# Requirements Capture Process in the Vehicle Authorisation Procedure

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*Abstract* – **Vehicle authorisation procedure required by Directive (EU) 2016/797 on the interoperability of the rail system within the European Union is in line with the Fourth Railway Package and the adopted one-stop shop approach. The main legal texts on the procedure are included in the Regulation (EU) 2018/545 and its article 13 relates to requirements capture process of all applicable requirements.**

**In the paper we analyse several topics, identify issues and doubts, provide clarifications, and propose two models of the requirements capture process in the context of the vehicle authorisation procedure.**

*Keywords* – **Railway subsystems, Vehicle authorisation, Interoperability, Safety integration, Requirements capture.**

## I. Introduction

A key component of the European transport policy in recent decades has been the achievement and continuous improvement of the quality, cost-efficiency, interoperability and safety of the rail transport. The implementation of this policy was enhanced by the adoption of the Fourth Railway Package (FRP), allowing opening up rail services for competition and creation of the Single European Railway Area. One of the goals of the FRP is to introduce a unified approach to the authorisation of railway vehicles and the issuing of safety certificates by the European Union Agency for Railways (EUAR) [1], [2].

The main legal framework related to the authorisation process is Directive (EU) 2016/797 [3], known as Interoperability Directive (ID) and Regulation (EU) 2018/545, establishing practical rules on the authorisation of vehicles [4]. In particular, [4] defines *requirements capture (RC)* process that includes hazard identification, risks, and requirements management in order to ensure that the vehicle and/or vehicle type concerned meets the applicable legislation and the essential requirements limited in Annex III of [3].

Within the RC process several roles are legally defined with specific obligations: [3], [4]

- *Applicant* for vehicle and/or vehicle type authorisation (VA) or *Entity managing a change* (EMC) in case of modifications documents the RC process, incl. its implementation for a particular project, elaboration of relevant evidences of the application of the process for that project;
- *Assessment body*, as defined in [5] (AsBo) performs independent assessment of the RC process for aspects related to safety and safe integration between subsystems and works out safety assessment report with the results;
- *Applicant* for VA issues a declaration that all risks and requirements are correctly managed and incorporates the relevant evidence in the file with the application for VA;
- *Authorising entity* (normally the EUAR) assesses the RC process and the evidences in the framework of issuing VA;
- *National Safety Authority* (NSA) for the area of use assesses the evidence of the RC process related to the applicable national rules in the framework of issuing of VA.

## II. Vehicle Authorisation, Requirements Capture and Independent Assessments

### A. Vehicle Authorisation and Requirements Capture

Vehicle authorisation (VA) procedure is required and different applicable cases are defined in Annex III of Directive (EU) 2016/797. The purpose of the procedure is to guarantee that the essential requirements *safety, reliability and availability, health, environmental protection, technical compatibility, and accessibility* are met [3]. To achieve this objective, the *requirements management* is provided to establish that, as far as is reasonably practicable, all considerations have been considered in the design, manufacture, and testing of a vehicle. It is a systematic approach including *capture* (identification), as well as *management* (implementation, verification and validation) of all requirements applicable to the vehicle.

In the context of the necessary requirements a vehicle must fulfil during its life cycle, two terms are applicable: *requirements capture* and *requirements management.* Requirements management covers all the requirements a vehicle needs to fulfill, no matter where they come from (mandatory laws, contractual requirements, standards, codes of

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practice or company specifications), while requirements capture is mandatory by law and applied only for essential requirements, as defined in Annex III of [3] (see Fig. 1). In other words, the requirements covered by RC are a subset of those to be covered by requirements management. However, the independent assessment required by [4] should focus on only to process applied to the essential requirements.

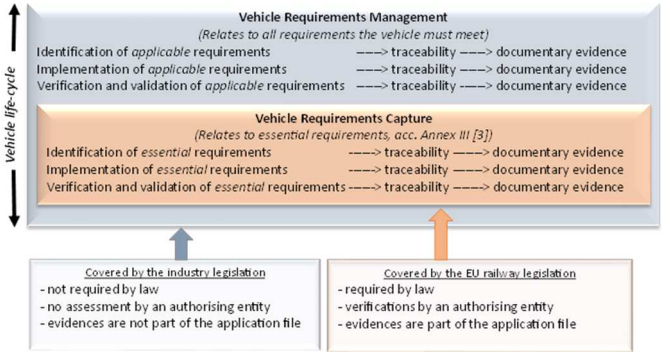


Fig. 1. Requirements management vs. Requirements capture

The RC process should be performed always, regardless of the authorisation case and starts as early as possible in the vehicle design and development process. Thus, proper management of requirements and risks could be ensured. The process ends at the time a vehicle or vehicle type is authorised.

