Specification (D2.6_9 Requirements for openETCS) ETCS_OBU_FunctionalStructure -Uwe Steinke- Software Requirements Test Specification Software Requirements Verification Report	Sylvain Baro and Jan Welte todo todo
Software Architecture Modeling	HR	System Specification Model (D3.5) Functional Model (D3.6) System Architecture Model with physical allocation (D3.7)-Alstom??- Data Dictionary -Bernd Hekele- Data Dictionary Design Specification =Data Dictionary Tool Development???- Cecile Braunstein- Internal Data Structure -Jan Welvaarts- Data Dictionary Data Catalog -Bernd Hekele- Data Model Description -Marielle Petit Doche- OpenETCS API Document -Alstom-(D2.7?) OpenETCS SSRS Interface Document EVC External Interfaces-Baseliyos Jacob- SRS analysis and functions -Bernd Hekele- Software Architecture Specification Software Design Specification Software Interface Specification Software Integration Test Specification ~~Software/Hardware Integration Test Specification~~ Software Architecture and design verification report	
Component Design	HR	Software Component design specification Software Component Test Specification Software Component design verification report	

Continued on next page

Table 13 – continued from previous page

Documentation Structure within the development process of the openETCS Software			
Phase	**SIL4**	**Document**	**Responsible**
Component Implementation and Testing	HR	1st V&V report on model (D4.2.1) 1st V&V report on implementation/ code (D4.2.2) Software source code and supporting documentation Software source code verification report Software Component Test Report	Ana Cavalli, João Santos, Huu-Nghia Nguyen, Stefan Rieger, Cécile Braunstein, Uwe Steinke, Benoît Lucet, Matthias Güdemann, Brice Gombault, Marielle Petit-Doche, Alexander Nitsch and Benjamin Beichler Marc Behrens, Jens Gerlach, Kim Völlinger, Andreas Carben and Izaskun de la Torre
Integration	HR	Software Integration Test Report ~~Software/Hardware Integration Test Report~~ Software Integration Verification Report	
Overall Software Testing/Final validation	HR	Overall Software Test Report Software Validation Report Tools Validation Report Release Note	
Systems configured by Application Data/ algorithms	HR	Application Requirements Specification Application Preparation Plan Application Test Specification Application Architecture and Design Application Preparation Verification Report Application Test Report Source Code of Application Data/Algorithms Application Data/Algorithms Verification Report	
Software Deployment	HR	Software Release and Deployment Plan Software Deployment Manual Release Notes Deployment Records Deployment Verification Report	Bernd Hekele
Software Maintenance	HR	Software Maintenance Plan Software Change Records Software Maintenance Records Software Maintenance Verification Report	todo

Continued on next page

Table 13 – continued from previous page

Documentation Structure within the development process of the openETCS Software			
Phase	**SIL4**	**Document**	**Responsible**
Software Assessment	HR	Software Assessment Plan (Internal Assessment Plan D4.5.1) Software Assessment Report	Cyril Cornu

6.2 Documentation Structure within the development process of the openETCS Tools chain

CENELEC Standard requires that all the off-line support tools have a manual as minimun required documentation. The Standard also established that tools in classes T2 and T3 should have documentation that defines the behaviour of the tools together with instructions and constrains on its use. This documentation should be a justification for use, a potencial failures identification and the ways to avoid or mitigate them, manuals and use restrictions. It is also required that tools to be assessed with the aim to determine the level of reliance that shall be placed on the tool, and potential failure mechanisms that may affect the executable software (T3 only).

For T3 class applications, evidence shall be available that the tool conforms to its specification or manual, so called tool assessment. Such tool assessment shall cover:

- A chronological record of the validation activities
- The version of the tool product manual being used
- The tool functions being validated
- Tools and equipment used
- The results of the validation activity; the documented results of validation shall state either that the software has passed the validation or the reasons for its failure
- Test cases and their results for subsequent analysis
- Discrepancies between expected and actual results

It is important to add, that every new version of a support tool shall be certified. This may rely on evidence provided for earlier versions if sufficient evidence provides that the modifications do not affect tool compatibility with the rest of the tools in the integrated tool chain and that the new version is unlikely to contain significant new, unknown faults.

Table 14. Documentation Structure

Documentation Structure within the development process of the openETCS Software			
Phase	**SIL4**	**Document**	**Responsible**
Planning	HR	Software Quality Assurance Plan (D1.3.1) Software Quality Assurance Verification Report Software Configuration Management Plan (SCMP) Software Verification and Validation Plan (D4.1) Hazard and Risk Analysis Methodology (D4.2.3) Dissemination Plan (D6.1) Tool chain Qualification Process Description	Izaskun de la Torre Todo Peer Jacobsen Hardi Hungar Jan Welte Stefan Rieger Cecile Braunstein, Jan Peleska and Stefan Rieger
OpenETCS Software Requirements	HR	Software Requirements Specification (D2.6_9 Requirements for openETCS) D2.3 Process Definiition D2.4 Methods Definition D2.5 Description of ETCS using those methodologies Requirements Modeling for SSRS Activities with ProR	Sylvain Baro and Jan Welte Marielle Petit-Doche and Matthias Güdemann Marielle Petit-Doche, David Mentre and Matthias Güdemann David Mentre, Stanislas Pinte, Guillaume Pottier Michael Jastram
OpenETCS Development Planning	HR	Tool Chain Development Plan Roadmap definition Release Process	Cecile Braunstein and Jan Peleska Cecile Braunstein ToDo
OpenETCS Tool chain Test Plan	HR	Tool Chain Test Plans Test Lab definition	ToDo
OpenETCS tool chain Architecture and design	HR	Tool chain Design Specification	Cecile Braunstein and Jan Peleska
OpenETCS Components Selections	HR	D7.1 Report on the Final Choice of the Primary Toolchain Evaluation of the models and tools against the WP2 requirements Evaluation of the tool platform against the WP2 requirements D7.2 Report on all aspects of secondary tooling Secondary Tools Evaluations (O7-2-1 Management, Safety, V&V, Transformation)	Michael Jastram Marielle Petit-Doche Cecile Braunstein Marielle Petit-Doche Marielle Petit-Doche

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Table 14 – continued from previous page

Documentation Structure within the development process of the openETCS Software			
Phase	**SIL4**	**Document**	**Responsible**
Tool chain Components Implementation	HR	Tools and supporting documentation (User Manual, developer documentation)	
OpenETCS Component Tests	HR	Tools Test Reports	
Tool chain Components Integration	HR	Tool chain Releases Tool chain Release note Tool chain Guideline Tool chain Integration Test Report	
Overall OpenETCS Tool chain Test Testing/Final validation	HR	Overall Tool chain Test report Tool chain Validation Report Tools Validation Report Release Note	
Tool chain Maintenance	HR	Tool chain Maintenance Plan Tool chain Change Records Tool chain Maintenance Records Tool chain Maintenance Verification Report	

6.3 Quality Control and Monitoring Activities

The monitoring activities of the Documentation Structure control involves a development of criteria, reviews and documentation audits to determine if the overall structure of the documentation is correctly followed. As well as assuring the compliance with CENELEC standard for a SIL 4 product.

The Quality Assurance Manager should do the following monitoring activity:

- Conduct an internal formal audit every month to confirm the documentation structure is maintained correctly. This audit consists in:
  - Verifying each document development in time and its correct classification inside the WP and Phase.
  - Controlling the document version labels and identifier
  - Benchmarking against CENELEC standard (verifying life cycle and assuring that every objective and requirement of the CENELEC Standard is fulfilled)
  - Assessing the document timeline's creation
- Produce and publish the corresponding quality reports

In order to do the formal review correctly it will be use the Document Structure Control and Monitoring Activities formal audit checklist. This Document Structure Checklist template is provided in [governance].

7 Documentation Control

The Documentation Control procedure describes the steps to follow to ensure that the documentation developed whiting the openETCS project is current and suitable for use by the Eclipse community, the project members and the key customers. The main control activities covered by the procedure include the document creation and review, the approval, dissemination, archiving, modification and update due to a change request or the monitoring of the evolution among the time among others.

The implementation of this procedure, shall ensure that openETCS documents can be located easily, be periodically reviewed, have the nomenclature updated when needed, be available at any time, and be moved and archived when they are labelled ad obsolete.

The whole procedure is fully described in the [Document Control Procedure] .

There is a signature copy inside the project office mandatory for all official deliverables and selected additional documents. The selection of the documents to be signed signed is in the resposibility of the workpackage leader

7.1 Quality Control and Monitoring Activities

The monitoring activities of the Documentation Control, carried on by the Quality Assurance Manager, implicate an in-depth analysis of the document development process. This analysis involves developing criteria, conducting reviews and examining documentation to determine how the process is conducted.

