Engineering Domain Ontology

Deliverable D4.2-4.4

FFG – IKT der Zukunft
SHAPE Project
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Table 2 History

Version	**Changes**	**Authors**
0.1	Created Structure	S. Steyskal
1.1	Adaptions based on reviews	S. Steyskal

Contents

1 Introduction

This deliverable ties the generic methodologies from WP2+3 to the concrete domain of engineering processes. We enrich and combine domain-specific ontologies for organizations, processes and roles, by models for regulations and domain specific process constraints utilizing recent additions to the Semantic Web Technology Stack such as the Shapes Constraint Language (SHACL) [1].

The results of this WP are tightly bonded to those of WP2 [2, 3]. While [2, 3] focus on representing and reasoning over business processes using Answer Set Programming and RAL [5], we will deploy the description language and constraint modeling techniques from WP2 in concrete domain models.

1.1 Structure of the Document

In the following, we start with discussing various ontology development approaches in Section 2. More particularly, we give an introduction in *METHONTOLOGY* in Section 2.1 and give a brief overview over other related methodologies in Section 2.2. We continue in Section 3 with specifying an *Ontology Requirements Specification Document*, and develop a conceptual model structuring domain knowledge in Section 4. Within this section, we discuss relevant concepts for representing (i) organizational knowledge (cf. Section 4.1), (ii) business processes (cf. Section 4.2), and (iii) regulations and compliance rules (cf. Section 4.3). Finally, we conclude the present document by giving an outlook on future work in Section 5.

2 Ontology Development Approaches

Ontologies have become an important component in many areas including *information retrieval and extraction*, *knowledge management*, and *ontology-based data access* [17]. As a result there exists a variety of different ontology engineering approaches and ontology development methodologies, all having different advantages and disadvantages, which makes it difficult to choose the most suitable approach for the problem at hand.

In the present section, we will focus on discussing *METHONTOLOGY* [10], the ontology development approach we found to be the most suitable one wrt. our use cases, in more detail by investigating its underlying workflow and methodology.

[1] http://www.w3.org/2014/data-shapes/wiki/Main_Page

We subsequently give a brief overview over other related well-known ontology development methodologies.

2.1 METHONTOLOGY

We have decided to follow the METHONTOLOGY approach as rough guideline for the development of our *Engineering Domain Ontology*. Primarily due to METHONTOLOGY's large acceptance in the ontology development community as well as its elaborate development process.

The METHONTOLOGY approach consists of 10 individual steps that can (but not necessarily have to) be performed during the development process (cf. Figure 1).

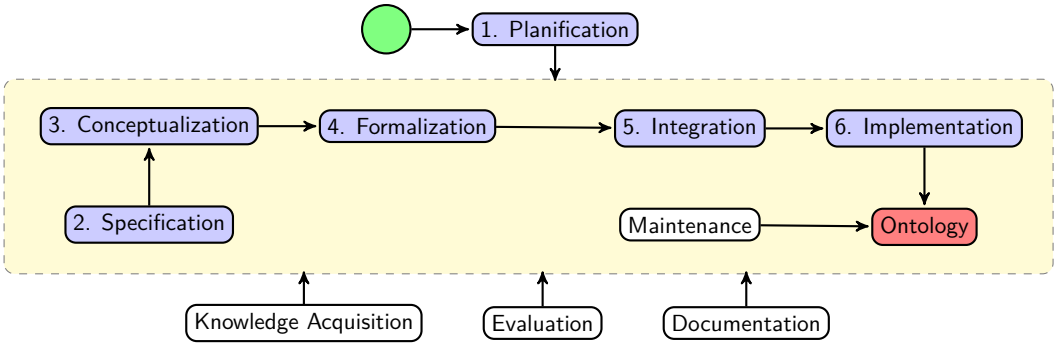

Figure 1 Process of creating an ontology using *METHONTOLOGY*.

Planification In this very first step, METHONTOLOGY proposes a plan which describes a potential scheduling of each of the subsequent steps. For our *Engineering Domain Ontology* we will only consider a subset of those steps.

Specification During *Specification*, requirements of the ontology that have to be fulfilled are defined.

Conceptualization In *Conceptualization*, domain knowledge will be structured in a conceptual model which describes expected concepts and roles of the final ontology.

Formalization Using previous defined conceptual model, a formal representation of that model using ontology languages like OWL is produced.