### *B. Independent Assessments*

The vehicle authorisation procedure is quite complex and involves several entities with different roles. In order to obtain the necessary evidence at the different stages of the vehicle's life cycle, the procedure envisages independent bodies with different assessment functions.

The AsBo is responsible for the assessment of the requirements capture process for aspects related to safety and safe integration between subsystems and works out an assessment report with the results. The other essential requirements could also be covered by the assessment, if requested by the applicant, but this is not required by law and creates confusion as to exactly what should be assigned for assessment to the AsBo.

It is important the independent assessment of the RC to start at early stage of the project, as any delay can lead to late identification of unconformities and subsequently can be impossible or expensive to solve. Practice shows that this problem is very common and the results in most cases lead to a delay in the vehicle authorisation procedure.

Compared to the verification of the Technical Specifications for Interoperability (TSI) compliance assessed by the Notified Body (NoBo), an independent AsBo assessment of the RC process is more about inspecting the process to manage all requirements.

In some cases of the AsBo assessments, evidence provided by a NoBo is required, in order to demonstrate compliance with an essential requirement of the TSI. At the same time, some TSIs (e.g. LOC&PAS, CCS) require an AsBo risk assessment to be carried out, as evidence of the fulfillment of an essential requirement *safety*. In the case of a more complex project, this case study also introduces confusion into the time frame for evaluation by the various assessment bodies and leads to unacceptable delays.

### *C. Unsolved Requirements Capture Issues*

The result of the application evaluation performed by EUAR shows that there are still outstanding issues regarding several points of the requirements capture process:

- How to derive all applicable requirements (origin of applicable requirements);
- Relationship between the application of Commission Implementing Regulation (EU) No 402/2013 in case of requirements capture and significant change;
- How to produce evidence from the RC procedure for essential requirements other than safety;
- Specific roles of the different assessment bodies and cross-acceptance of the assessment results (reports) they produce;
- The obligation to appoint an AsBo for the assessment of the RC process;
- Content of the independent assessment report issued by the AsBo in case of different type of assessments (RC process as per [4] and significant change as per [5])
- Content of the declaration covering the RC process

## III. Modelling Requirements Capture

The models presented are based on all aspects involved in the complex process of capturing applicable requirements at the vehicle authorisation procedure.

The scope of the RC process is not limited to the identification of the applicable TSIs or different standards. The depth of RC should be such as to allow requirements to be allocated downwards to subsystems, constituents, functions, etc. and following correspondent implementation, verification, and validation.

In most cases, it is better to break down a high-level requirement (e.g. TSI or EN standard) into detailed requirements to manage them more easily and independently.

### *A. Nested V-model*

The requirements capture process is most often represented by means of the V-cycle model of the CENELEC EN 50126-1 standard [6], [7], [8].

Here, a modified *Nested V-cycle model* is presented and the system (vehicle) life-cycle process is given in Fig. 2. Requirements normally pass three levels of evolution during the vehicle life-cycle following a decomposition approach. At the beginning, the requirements are identified as those for the vehicle - *Concept* and *System definition and conditions of use*. In the next step, after categorisation, the requirements evolve

into one or more subsystems requirements (rolling stock, on-board control-command and signalling, etc.) – *Risk analysis and evaluation* and *Apportionment of system requirements*. At this stage, applying the Common Safety Method on Risk Assessment (CSM-RA) [5] is legally required to identify and specify the safety-related requirements that must be subject to an independent safety assessment by the AsBo (forming the *nested V-cycle*). Finally, subsystem requirements are decomposed into detailed constituent level requirements – *Design and Implementation* and *Manufacture*.