The Quality Assurance Manager should do the following monitoring activity:

- Conduct an internal formal review every 2 months to confirm the documentation control is done correctly. This review consists in:
  - Verifying each document correct location and labeling in the GITHUB repository
  - Verifying the roles of the documentation.
  - Verifying that the terminology, acronyms or abbreviations have the same meaning in every document
  - Verifying the document schedule fulfillment
  - Controlling obsolete documentation labels and location
  - Benchmarking compliance with CENELEC standard
  - Assessing that every document applies the conditions and requirements of the preceding document with which it has a hierarchical relationship. It should not be contradictions among the documentation and its preceding documents
  - Assessing that there is a reference with the same name and description for each element or concept in every document
- Conduct an internal informal review every month using the plans, goals and objectives established in the project to verify control documentation and documentation development is done satisfactorily.

- Participate in the review processes of the different documents
- Maintain a set of metrics for the Document Control process.
- Produce and publish the corresponding quality reports.

In order to do the formal review correctly it will be use the Document Control and Monitoring Activities formal review checklist. This Document Control Checklist template is provided in [governance].

8 Tracking and tracing of deviation

8.1 Traceability (openETCS software + Tools chain)

The monitoring activities of the Traceability help to determine how the traceability among the different elements of the project is conducted. In order to have a good traceability, it has been established to develop a traceability matrix.

During the whole project different traceability matrix will be used and all of them will monitor in the same way.

The Quality Assurance Manager should do the following monitoring activity:

- Verify that the means to demonstrate traceability throughout all phases of the lifecycle are provided
- Verify that the output of the traceability process is the subject of formal configuration management
- Verify that the requirements traceability is covered completely
- Assure that any untraceable material (requirement, model, code, ...) to have no bearing upon the safety or integrity of the system
- Ensure that each specific CENELEC role is responsible for establishing and maintaining traceability to and from the specific elements.
- Monitor the different matrix with informal reviews every month and with formal reviews every 3 months. These reviews will consist in assuring that the generated matrix table has well traced every element of the project.

  In order to do this the following relations among elements will be reviewed:

  1. Traceability between requirements and models (design)
  2. Traceability between models and the generated code
  3. Traceability among requirements, models, test plans, specifications to the test or other reports which record the results of their application and tool chain.

In order to do the formal review correctly it will be use the Traceability Activities formal review checklist. This Traceability Checklist template is provided in [governance].

8.2 Configuration Management

Configuration Management (CM) is used to handle changes systematically so that a system maintains its integrity over time. The Software Configuration Management Plan [SCMP] [24] defines the procedures, techniques, and tools that are required to manage the software development, evaluate proposed changes, trace the status of changes, and to support an inventory of the system.

The main points to perform the configuration management process are:

- Configuration Management Tools
- Configuration Items
- Configuration Management Organization
- Configuration Control/Change Management
- Configuration Audits
- Baselines

The Quality Assurance Manager is accountable for the implementation of the System Configuration Management Plan (SCMP).

The QA Manager will be in charge of:

- perform periodical audits
  - Audits to verify the process itself: the correct implementation of the process and the compliance of the process with CENELEC Standard
- Produce and publish the corresponding quality reports.

8.3 Fault Management

A failure is a deviation of the component or system from its expected delivery, service or result. A failure is the consequence of a fault or error in a system but not all faults result in failures.

Faults, failures and errors encountered during the review activities (QA. Verification, Validation, Assessment) planned in the software development life-cycle, problems reported by users and customers as well as change requests initiated by any of the system stakeholders will be reported and managed following the Change/Problem Management Process [3] detailed in [governance] and through the Change/Problem Management Tool. This tool will be integrated with the Configuration management tool *GIT* and will be configured to implement and record all the information generated during the process.

The integration with the Configuration management tool *GIT* will permit:

- Traceability between Change/Problem Requests and the configuration items where the problem was located.

- Traceability between the configuration items modified and the corresponding Change/problem request.

The implementation of the workflow will permit:

- A complete history trail of the Change Request/Problem Report

The purpose of the Change/Problems Management implementation at OpenETCS project is to ensure that standardized methods and procedures are used for efficient and prompt handling of all changes/problems associated with the OpenETCS products, in order to minimize the number and impact of any related changes/problems. Changes/problems in the products may arise reactively in response to incidents, or proactively from seeking improved efficiency and effectiveness, as well as to enable or reflect OpenETCS initiatives, or products improvements.

The QA Manager will be in charge of:

- perform periodical audits and quality assessments of the bugs received
  - Audits to verify the process itself
  - Quality Assessments to verify the evolution of the product quality
- Assist in determining QA impacts
- Support Problem owner in analysis

8.4 Grievance Handling

It is a good culture to solve concerns as close as possible to the root cause of an problem or a misunderstanding. This means, the team where a problem is seen first is empowered to search for a solution of the problem first.

If the partners cannot agreed on a solution, the impediment is escalated to the next level in the project hierarchy.

When a member of the openETCS community has a concern about a Project, the member will raise that concern with the Project's Leadership (e.g., task leader in openETCS). If the member is not satisfied with the result, the member can raise the concern with the parent Project's Leadership, typically the workpackage leader.

The Member can continue appeals up the Project Leadership Chain and, if still not satisfied, thence to the project management board PMB, then the openETCS project lead, and finally to the project co-operation committee (PCC). All appeals and discussions will abide by the Guiding Principles of being open, transparent, and public.

Member concerns may include:

- Out of Scope. It is alleged that a Project is exceeding its approved scope.
- Dysfunctional. It is alleged that a Project is not functioning correctly or is in violation of one or more requirements of the Development Process.

- Contributor Appeal. It is alleged that a Contributor who desires to be a Committer is not being treated fairly.
- Invalid Veto. It is alleged that a -1 vote on a Review is not in the interests of the Project and/or of Eclipse.

A variety of grievance resolutions are available to the PMB up to, and including, rebooting or restarting a project with new Committers and leadership.

The issues seen during a sprint shall be taken to the sprint retrospective in order to help the team find an easy way in the future.

8.5 Software Maintenance

8.5.1 Software Maintenance Plan

Software Maintenance Plan introduces the approach that the OpenETCS-Software and OpenETCS-Toolchain project adopts for the maintenance of the software components.

The procedures for software maintenance will be contained in the Software Maintenance Plan for OpenETCS-Software (SMP-SW) and the Software Maintenance Plan for OpenETCS-ToolChain (SMP-toolchain). These procedures should also contain information about:

- Control of the error report, the error log, maintenance records, authorizations to make changes and software configuration / system and the techniques for estimation impact analysis and record and data analysis.
- Evaluation, Verification and Validation of every change
- Definition of software modification process (definition of the Authority which approves the changed software, etc...)

8.5.2 Modification and change control

A change is the addition, modification, or removal of a configuration item (CI), product, or product component, and/or its associated elements

The change requests initiated by any of the system stakeholders will be reported and managed following the Change/Problem Management Process [3] detailed in [governance] and through the Change/Problem Management Tool.

The Change/problem Management process aims to evaluate and plan the change/problem process to ensure that, if a change is made, it is done in the most efficient way possible, following the established procedures and ensuring the quality and continuity of the OpenETCS project and products at all times.

The Change/problem Management process should define at least the following:

- the necessary documentation to report a problem
- analysis of the collected information

- practices to be followed to report, track and resolve identified problems
- responsabilities
- controls to ensure that corrective actions have been taken and are effective
- impact analysis
- approval before implementation

8.5.3 Quality control and monitoring activities

For Software Maintenance the following metrics to follow in order to control the Maintenance phase are identified:

- Maintenance efficiency
- Maintenance effectiveness

Any trends and changes that occur provide an analytical basis for managerial decision making, regarding issues such as; examining resource requirements and initiation of corrective and preventive actions.

The QA Manager will be in charge of:

- perform periodical audits and quality assessments of the change request received
  - Audits to verify the processes themself: the correct implementation of the processes and the compliance of the processes with CENELEC Standard
  - Quality Assessments to verify the evolution of the product quality
- Assist in determining QA impacts
- Support Change owner in analysis

9 Supplier Control

This section describes what openETCS consortium expects its suppliers to do to ensure that all openETCS products' requirements and expectations are met.

This Supplier control applies to all Suppliers providing openETCS project with materials, products, processing, and related services.

At following, the expected Suppliers' general requirements are listed:

- Supplier shall ensure the confidentiality of openETCS project and products under development, and related product information, as well as intellectual property shared as a result of the working relationship.
- Suppliers are expected to have an effective quality system that ensures conforming product is delivered.