Integration Whenever applicable, existing ontologies which are able to cover parts of the application domain shall be reused and integrated into the ontology.

Implementation During *Implementation*, results of *Formalization* and *Integration* are combined and merged into an ontology.

Maintenance After the ontology has been released, modification and maintenance tasks are carried out whenever necessary to ensure the ontology's usefulness and usability.

The next three steps shall be performed during the entire development process and in parallel with previous defined phases.

Knowledge Acquisition As the name suggests, this step mainly covers the acquisition of knowledge about the domain of interest.

Evaluation On the basis of previous defined documents, the ontology is evaluated throughout the whole development process in order to ensure it is meeting its requirements.

Documentation After each phase, a document describing its results should be created.

2.2 Other Ontology Development Methodologies

Methodology by Uschold & King The authors of [21] were one of the first to propose a skeletal methodology for developing ontologies based on guidelines and hints reported in related literature such as *(i) principles for designing ontologies [13]*, and *(ii) evaluation of knowledge sharing technology [12]*. Although the methodology of *Uschold & King* can be considered to be outdated, its main steps served as foundation of many other development approaches proposed in the recent past (e.g. *Ontology 101* [16], *METHONTOLGY* [10]). Uschold & King's approach is a quite simple and straight-forward methodology for creating ontologies. It only consists of few steps to be considered while developing an ontology and therefore deemed to be suitable for small-scale ontologies and non-productive ones. Due to the fact that this methodology describes a general workflow to develop ontologies rather than providing precise tasks that must be conducted in order to develop an ontology, it is not feasible to use it for building ontologies which need to be well documented and/or are used in an highly productive environment.

Unified Process for Ontology Building (UPON) The authors of [6] mapped principles of software engineering, more precisely principles of the *Unified Process* [14], to ontology engineering resulting in their proposed approach called *Unified Process for Ontology Building (UPON)*. The biggest advantage of building an ontology using UPON is the exhaustiveness of the ontology which should be built once the development process is finished, based on the fact that it maps best practices from software development to ontology engineering (i.e.

Unified Process [14, 15]). Since UPON proposes only an informal guideline for the ontology development process, it is possible to slightly alter the different phases or workflows in order to fit the scope of the ontology more precisely. As the description above might already suggests, there is a huge effort in carrying out a development of an ontology with the UPON approach. The execution of various development cycles, each consisting of various phases, iterations and their underlying workflows leads to a development effort, which is only feasible when building large-scale knowledge bases.

Ontology 101 In their approach called *Ontology 101* [16], the authors describe an iterative strategy to develop ontologies. They emphasize three fundamental rules, which can easily be applied to any other ontology building methodology and should help to make decisions during the design of the ontology (paraphrased from [16]):

1. *There is no one correct way to model a domain. The best solution almost always depends on the application that you have in mind and the extensions that you anticipate.*
2. *Ontology development is necessarily an iterative process.*
3. *Concepts in the ontology should be close to objects and properties in your domain of interest. These are most likely to be nouns or verbs in sentences that describe your domain.*

Ontology 101 is probably one of the most prominent representatives of ontology development approaches and due to its simplicity rather easily understandable. Based on that simplicity, it is perfectly suitable for developing small-scale ontologies which does not need to be thoroughly documented in a fast way.

Like the previous introduced methodology by Uschold & King, it lacks a standardized procedure the tasks must be performed in order to develop an ontology. Which might lead to inconsistent results when integrating ontologies, created following that approach. Furthermore, it does not enforce the creation of documentation artifacts in any way.

3 Specification

The first actual step proposed by *METHONTOLOGY* called *Specification* imposes all requirements for the ontology which shall be developed by creating an *Ontology Requirements Specification Document* [19].

3.1 Ontology Requirements Specification Document

Name: *Engineering Domain Ontology*
Purpose: The *Engineering Domain Ontology* represents a formalization of domain-specific data such that it can be readily used for querying and monitoring.
Scope: The present ontology covers three main domains that are relevant for safetycritical engineering applications, namely:
- *Business Process Information*
- *Organizational Knowledge & Resource Information*
- *Access Control & Regulatory Information*

Implementation Language: The ontology is realized using OWL, RDFS, and the Shapes Constraint Language (SHACL). The latter is used for specifying constraints which are not expressible in OWL/RDFS.
Intended Users: Systems and system engineers of the project domain.
Intended Use: The ontology enables the possibility to model:
1. organizations and stakeholders in the engineering domain,
2. engineering tasks & processes and engineering project lifecycles,
3. SIL and other regulatory and legal frameworks for safetycritical applications that guide such processes.