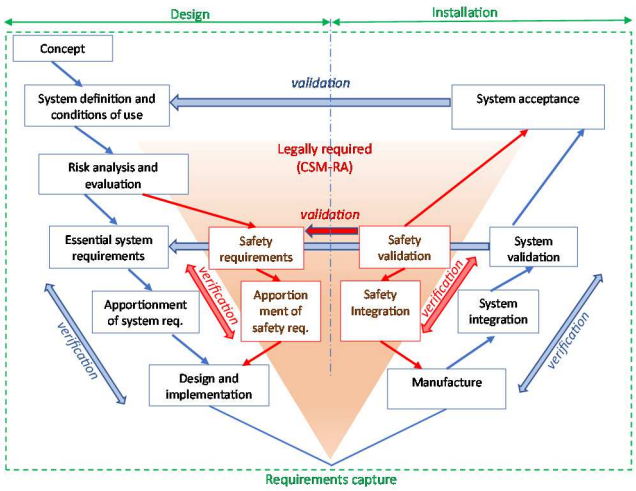


Fig. 2. Nested V-Cycle

The RC process is concerned with identifying, implementing, verifying, validating, and producing relevant evidences of *only* the essential requirements to the subsystems composing the vehicle. In most cases, these requirements are determined, fixed, and clearly defined by mandatory rules like Technical Specifications for Interoperability (TSI), national technical and/or safety rules and other Union legislation (legal requirements). Their verification is most often carried out by a conformity assessment body (NoBo/DeBo), which checks the compliance of the subsystems with these requirements at the stages of design, implementation, manufacture and testing, i.e. the verification is done at well-defined points in the lifecycle of the subsystem and by using well-defined results/evidences. The focus is on verification at each stage and validation. Thus, the model is suitable for fixed and clear requirements such as TSI, national technical and safety rules, that is where a rule-based approach is applied. In this case, the RC process is best represented using the V-cycle model on Fig. 2.

In identifying the essential requirement *safety*, CSM-RA requires the application of systematic approach through risk assessment (model *nested V-part*). Multiple iterations are possible going through each of the risk assessment stages and the results will lead to extraction of increasingly clear and unambiguous requirements until the RC process for *safety* is complete. Thus, the implementation of a proper approach is needed to ensure correct and comprehensive results. For this reason, the nested V-part is represented by a *three-dimensional model* of the RC process for requirements related to *safety* and *safe integration*.

*B. Three-dimensional Model*

The proposed model in Fig. 3 presents an approach to RC that makes a focus on the requirements transformation instead of validation. The key point in this approach is the *requirements evolution*. The term *requirements evolution* is used in case a fuzzy or existing requirement is updated and renewed. *Safety requirements evolution* is a consequence of the iterative process used in the risk assessment performed according to CSM-RA.

In the proposed *three-dimensional model* requirements evolve from:

- *fuzzy requirements* at the beginning of the RC process to *comprehensive requirements (complete system specification)* at the end;
- *ambiguous informal requirements* into *unambiguous formal requirements;*
- almost *contradictory requirements* to a *commonly accepted set of requirements.*

Within the risk assessment framework, the remaining metrics for the completion of the RC process also evolve. The expert consolidation around a common decision evolves from individual *expert view* to *common view* (agreement). Similarly, documentary evidence evolves from *informal* at the beginning to *formal* at the end.

The model is presented as a diagram in Fig. 3.

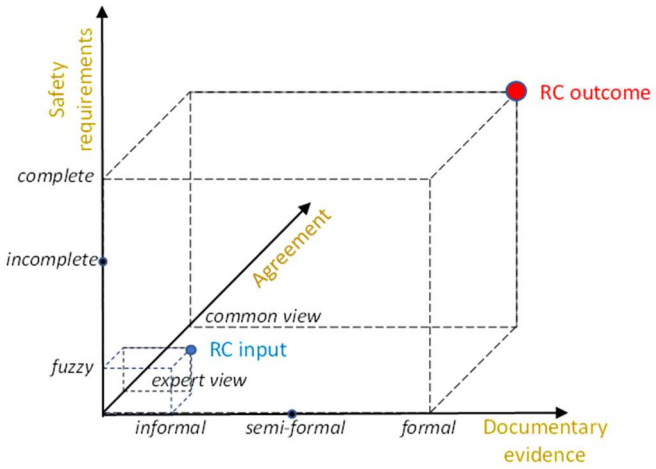


Fig. 3. Three-dimensional model

Uncertain data at the beginning and results at the end of the RC process can be formalised respectively as:

*RCinput = {informal documentary evidence, expert view, fuzzy safety requirements}*

*RCoutcome = {formal documentary evidence, common view, complete safety requirements}*

The proposed three-dimensional model represents the RC process applicable to the essential requirement *safety* and *safe integration* between subsystems within a vehicle for which a CSM-RA application is required.

## IV. Conclusion

The article analyses the vehicle authorisation procedure, as required in the Directive (EU) 2016/797 of the European Parliament and of the Council of 11 May 2016 on the interoperability of the rail system within the European Union (Interoperability Directive), in the context of the implementation of requirements capture process.

The legal framework on which the authorisation procedure is based, as well as participants and their roles are identified.

Specifics between the *requirements capture* and *requirements management* processes are discussed.

Involved different independent and conformity assessment bodies and their specific roles are described together with problems related to cross-acceptance of their results, etc.

Two models representing the specific approach to the requirements capture process are proposed. The first one, *Nested V-model*, applied to all essential requirements and the second one, *Three-dimensional model*, applied to the essential requirement "safety".

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