  - Suppliers shall maintain a Quality Management System suitable to the products and services provided to openETCS, that is certified by an accredited third-party certification body, i.e. ISO9001. This letter of accreditation should be provided to the respective QA personnel
  - In the absence of third-party certification, depending on the product, its application, value, and criticality, the OpenETCS community and Quality Assurance Manager may authorize the acceptance of other evidence of compliance

- Supplier should assure that all performance, endurance, maintenance, safety and warning requirements are met.
- The Supplier shall maintain documented procedures for identification of product from receipt and during processes of production and delivery. When traceability is a specified requirement, the Supplier shall establish and maintain a documented procedure for unique identification of individual product or batches
- The supplier shall provide and maintain suitable gauges, measuring instruments and test equipment to measure/test all material for conformance to OpenETCS requirements.
- Copies of quality conformance inspection data pertinent to material inspection must be provided by the supplier if required for each shipment or retained at Suppliers premises for future verification.
- The Supplier shall provide evidence that the following verifications required by the design record and control plan have been completed and that results indicate compliance with specified requirements
- Suppliers will be responsible for corrective action when changes to product specifications without prior notification to QA result in non- conformity to product or processes.
- OpenETCS requires all Suppliers to be approved prior to the issuance of contracts

Supplier Approval Process

- **Registration:** New suppliers must complete a registration form. This form initiates the approval
- **Evaluation:**
  - Ensure Supplier Risk Assessment considers both:
    - Quality risk
      - Finished Device Quality implications
    - Supply risk
      - Including implications of supplier going out of business
  - Evaluate Suppliers using Questionnaires, Self surveys and Audits techniques
  - Supplier's grading based upon evaluation results and assigned an evaluation status: Approved, conditional or not approved
- **Certification**: Classify Suppliers based on both QUALITY Risk and SUPPLY Risk.

The QA Manager will be in charge of:

- inspect records/evidence of a supplier's quality management systems at their facility
- monitoring and feedback processes: Include periodic review of critical product/process data
- documents problem issues and requirements for the supplier
- analyses the supplier operating conditions,
- Establish Minimal performance for Quality and Delivery
- When a supplier provides a product/part, apply supplemental controls to further mitigate risk
  - Product Acceptance Activities
  - Supplier Performance and Monitoring: augmented frequency of reviews
- creates a corrective development profile together with the supplier,

10 Publishing Guideline

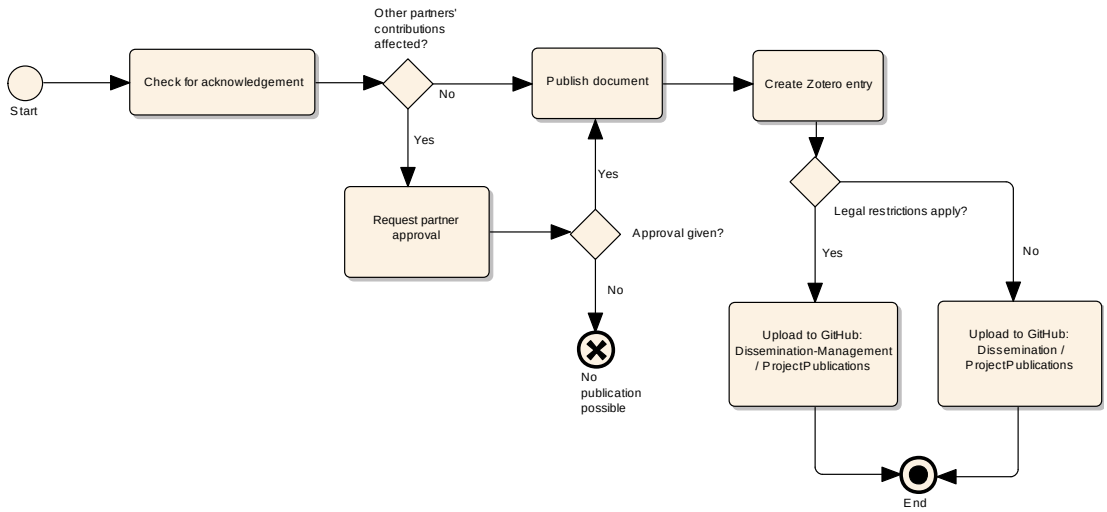

Figure 5. The publishing process as BPMN diagram

When publishing in the context of the openETCS project authors shall adhere to this guideline. Figure 5 depicts the steps as graphical BPMN process. The individual steps are described in detail in the following.

1. It must be ensured that the *project*, the *funding authority* and the *grant number* is mentioned in the paper/presentation. The following acknowledgements can be used:

   Germany This work was funded by the German Federal Ministry of Education and Research (Grant No. 01IS12021) in the context of the ITEA2 project openETCS.

   Belgium/Brussels region This work was funded by the Région de Bruxelles-Capitale / Brussels Hoofdstedelijk Gewest (Grant No. RBC/12 R 11) in the context of the ITEA2 project openETCS.

Belgium/Walloon region This work was funded by the Walloon Region (DG06) (Grant No. 6921) in the context of the ITEA2 project openETCS.

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Spain This work was funded by the "Gobierno de España, Ministerio de Ciencia e Innovación" in the context of the ITEA2 project openETCS

2. Publications potentially affecting project contributions of other partners require explicit approval. A request for approval shall be accompanied with a reasonable deadline (e.g., two weeks). Please consider a joint publication with the involved partners.

3. An entry with the details of the publication should be added to the Zotero group *openETCS Publications* by using the Zotero tool or the website zotero.org. A how-to regarding the use of Zotero in openETCS is provided here. A link to an official and public webpage where the publication can be obtained/purchased should be included.

4. The final document should be uploaded to GitHub to one of the following directories:

   - To Dissemination-Management/ProjectPublications if legal restrictions apply for publication.
   - To Dissemination/ProjectPublications if it can be published freely under the openETCS Open License.

11 Perimeter of the System

11.1 List of Functions

Table 15. Functions

Functions			
Number	Name	Block/ Function	Complexity
1	DataPreparation	B	
1.1	Board_External_Interface	F	
1.2	GATC TRAINBORNE SUB SYSTEM	B	
1.2.1	Filter_information_from_ERTMS_trackside (including linking)	F	3
1.3	Provide_automatic_train_protection	B	
1.3.1	Manage_STMs	F	3
1.3.2	Determine_train_location_information	F	3
1.3.3	Control_route_suitability	F	1
1.3.4	Manage_track_conditions	F	2
2	Ensure_train_protection	B	
2.1	Manage_reception_of_MA_information	F	2
2.2	Manage_TSR	F	1

Continued on next page

Table 15 – continued from previous page

Functions			
Number	Name	Block/ Function	Complexity
2.3	Manage_Speed_Supervision_Inputs	F	2
2.4	Active_and_Manage_train_protection	B	
2.4.1	Activate_train_protection_in_FS	F	3
2.4.2	Activate_train_protection_in_OS	F	3
2.4.3	Activate_train_protection_in_LS	F	3
2.4.4	Activate_train_protection_in_SR	F	2
2.4.5	Activate_train_protection_in_UN	F	2
2.4.6	Activate_train_protection_in_SH	F	2
2.4.7	Activate_train_protection_in_TR	F	2
2.4.8	Activate_train_protection_in_SF	F	1
2.4.9	Activate_train_protection_in_SB	F	2
2.4.10	Activate_train_protection_in_PT	F	2
2.4.11	Activate_train_protection_in_RV	F	2
2.4.12	Activate_train_protection_in_IS	F	1
2.4.13	Perform train protection	F	3
2.4.14	Perform train protection related actions	F	3
2.4.15	Activate_train_protection_in_SN	F	2
2.4.16	Activate_train_protection_in_PS	F	2
2.4.17	Activate_train_protection_in_NP	F	1
2.5	Manage_emergency_stop_messages	F	2
3	Manage_mode_and_level_and_procedures_and_ancillary_fu	B	
3.1	compute_mode	F	2
3.2	compute_level	F	2
3.3	Manage_procedures	B	
3.3.1	capture_data_for_mission	F	2
3.3.2	handle_mode_profile_procedure	F	
3.3.3	handle_SH_procedure	F	
3.3.4	handle_RV_procedure	F	
3.3.5	handle_override_EOA	F	
3.4	Perform_ancillary_functions	B	
3.4.1	Manage_track_ahead_free	F	2
3.4.2	Display_text_messages_coming_from_trackside	F	1
3.4.3	Display_geographical_position	F	1