Ontology Requirements: A comprehensive list of requirements can be found in the requirements section of Deliverable 4.1.

4 Conceptualization

After specifying the requirements of the to be developed ontology, its concepts, properties, and individuals are conceptualized in the present section.

4.1 Representing Engineering Domain & Organizational Knowledge

For representing engineering domain & organizational knowledge, we use parts of the organizational meta model described in [18] and enriched it with concepts for modeling teams [4] (cf. Figure 2).

Concepts

Person Persons represent human resources of a company and are responsible for supervising and/or executing activities of business processes.

Capability A person can have several capabilities, such as professional experience or specific (academic) degrees.

Position Each person occupies one or more positions within an organization.

Role & UnitType & OrgUnit One or more positions participate in several roles and belong to an organizational unit. Roles only make sense within a specific unit type (e.g. project coordinator, head of a research group, etc.).

Team A team is a set of people collaborating in the completion of a specific activity with a common objective.

TeamMember Is a person that is part of a team due to playing a role in it.

TeamType A team can have a type that is associated with a specific configuration of the organisational roles.

TeamRole It has to be emphasized that team roles are fundamentally different from organisational roles.

TeamRoleType Each team role has a specific type according to types explicitly defined in the company, such as investigator, coordinator, implementer or specialist.

TempTeam In certain occasions new teams are composed for specific purposes. Such teams are called temporary teams, because they have a expiry date defined as a specific scope.

PermTeam A permanent team is defined without a expiry date. Permanent teams can be referenced by their identifier at any moment.

Scope A scope defines the expiry date of a temporal team.

Agent Allows to assign both persons and teams to a business process activity/-task (= pn:Transition).

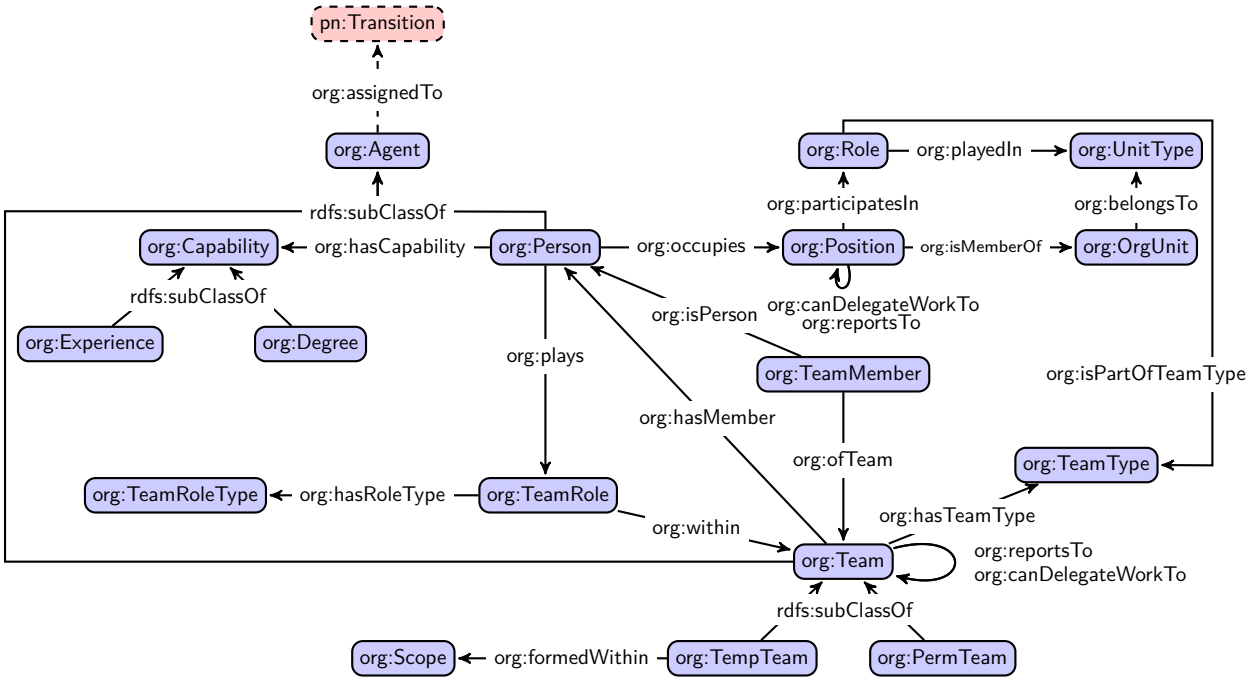

Figure 2 Ontology for engineering domain & organizational knowledge.