Continued on next page

Table 15 – continued from previous page

Functions			
Number	Name	Block/ Function	Complexity
3.4.4	End_mission	F	1
3.4.5	Manage_national_values	F	1
3.4.6	store_configuration_data	F	1
3.4.7	Management of MA request	F	2
3.4.8	Sending of position report	F	1
3.4.9	Determine train integrity	F	1
3.4.10	Detect_change_of_orientation	F	2
3.4.11	Manage_cold_movement_detection	F	1
3.4.12	Provide_train_movement information	F	
3.4.13	Manage_radio_sessions	F	
3.4.14	Record_juridical_data	F	2
3.4.15	Interface with train	F	2
3.4.16	Interface with DMI	F	2

11.2 List of Risks

Table 16. Risks

Risks	
Event Id.	Event Description
MMI-1a	False acknowledgement of mode change to less restrictive mode
MMI-1b	False command to enter Non-leading mode
MMI-1c	False command of Override request
MMI-1d	False acknowledgement of Level Transition
MMI-1e	False acknowledgement of Train Trip
MMI-1f	False acknowledgement of Track Ahead Free
MMI-1g	False shunting request
MMI-1h	False acknowledgement of undesired train movement (RAP, RMP and SSS)
MMI-2a.1	False presentation of train speed on the DMI
MMI-2a.2	False presentation of speed (except train speed) or distance on the DMI, including supervision status
MMI-2b	False presentation of mode on the DMI

Continued on next page

Table 16 – continued from previous page

Risks	
Event Id.	Event Description
MMI-2c	False presentation of track adhesion
MMI-2d	Failure to present Entry in FS/OS informa-tion
MMI-2e	False presentation of train data/additional data
MMI-2f	False presentation of Override status, including false enabling of override selection
MMI-2g	Failure to present acknowledgement message to a less restrictive mode
MMI-2h	False presentation of TAF request
MMI-2i	Failure to present LX “not protected” infor-mation
MMI-2j	False presentation of reversing allowed
MMI-2k	False presentation of level transition an-nouncement
MMI-3	Falsification of driver’s train data / addi-tional data input stored onboard
MMI-4	Falsification of SR speed/distance data
MMI-5	Falsification of train integrity input
MMI-6	Falsification of Virtual Balise Cover
ODO-1	Incorrect standstill indication
ODO-2	Speed measurement underestimates trains actual speed
ODO-3	Incorrect actual physical speed direction
ODO-4	The confidence interval for distance measurement does not include the real position of the train
KERNEL-1	Balise linking consistency checking failure
KERNEL-2	Balise group message consistency checking failure
KERNEL-3	Failure of radio message correctness check
KERNEL-4	Radio sequencing checking failure
KERNEL-5	Radio link supervision function failure
KERNEL-6	Manage communication session failure
KERNEL-7	Incorrect LRBG
KERNEL-8	Emergency Message Acknowledgement Failure
KERNEL-9	Speed calculation underestimates train speed
KERNEL-10	Functional failure of standstill detection
KERNEL-11	Incorrect traction/braking model (e.g. brake use restrictions)
KERNEL-12	Failure of standstill supervision
KERNEL-13	Failure of backward distance monitoring
KERNEL-14	Failure of reverse movement protection
KERNEL-15	Incorrect cab status (TIU failure)

Continued on next page

Table 16 – continued from previous page

Risks	
Event Id.	Event Description
KERNEL-16	Incorrect train status TIU sleeping/cab status
KERNEL-17	Wrong Acceptance of MA
KERNEL-18	Failure to manage RBC/RBC
KERNEL-19	Failure of train trip supervision in OS, LS and FS
KERNEL-20	Failure of train trip supervision, shunting and SR
KERNEL-21	Incorrect supervision of stop in SR
KERNEL-22	Incorrect current EoA
KERNEL-23	Incorrect train position / train data sent from on-board to trackside
KERNEL-24	Failure of message acknowledgement
KERNEL-25	Incorrect traction/braking model (Accelera-tion only)
KERNEL-26	Deleted
KERNEL-27	Incorrect System Data (e.g. current level)
KERNEL-28	Incorrect confidence interval
KERNEL-29	Failure to shorten MA
KERNEL-30	Incorrect shortening of MA
KERNEL-31	Deleted
KERNEL-32	Failure of loop message consistency checking
KERNEL-33	Wrong processing of MA information
KERNEL-34	Incorrect supervision of MA time-outs (sections and overlaps)
TI-1	Service brake / emergency brake not commanded when required
TI-2	Service brake / emergency brake release commanded when not required
TI-3	Inappropriate sleeping request
TI-4	Incorrect brake status (TIU failure)
TI-5	Incorrect direction controller position report (TIU failure)
TI-6a	Loss of Cabin Active signal
TI-6b	Wrong Cabin considered as Active
EUB-H1	A balise group is not detected, due to fail-ure of a balise group to transmit a detectable signal
EUB-H4	Transmission of an erroneous telegram interpretable as correct, due to failure within a Balise
EUB-H7	Erroneous localisation of a Balise Group, with reception of valid telegrams, due to failure within Balises (too strong up-link signal)
EUB-H8	The order of reported Balises, with reception of valid telegram, is erroneous due to failure within a Balise (too strong up-link signal)

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Table 16 – continued from previous page

Risks	
Event Id.	Event Description
EUB-H9	Erroneous reporting of a Balise Group in a different track, with reception of valid telegrams, due to failures within Balises (too strong up-link signal)
BTM-H1	A balise group is not detected, due to failure within the onboard BTM function
BTM-H4	Transmission to the on-board kernel of an erroneous telegram, interpretable as correct, due to failure within the onboard BTM function
BTM-H7	Erroneous localisation of a Balise Group, with reception of valid telegrams, due to failure within the on-board BTM function (erroneous threshold function or significantly excessive Tele-powering signal)
BTM-H8	The order of reported Balises, with reception of valid telegrams, is erroneous due to failure within the on-board BTM function (erroneous threshold function or significantly excessive Tele-powering signal)
BTM-H9	Erroneous reporting of a Balise Group in a different track, with reception of valid telegrams, due to failure within the on-board BTM function (erroneous threshold function or significantly excessive Tele-powering signal)
OB-EUR-H4	Radio message corrupted in onboard Euroradio, such that the message appears as consistent
TR-EUR-H4	Radio message corrupted in trackside Euroradio, such that the message appears as consistent
LEU-H4	Transmission of an erroneous telegram / telegrams interpretable as correct, due to failure within the LEU function
EUL-H4	Transmission of an erroneous telegram / telegrams interpretable as correct, due to failure within a Loop
LTM-H4	Transmission of an erroneous telegram / telegrams, interpretable as correct, due to failure within the on-board LTM function
RBC-2	Incorrect radio message sent from RBC Kernel, such that the message appears as consistent
RBC-3	Incorrect radio message from an adjacent RBC, causing incorrect message to ETCS onboard

Appendices

A CAT1: Open Source Development Process Roles and Competence Matrix

Table 17. CAT1: Open Source Development Process Roles/Competences

CAT1: Open Source Development Process Roles/Competences				
Code	Role	Responsibilities	Core Competences	Specific Competences /Responsibilities per project
OPL	OpenETCS project Leader	Responsible to guarantee progress Promote that the most appropriate community is engaged in the project life-cycle Ensure that all personnel involved in all phases of the software, tool chain (products) and project life-cycle, including management activities, have the appropriate training, experience and qualifications	Good Project Management Skills Communication Skills Presentation Skills Moderation Skills Risk Management Skills	Not Applicable
WPL	WP Leader/Top-level project leader	Make sure the required competence to develop a task is covered by the engaged committers To ensure that all personnel who have responsibilities for the software are competent to discharge those responsibilities Ensure that the parties involved throughout the product life-cycle are independent, to the extent required by the software safety integrity level, in accordance with cenelec	Project Management Skills Good Technical Knowledge of the Workpackage Communication Skills Presentation Skills Moderation Skills Risk Management Skills	Good Technical Knowledge of the specific Workpackage

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Table 17 – continued from previous page

CAT1: Open Source Development Process Roles/Competences				
Code	Role	Responsibilities	Core Competences	Specific Competences /Responsibilities per project
TL	Task Leader/ project leader	Maintains the corresponding backlog	Project Management Skills Technical Knowledge of the Workpackage Communication Skills Presentation Skills Moderation Skills Risk Management Skills	Technical Knowledge of the specific Workpackage. For example: Project: QA activities responsible for the identification, supervision and control of all the processes, methods and tools required to meet the quality targets of the project
US	User	Not Applicable		
AD	Adopter	Reuse of the frameworks (within the companies that are contributing to the project and outside of the project), Reuse of the tools (within the companies that are contributing to the project and outside of the project,	Not in the scope of this document	Not in the scope of this document

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Table 17 – continued from previous page

CAT1: Open Source Development Process Roles/Competences				
Code	Role	Responsibilities	Core Competences	Specific Competences /Responsibilities per project
CTB	Contributor	Contribute content, code, fixes, tests, documentation, or other work that is part of the Project Provide feedback Help new users Test, report or fix bugs Request new features Write or update documentation Write and update software	Not relevant	See "how to become a committer in openETCS" Good technical skills for the task of the workpackage
CMT	Committer	Have the exclusive right to elect new Committers to their Project–no other group, including a parent Project, can force a Project to accept a new Committer. Monitor and contribute to the mailing lists Proactively report problems in the task tracking system, and annotating problem reports with status information, explanations, clarifications, or requests for more information from the submitter	Not relevant	Good technical skills for the task of the workpackage

B CAT2: SCRUM Roles and Competence Matrix

Table 18. CAT2: SCRUM Roles/Competences

CAT2: SCRUM Roles/Competences			
Code	Role	Responsibilities	Core Competences
POw	Product Owner	Managing and prioritizing the Product Backlog Planning the release Software and Tool chain acceptance Understand the value of the project Stakeholder Management We expect the WP-/Task Leader to act in this role	Agile Product Owner Training and Certificate is highly recommended Customer Orientation Deep Technical Knowledge of the Product he/she is responsible for Good knowledge of the use-case of the product Project Management Skills Risk Management Skills
ScM	Scrum Master	Team Coach Change Agent Owner of the Impediment Backlog Manage the development process Prepare Burndown charts Identify and eliminate obstacles that prevent the team from achieving their goals Ensures that the team is fully functional and productive Enables close cooperation across all roles and functions Ensure clear communication among everyone involved in the project	Agile Scrum Master Training and Certificate is highly recommended Moderation Skills Team Coaching Skills Experiences in the tasks the team is responsible for

Continued on next page

Table 18 – continued from previous page

CAT2: SCRUM Roles/Competences			
Code	Role	Responsibilities	Core Competences
ScT	Scrum Team	Self organizing (organizes itself and its work) Identify obstacles and informing the Scrum Master Development to achieve sprint goals. Implementing test cases Unit and initial Acceptance testing	Some Basic Scrum Training is needed Team needs to cover skills for all tasks needed to develop and release the product Looking at CENELEC, the roles to be covered in each team are Requirement Manager, Designer, Implementer, Tester, Verifier, and Integrator.

C CAT3: CENELEC Roles and Competence Matrix for OpenETCS software product

Table 19. CAT3: CENELEC Roles/Competences for OpenETCS application software project

CAT3: CENELEC Roles/Competences for OpenETCS application software project			
Code	Role	Responsibilities	Competences
PM	OpenETCS software Project Manager	Identify which roles are needed for the project Verify that at least one person fulfills an identified project role Guarantee the required competence for the project is covered by the effective committers Initialize the distribution of roles between partners to ensure independence of the roles Ensure compliance with the quality management system Responsible to guarantee progress according to scheduled plans Responsible for the delivery and implementation of the software Ensure the compliance and the delivery of safety requirements Approve full and partial products to be delivered by the development process Ensure that records and traceability are maintained throughout the decision making and project Ensure appropriate validation for the project through project partners	Understand requirements of software development process Understand quality, competencies, organizational and management requirements according to relevant standards Understand the requirements of the verification, validation and safety process Able to evaluated the impact of different options for the performance concerning implementation, validation and safety

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Table 19 – continued from previous page

CAT3: CENELEC Roles/Competences for OpenETCS application software project			
Code	Role	Responsibilities	Competences
RQM	Requirement manager	Responsible for the software model and source code requirement specification Establishes and maintain traceability to and from the system-level requirements Ensure that software and derived specifications requirements are under system configuration and changes management control. Ensure consistency and completeness of the software requirements specification Develop and maintain documents related to software requirements	experience in railways sector and safety attributes in the railway domain experience with requirements management process and tools knowledges of Technical Specification for Interoperability (TSI) and related CENELEC requirements

Continued on next page

Table 19 – continued from previous page

CAT3: CENELEC Roles/Competences for OpenETCS application software project			
Code	Role	Responsibilities	Competences
designer (DES)	Designer	Transform software requirements on acceptable solutions Derive the requirements for the system and software architecture Identify the key design issues that must be resolved to support successful development of the software Allocate the software and derived requirements to the chosen architecture components and interfaces Maintain requirement traceability for the software architecture's requirements, and to and from software requirements Identify suitable derived requirements that address the effectiveness and cost of life-cycle phases following development, such as production and operation Develop and maintain design documentation Ensure that the design documents are under system configuration and changes management control. Design or select design methods and support tools Apply principles and suitable design standards Develop component specifications if it is applicable	Competent in software development in the railway domain Competent in safety design principles Familiarity with methods and tools for design analysis and design testing Ability to work with design constraints for safety relevant software in On-Board systems Understanding of the system constraints created through the TSI Understanding of the relevant parts of EN 50128 like design methods

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Table 19 – continued from previous page

CAT3: CENELEC Roles/Competences for OpenETCS application software project			
Code	Role	Responsibilities	Competences
implementer (IMP)	Implementer	Transform design solutions in data, models, source code and finally executable code for the demonstrator Apply safety design principles Apply specific rules for data preparation/codification Perform analysis to verify intermediate results Develop and maintain implementing documents comprising the methods, types of data, models and listings applied Maintain traceability to and from the design Maintain the generated or modified data/codes/models under system configuration and changes management control.	Competent in safety relevant software implementation for embedded systems Competent in the implementation language and supporting tools Capable of applying the specified coding standards and programming styles Understanding of the system constraints created through the On-Board hardware respectively the demonstrator Understanding of the relevant parts of EN 50128 like design methods
tester (TST)	Tester	Ensure the test activities planning Develop tests specification (goals and cases) Ensure traceability of test objectives to specified software requirements Ensure traceability of test cases to the specified tests objectives Ensure that the planned tests are implemented and performed Identify deviations from the expected results and record in the test reports Communicate deviation to the authority in charge of the changes management for evaluation and decision making Record the results reports Select the equipment for testing the software	Competent in ETCS specification, used means of description (model/ source code), used train and track parameter and other application data source Competent in various test approaches/methods to identify to identify the most appropriate method or combination of methods for every aspect of an artifact Capable of deriving test cases from TSI (specifically Subset 26) and the specification model Understanding of the relevant parts of EN 50128 like test methods

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Table 19 – continued from previous page

CAT3: CENELEC Roles/Competences for OpenETCS application software project			
Code	Role	Responsibilities	Competences
verifier (VER)	Verifier	Develop a software (SW) Verification Plan Check the documented test suitability (completeness, coherency, relevance, traceability) with the verification objectives Identify anomalies, evaluate in terms of the risk, record them and communicate them to the authority in charge of the changes management for evaluation and decision making Manage the verification process (revision, integration and testing) and ensure the independence of the activities as needed Develop a verification report with the results of the verification activities	Competent in ETCS specification, used means of description (model/ source code), used train and track parameter and other application data source Competent in various verification approaches/methods to identify the most appropriate method or combination of methods for every aspect of an artifact Capable of deriving verification procedures from TSI (specifically Subset 26) and the specification model Understanding of the relevant parts of EN 50128 like verification methods
integrator (INT)	Integrator	Manage the integration process using software baselines Develop sw and sw /hw integration test specification for sw components based on the specifications and on the designer's components architecture Develop and maintain records of the integration activities Identify integration anomalies; record them and communicate them to the authority in charge of the changes management for evaluation and decision making Develop a report of components and the overall system integration covering the integration results	Competent in ETCS specification, used programming language, used API and demonstrator hardware Competent in various integration approaches/methods to identify the most appropriate method or combination of methods for the demonstrator implementation Understanding the design and functionality requirements for intermediated development levels Capable of deriving integrator tests from the set of integrated functions Understanding of the relevant parts of EN 50128 like integration tests

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Table 19 – continued from previous page