4.2 Representing Business Processes

We map business processes to Petri nets following mapping rules proposed by [7, 8]. For modeling Petri nets themselves we use selected concepts of the Petri Net Markup Language (PNML) [23] (cf. Figure 3).

All subsequently illustrated mappings are also used for serializing business processes in Deliverable 2.2.

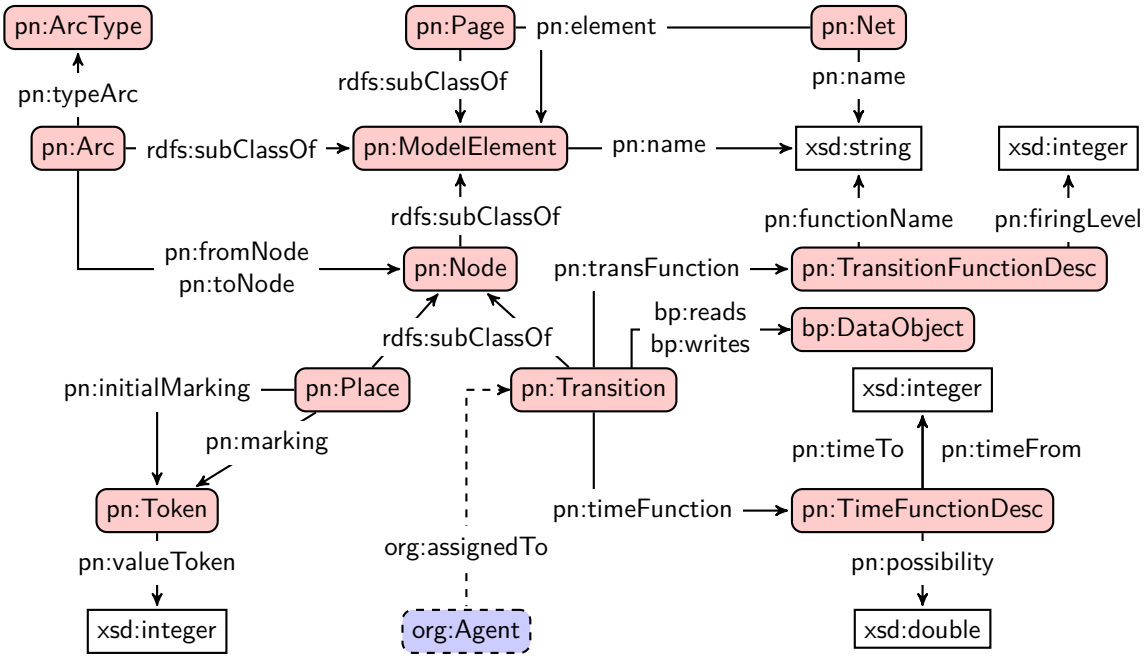

Figure 3 Ontology for representing petri nets utilizing parts of PNML [23].

Start Event

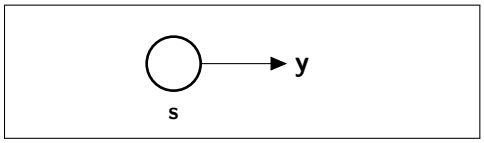

Figure 4 BPMN representation of **s**

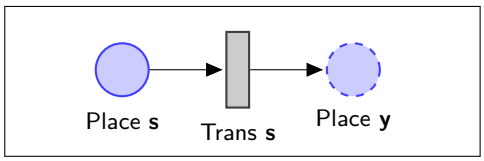

Figure 5 PN representation of **s**

Description: A start event is mapped onto a silent transition which models the execution of the event and is connected to one input place and one output place. See Listing 2 for an ontological representation of Figure 5.