CAT3: CENELEC Roles/Competences for OpenETCS application software project			
Code	Role	Responsibilities	Competences
validator (VAL)	Validator	Develop a Validation Plan specifying the main tasks and activities for the sw validation Agree on the Validation Plan with the assessor Review Sw requirements in relation to their intended use/environment Ensure sw fulfill all sw requirements Evaluate the assessment of the software process and of the software according to CENELEC requirements and the assigned SIL Review the verification and tests correctness, consistency and suitability Check the correctness, consistency and suitability of the test cases and executed tests Ensure that all validation plan activities are carried out Review and classify deviations, evaluate in terms of the risk, record them and communicate them to the authority in charge of the changes management for evaluation and decision making Provide recommendation about sw suitability Record Validation Plan deviations Conduct audits, inspections or reviews of the overall project at various stages of development as may be appropriate Review and analyse validation reports of the previous sw Check whether the developed solutions are traceable to the sw requirements Ensure that records associated hazardous situations and nonconformances are reviewed Ensure that all dangerous situations are appropriately resolved Develop a Validation Report Express their agreement or disagreement about the sw version	Competent in ETCS On-Board units Experience in safety attributes for train control systems Competent in various validation approaches/methods to identify the most appropriate method or combination of methods for the demonstrator implementation Capable of deriving types of validation evidence required for the TSI with respect to the train control functionality Capable to combine different sources and types of evidence and synthesize an overall view about fitness for purpose or constraints and limitations of the On-Board application Overall software understanding and perspective including the general railway environment Understanding the requirements of EN 50128

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Table 19 – continued from previous page

CAT3: CENELEC Roles/Competences for OpenETCS application software project			
Code	Role	Responsibilities	Competences
assessor (ASR)	Assessor	Develop an assessment plan and communication with safety authority and client organization Evaluate the assessment of the software process and of the software according to CENELEC requirements and the assigned SIL Assess the project team and the organization competences for the sw development Evaluate the Verification & Validation activities and the supporting evidences Evaluate quality management systems adopted for the sw development Evaluate the changes management and the Configuration Management Systems and their use Identify and assess risk in terms of any deviation from the sw requirements in the evaluation report Ensure the evaluation Plan is implemented Performs independent checks of: The development process (audits) and the products safety functions (spot checks) during different development phases. Should perform audits, based on the Safety plan, of the Quality and Safety management systems of the Supplier, the Infrastructure owner and the Operator and be convinced that these systems works The Assessor can also perform spot checks on detailed technical issues to see that safety functions are correctly implemented. The safety functions key documentation (Hazard Log, Safety Requirements and Safety Case) should be examined too. Give an opinion on the validity of sw developed for its intended use detailing any constraints, application conditions and observations for risk control appropriate Develop an assessment report and maintain records about the assessment process	Competences in the railway domain and technology specifically concerning On-Board systems Acceptance/License from a recognized safety authority Continually gained sufficient level of experience in the safety principles and the application of these principles within the railway domain Competence to evaluated that a suitable method or combination of methods in a given context have been applied Understanding the relevant safety, human resource, technical and quality management processes to fulfill the requirements of the EN 50128 Competence in assessment approaches/ methods Capable to combine different sources and types of evidence and synthesize an overall view about fitness for purpose or constraints and limitations of the On-Board application Overall software understanding and perspective including the general railway environment Ability to judge the adequacy of all development processes (like quality management, configuration management, validation and verification processes) Understanding the requirements of EN 50128

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Table 19 – continued from previous page

CAT3: CENELEC Roles/Competences for OpenETCS application software project			
Code	Role	Responsibilities	Competences
CM	Configuration Manager	Responsible for the configuration management plan [24] System configuration management owner Establish that all sw components are clearly identified and have independent versions within the system configuration management Prepare the published release notes mentioning incompatible versions of sw components	Competences in software configuration management Understanding the requirements of EN 50128

D CAT3: CENELEC Roles and Competence Matrix for OpenETCS Tool Chain product

Table 20. CAT3: CENELEC Roles/Competences for OpenETCS Tool Chain product

CAT3: CENELEC Roles/Competences for OpenETCS Tool Chain product			
Code	Role	Responsibilities	Competences
PM	OpenETCS project Manager	Guarantee the required competence for the project is covered by the effective committers Identify which roles are needed for the project Verify that at least one person has been identified per project role ensure the independence of the roles according to CENELEC ensure compliance with the quality management system Responsible to guarantee progress according to scheduled plans devote sufficient resources to perform the task, including security tasks responsible for the delivery and implementation of the software ensure the compliance and the delivery of security requirements provide enough time for proper implementation and enforcement of security tasks approve full and partial products to be delivered by the development process ensure that records and traceability are maintained throughout the decision making and project ensure that it has appointed an appropriate validator for the project according to cenelec	Understand requirements of software development process Understand quality, competencies, organizational and management requirements according to relevant standards Understand the requirements of the verification, validation and safety process Able to evaluated the impact of different options for the performance concerning implementation, validation and safety

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Table 20 – continued from previous page

CAT3: CENELEC Roles/Competences for OpenETCS Tool Chain product			
Code	Role	Responsibilities	Competences
RQM	Requirement manager	Responsible for the Software requirement specification Establishes and maintain traceability to and from the system-level requirements ensure that tool chain and derived specifications requirements are under system configuration and changes management control. ensure consistency and completeness of the tool chain requirements specification develop and maintain documents related to tool chain requirements	experience in railways sector and safety attributes in the railway domain experience with requirements management process and tools knowledges of TSI and related CENELEC requirements

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Table 20 – continued from previous page

CAT3: CENELEC Roles/Competences for OpenETCS Tool Chain product			
Code	Role	Responsibilities	Competences
DES	Designer	Transform software requirements on acceptable solutions Derive the requirements for the system and software architecture Identify the key design issues that must be resolved to support successful development of the software Allocate the tool chain and derived requirements to the chosen architecture components and interfaces Maintain requirement traceability for the software architecture's requirements, and to and from software requirements Identify suitable derived requirements that address the effectiveness and cost of life-cycle phases following development, such as production and operation Develop and maintain design documentation Ensure that the design documents are under system configuration and changes management control. Design or select design methods and support tools Apply principles and suitable design standards Develop component specifications if it is applicable	Competent in software development in the railway domain Competent in safety design principles Familiarity with methods and tools for design analysis and design testing Ability to work with design constraints for safety relevant software in On-Board systems Understanding of the system constraints created through the TSI Understanding of the relevant parts of EN 50128 like design methods

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Table 20 – continued from previous page

CAT3: CENELEC Roles/Competences for OpenETCS Tool Chain product			
Code	Role	Responsibilities	Competences
IMP	Implementer	Transform design solutions in data, source code, models and / or other design representations Apply design principles Apply specific rules for data preparation/codification Perform analysis to verify intermediate results Develop and maintain implementing documents comprising the methods, types of data, models and listings applied Maintain traceability to and from the design Maintain the generated or modified data/codes/models under system configuration and changes management control.	Competent in safety relevant software implementation for embedded systems Competent in the implementation language and supporting tools Capable of applying the specified coding standards and programming styles Understanding of the system constraints created through the On-Board hardware respectively the demonstrator Understanding of the relevant parts of EN 50128 like design methods
TST	Tester	Ensure the test activities planning Develop tests specification (goals and cases) Ensure traceability of test objectives to specified software requirements Ensure traceability of test cases to the specified tests objectives Ensure that the planned tests are implemented and performed Identify deviations from the expected results and record in the test reports Communicate deviation to the authority in charge of the changes management for evaluation and decision making Record the results reports Select the equipment for testing the software	Competent in ETCS specification, used means of description (model/ source code), used train and track parameter and other application data source Competent in various test approaches/methods to identify to identify the most appropriate method or combination of methods for every aspect of an artifact Capable of deriving test cases from TSI (specifically Subset 26) and the specification model Understanding of the relevant parts of EN 50128 like test methods

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Table 20 – continued from previous page

CAT3: CENELEC Roles/Competences for OpenETCS Tool Chain product			
Code	Role	Responsibilities	Competences
INT	Integrator	Manage the integration process using software baselines Develop sw and sw /hw integration test specification for sw components based on the specifications and on the designer's components architecture Develop and maintain records of the integration activities Identify integration anomalies; record them and communicate them to the authority in charge of the changes management for evaluation and decision making Develop a report of components and the overall system integration covering the integration results	Competent in ETCS specification, used programming language, used API and demonstrator hardware Competent in various integration approaches/methods to identify the most appropriate method or combination of methods for the demonstrator implementation Understanding the design and functionality requirements for intermediated development levels Capable of deriving integrator tests from the set of integrated functions Understanding of the relevant parts of EN 50128 like integration tests
VER	Verifier	Develop a SW Verification Plan Check the documented test suitability (completeness, coherency, relevance, traceability) with the verification objectives Identify anomalies, evaluate in terms of the risk, record them and communicate them to the authority in charge of the changes management for evaluation and decision making Manage the verification process (revision, integration and testing) and ensure the independence of the activities as needed Develop a verification report with the results of the verification activities	Competent in ETCS specification, used means of description (model/ source code), used train and track parameter and other application data source Competent in various verification approaches/methods to identify the most appropriate method or combination of methods for every aspect of an artifact Capable of deriving verification procedures from TSI (specifically Subset 26) and the specification model Understanding of the relevant parts of EN 50128 like verification methods

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Table 20 – continued from previous page

CAT3: CENELEC Roles/Competences for OpenETCS Tool Chain product			
Code	Role	Responsibilities	Competences
VAL	Validator	Develop a Validation Plan specifying the main tasks and activities for the sw validation Agree on the Validation Plan with the assessor Review Sw requirements in relation to their intended use/environment Ensure sw fulfil all sw requirements Evaluate the assessment of the software process and of the software according to CENELEC requirements and the assigned SIL Review the verification and tests correctness, consistency and suitability Check the correctness, consistency and suitability of the test cases and executed tests Ensure that all validation plan activities are carried out Review and classify deviations, evaluate in terms of the risk, record them and communicate them to the authority in charge of the changes management for evaluation and decision making Provide recommendation about sw suitability Record Validation Plan deviations Conduct audits, inspections or reviews of the overall project at various stages of development as may be appropriate Review and analyse validation reports of the previous sw Check whether the developed solutions are traceable to the sw requirements Ensure that records associated hazardous situations and nonconformances are reviewed Ensure that all dangerous situations are appropriately resolved Develop a Validation Report Express their agreement or disagreement about the sw version	Competent in ETCS On-Board units Experience in safety attributes for train control systems Competent in various validation approaches/methods to identify the most appropriate method or combination of methods for the demonstrator implementation Capable of deriving types of validation evidence required for the TSI with respect to the train control functionality Capable to combine different sources and types of evidence and synthesize an overall view about fitness for purpose or constraints and limitations of the On-Board application Overall software understanding and perspective including the general railway environment Understanding the requirements of EN 50128

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Table 20 – continued from previous page

CAT3: CENELEC Roles/Competences for OpenETCS Tool Chain product			
Code	Role	Responsibilities	Competences
ASR	Assessor	Develop an evaluation Plan Evaluate the assessment of the software process and of the software according to CENELEC requirements and the assigned SIL Assess the project team and the organization competences for the sw development Evaluate the Verification & Validation activities and the supporting evidences Evaluate quality management systems adopted for the sw development Evaluate the changes management and the Configuration Management Systems and their use Identify and assess risk in terms of any deviation from the sw requirements in the evaluation report Ensure the evaluation Plan is implemented Performs independent checks of: The development process (audits) and the products safety functions (spot checks) during different development phases. Should perform audits, based on the Safety plan, of the Quality and Safety management systems of the Supplier, the Infrastructure owner and the Operator and be convinced that these systems works The Assessor can also perform spot checks on detailed technical issues to see that safety functions are correctly implemented. The safety functions key documentation (Hazard Log, Safety Requirements and Safety Case) should be examined too. Give an opinion on the validity of sw developed for its intended use Develop an evaluation report and maintain records about the evaluation process	Competences in the railway domain and technology specifically concerning On-Board systems Acceptance/License from a recognized safety authority Continually gained sufficient level of experience in the safety principles and the application of these principles within the railway domain Competence to evaluated that a suitable method or combination of methods in a given context have been applied Understanding the relevant safety, human resource, technical and quality management processes to fulfill the requirements of the EN 50128 Competence in assessment approaches/ methods Capable to combine different sources and types of evidence and synthesize an overall view about fitness for purpose or constraints and limitations of the On-Board application Overall software understanding and perspective including the general railway environment Ability to judge the adequacy of all development processes (like quality management, configuration management, validation and verification processes) Understanding the requirements of EN 50128

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Table 20 – continued from previous page

CAT3: CENELEC Roles/Competences for OpenETCS Tool Chain product			
Code	Role	Responsibilities	Competences
CM	Configuration Manager	Responsible for the configuration management plan [24] System configuration management owner Establish that all sw components are clearly identified and have independent versions within the system configuration management Prepare the published release notes mentioning incompatible versions of sw components	Competences in software configuration management Understanding the requirements of EN 50128

E Methods & Tools for Application Software

Code	Method/Technique	SIL 4	Applied (Yes/No)	Details and References
1	Formal Methods	HR	Yes	Formal Methods are applied where possible. However, we will start in the ITEA project only with a small portion to proof the concept.
2	Modelling	HR	Yes	The models in the requirements specification phase are to be provided in SysML (Papyrus). The link to traqcebility is given based on ProR extension of the openETCS toolset.
3	Structured Methodology	HR	No	Not relevant since we are using Formal Methods and Modelling.
4	Decision Table	HR	No	Not relevant since we are using Formal Methods and Modelling.
Justification: **(To be fulfilled)**				
OpenETCS uses a combination of natural language Software Requirement Specifications, which are derived from th				

Table 21. Software Requirements Specification Phase

Code	Method/Technique	SIL 4	Applied (Yes/No)	
1	Defensive Programming	HR	Yes	Inherent with the chosen Scade Suite solution.
2	Fault Detection & Diagnosis	HR	Yes	Inherent with the chosen Scade Suite solution.
3	Error Correcting Codes	-	No	
4	Error Detecting Codes	HR	No	Error Detecting codes are not relevant in the scope of the openETCS Application. They might be implemented in a product being based around openETCS.
5	Assertion Programming	HR	Yes	Handling of assertions will be part of the scade model.
6	Safety Bag Techniques	R	No	

Code	Method/Technique	SIL 4	Applied (Yes/No)	
7	Diverse Programming	HR	No	Diverse Programming is an option for a real openETCS product. Since it as to be supported by the architecture of the product the method can not be implemented in the generic approach of openETCS.
8	Recovery Block	R	No	Recovery Block is an option for a real openETCS product. Since it as to be supported by the implementation approach the method can not be implemented in the generic approach of openETCS.
9	Backward Recovery	NR	No	Not suited for openETCS.
10	Forward Recovery	NR	No	Not suited for openETCS.
11	Retry Fault Recovery Mechanisms	R	No	Retry Fault Recovery Mechanisms is an option for a real openETCS product. Since it as to be supported by the implementation approach the method can not be implemented in the generic approach of openETCS.
12	Memorising Executed Cases	HR	No	Graceful degradation is an option for a real openETCS product. Since it as to be supported by the architecture of the product the method can not be implemented in the generic approach of openETCS.
13	Artificial Intelligence - Fault Correction	NR	No	
14	Dynamic Reconfiguration of software	NR	No	
15	Software Error Effect Analysis	HR	No	SEEA is not superior compared to the chosen formal approach of openETCS.
16	Graceful Degradation	HR	No	
17	Information Hiding	-	No	
18	Information Encapsulation	HR	Yes	Information Encapsulation is covered by the modelling guideline.

Code	Method/Technique	SIL 4	Applied (Yes/No)	
19	Fully Defined Interface	M	Yes	This concept is part of both, the architecture model and the actual implementation in Scade. In Scade the method is inherent.
20	Formal Methods	HR	Yes	According to the openETCS project proposal formal methods are a the main part part of the concept for safety critical software. However, not the full scope will be possible to implement in the Framework of the Itea project. A proof of concept is required for this option.
21	Modelling	HR	Yes	The architecture model is to be implemented in SysML / Papyrus.
22	Structured Methodology	HR	No	Not relevant since we are using Formal Methods and Modelling.
23	Modelling supported by computer aided design and specification tools	HR	Yes	The openETCS toolchain include interfaced design and specification tools.
Justification: **(To be fulfilled)**				
Techniques use in openETCS cover all relevant architecture and design issues, but due to the generic concept of op				

Table 23. Software Design and Implementation Phase

Software Design and Implementation Phase				
Code	Method/Technique	SIL 4	Applied (Yes/No)	Details and Ref
1	Formal Methods	HR	Yes	In openETCS formal methods are a the main methodology to design safety critical software. However, not the full scope will be possible to implement in the Framework of the Itea project. A proof of concept is required for this option.
2	Modelling	HR	Yes	The design model is implemented in Scade.
3	Structured Methodology	HR	No	Not relevant since we are using Formal Methods and Modelling.

Table 23 – continued from previous page

Software Design and Implementation Phase				
Code	Method/Technique	SIL 4	Applied (Yes/No)	Details and Ref
4	Modular Approach	M	Yes	Well supported with Scade. Different Moduls are designed and implement as independent blocks based on the overall architecture.
5	Components	HR	Yes	Well supported with Scade. All internal interfaces are fully defined and the data access is limited due to data flows.
6	Design and Coding Standards	M	Yes	Part of D2.4 and the Modelling Description of Work.
7	Analysable Programs	HR	Yes	Static Analysis is supported by the Scade Suite Code generator and is part of the development guideline.
8	Strongly Typed Programming Language	HR	Yes	The chosen Scade Language is strongly typed.
9	Structured Programming	HR	Yes	The Scade Suite encourages for a reduction of complexity in modelling (1 page approach). The structure of the code is as such is made by the Scade code generator. The modeller has an indirect impact on the generation.
10	Programming Language	HR	Yes	Scade approach is a certified language for SIL 4 implementation.
11	Language Subset	HR	Yes	Not relevant here since the Scade approach is a certified language for SIL 4 implementation.
12	Object Oriented Programming	R	No	
13	Procedural Programming	HR	No	Not relevant here since the Scade approach is a certified language for SIL 4 implementation.
14	Metaprogramming	R	No	
Justification: **(To be fulfilled)**				
The openETCS techniques based on use of a structured, strongly typed programming language in SCADE fulfils des				

Code	Method/Technique	SIL 4	Applied (Yes/No)	
1	Formal Proof	HR	Yes	Various formal methods are used to check the SysML and SCADE modells and to prove required properties. Specifics are documented in he V&V plan and all corresponding reports.
2	Static Analysis	HR	Yes	Static checks covering consistency of interfaces and data types are implemented in Papyrus. Further static analysis as boundary checks and data flow analysis are covered during the SCADE design. Details are presented in the V&V plan
3	Dynamic Analysis and Testing	HR	Yes	openETCS uses a variety of dynamic analysis and testing approach mainly on SCADE modell and C-Code level e.g. Test cases from boundary Values and Performance Modelling. Details are presented in the V&V plan.
4	Metrics	R	Yes	Various metrics are evaluated on the C-Code level. Further metrics are already addressed during the SCADE modelling.
5	Traceability	M	Yes	Traceability between all abstraction levels is covered by tool supported traces and manual traceability reviews.
6	Software Error Effect Analysis	HR	Yes	The Error Analysis is performed during the modelling process on various levels using the modell-based approach for related component analysis.
7	Test Coverage for code	HR	Yes	As openETCS uses a modell based test generation the coverage follows a complete coverage principal for all relevant data flows. Details are given in the V&V plan.

Tabl

Code	Method/Technique	SIL 4	Applied (Yes/No)	
8	Functional/ Black-box Testing	M	Yes	Functional test are the main focus for all parts, which are not covered by formal proofs. Black-box test are performed for validation aspects. Details are given in the V&V plan.
9	Performance Testing	HR	Yes	Performance test mainly response timing are checked where generic timing constrains can be identified. Due to the generic concept of openETCS further tests are required to demonstrated a sufficient implementation.
10	Interface Testing	HR	Yes	Interface tests are performed on various levels to ensure consistence and correctness. Hardware tests are not part of openETCS.
Justification: **(To be fulfilled)**				
The openETCS methodology covers at least in parts all relevant verification techniques. Due to the generic concept				

Table 25. Integration Ph

Integration Phase				
Code	Method/Technique	SIL 4	Applied (Yes/No)	
1	Functional and Black-box Testing	HR	No	Due to the generic approach of openETCS implementation is only done in a demonstrator context, which does not satesfy any needs for systematic implementation tests.
2	Performance Testing	HR	No	Due to the generic approach of openETCS implementation is only done in a demonstrator context, which does not satesfy any needs for systematic implementation tests.
Justification: **(To be fulfilled)**				
Implementation is only part of the generic functional openETCS development up to the API level. A follow-up pro				

Table 26. Ove

Overall S				
Code	Method/Technique	SIL 4	Applied (Yes/No)	
1	Performance Testing	M	Yes	Performance test mainly response timing are checked where generic timing constrains can be identified. Due to the generic concept of openETCS further tests are required to demonstrated a sufficient implementation.
2	Functional and Black-box Testing	M	Yes	Functional test are the main focus for all parts, which are not covered by formal proofs. Black-box test are performed for validation aspects. Details are given in the V&V plan.
3	Modelling	R	Yes	As the openETCS software development is based on SysML and SCADE modells, overall software tests are also performed based on test modells. Therefore, various methods are used to address different validation aspects. Deatils are given in the V&V plan.
Justification: **(To be fulfilled)**				
The openETCS project uses different modell-based testing approaches for validation in combination with performa				

Table 27. Software Analysis Techniques

Software Analysis Techniques				
Code	Method/Technique	SIL 4	Applied (Yes/No)	Details and References
1	Static Software Analysis	HR	Yes	Static Software Analysis performed based on SysML and SCADE modells. Details are presented in the V&V plan.
2	Dynamic Software Analysis	HR	Yes	Dynamic Software Analysis performed by tests and simulation of SCADE modells. Details are presented in the V&V plan.

Continued on next page

Table 27 – continued from previous page

Software Analysis Techniques Phase				
Code	Method/Technique	SIL 4	Applied (Yes/No)	Details and References
3	Cause Consequence Diagrams	R	No	Indirectly covered by SysML and SCADE modell analysis
4	Event Tree Analysis	R	No	Indirectly covered by SysML and SCADE modell analysis
5	Software Error Effect Analysis	HR	Yes	The Error Analysis is performed during the modelling process on various levels using the modell-based approach for related component analysis.
Justification: **(To be fulfilled)**				
Software Analysis is performed based on SysMl and SCADe modells and additional model-based tests.				

Table 28. Software Quality Assurance Techniques

Software Quality Assurance Techniques				
Code	Method/Technique	SIL 4	Applied (Yes/No)	Details and References
1	Accredited to EN ISO 9001	HR	No	The openETCS project itself can not be accredited, but most partners are.
2	Compliant with EN ISO 9001	M	Yes	Overall project process follow those basic guidelines.
3	Compliant with ISO/IEC 90003	R	No	Standard cn not be applied directly to research projects as openETCS.
4	Company Quality System	M	Yes	openETCS has defined project specific quality principals and uses various review systems to enforce these rules.
5	Software Configuration Management	M	Yes	Has been specified in detail in the Configuration Management plan
6	Checklists	HR	Yes	Checklists are use in certain phases during the development, but due to the modelling do not present the main work documentation.

Continued on next

Table 28 – continued from previous page

Software Quality Assurance Phase				
Code	Method/Technique	SIL 4	Applied (Yes/No)	Details and References
7	Traceability	M	Yes	Traceability is ensured between all development phases by the use of different traces implemented in the openETCS toolchain and manual traceability reviews.
8	Data Recording and Analysis	M	Yes	All development activities are performed and respectively recorded via the github system.
Justification: **(To be fulfilled)**				
As openETCS is a research project specific quality processes and tools have been applied to ensure respective stand				

Table 29. Software Maintenance Phase

Software Maintenance Phase				
Code	Method/Technique	SIL 4	Applied (Yes/No)	Details and References
1	Impact Analysis	M	Yes	Performed during every mayor software iteration.
2	Data Recording and Analysis	M	Yes	Performed via github.
Justification: **(To be fulfilled)**				
Due to the agile work in openETCS via github maintenance is performed during every iteration and controlled via s				

Table 30. Data Preparation Techniques

Data Preparation Techniques				
Code	Method/Technique	SIL 4	Applied (Yes/No)	Details and Ref
1	Tabular Specification Methods	R	No	As ETCS is a dynamic system with complex data relations tables provide only limited options for data specifications.
2	Application specific language	R	No	Not relevant in the openETCS model-based development process based on SCADE modells.
3	Simulation	HR	Yes	Using SCADE modells and further validation modells.

Table 30 – continued from previous page

Data Preparation Techniques Phase				
Code	Method/Technique	SIL 4	Applied (Yes/No)	Details and Ref
4	Functional testing	M	Yes	Using SCADE modells and further validation modells.
5	Checklists	M	Yes	Depending on typ of input and configuration data.
6	Fagan inspection	R	No	Traditional review process are used in openETCS.
7	Formal design reviews	HR	Yes	Based on formal modells used.
8	Formal proof of correctness (of data)	HR	Yes	Based on formal modells used.
9	Walkthrough	HR	Yes	Applied in different variations of the review process.
Justification: **(To be fulfilled)**				
As openETCS is a genric research project data is only prepared for specific aspects. Details are defined in the corre				

Table 31. Quality mechanisms for Safe deployment

Quality mechanisms for Safe deployment	Technique & Approach
Software Self-identification Mechanisms (9.1.4.11)	**(To be fulfilled)**
Error detection and/or avoidance mechanisms during deployment process (store, transfer, transmission and/or duplication of code operations) (9.1.4.20)	**(To be fulfilled)**
Automatic detection and safe management of incompatible components/versions (9.1.4.8, 9.1.4.9)	**(To be fulfilled)**
Provision of appropriate and accurate diagnostic information	**(To be fulfilled)**
Safe Roll back capabilities	**(To be fulfilled)**

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