End Event

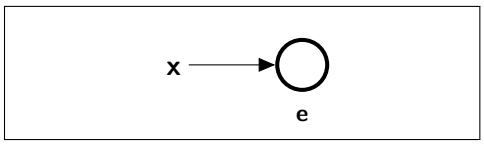

Figure 6 BPMN representation of **e**

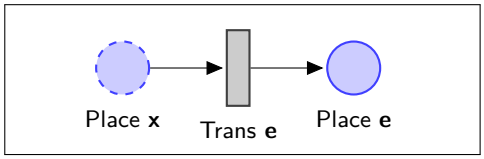

Figure 7 PN representation of **e**

Description: An end event is mapped onto a silent transition which models the execution of the event and is connected to one input place and one output place. See Listing 3 for an ontological representation of Figure 7.

Intermediate Event

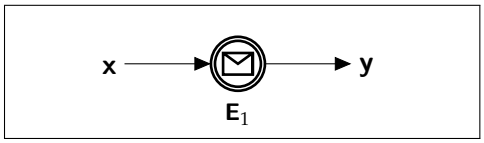

Figure 8 BPMN representation of E_1

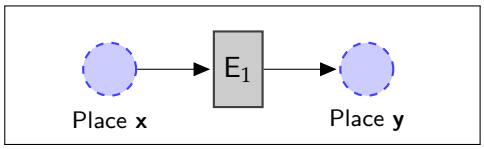

Figure 9 PN representation of E_1

Description: An intermediate event is mapped onto a transition which is labeled with the name of the event and that models its execution. It is connected to one input place and one output place. See Listing 4 for an ontological representation of Figure 9.

Task

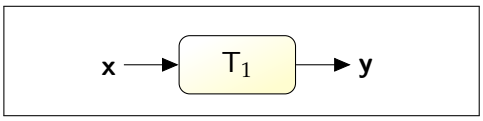

Figure 10 BPMN representation of $\mathbf{T}_1$

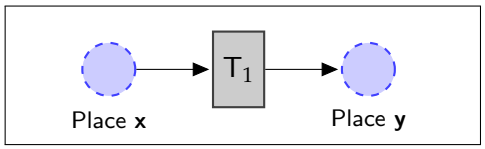

Figure 11 PN representation of $\mathbf{T}_1$

Description: A task is mapped onto a transition which is labeled with the name of the task and that models its execution. It is connected to one input place and one output place. See Listing 5 for an ontological representation of Figure 11.

AND-Split

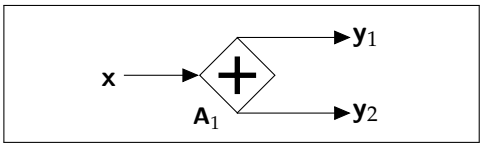

Figure 12 BPMN representation of $\mathbf{A}_1$

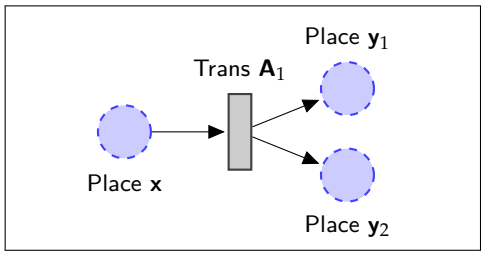

Figure 13 PN representation of $\mathbf{A}_1$

Description: All gateways, except event-based decision gateways and OR-split gateways, are mapped onto Petri net modules with silent transitions capturing their routing behavior. See Listing 6 for an ontological representation of Figure 13.

AND-Join

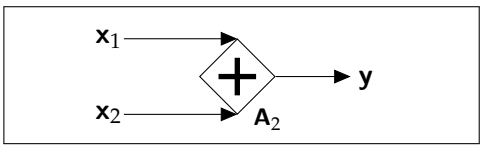

Figure 14 BPMN representation of $\mathbf{A}_2$

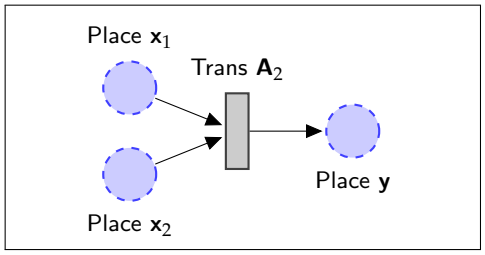

Figure 15 PN representation of $\mathbf{A}_2$

Description: All gateways, except event-based decision gateways and OR-split gateways, are mapped onto Petri net modules with silent transitions capturing their routing behavior. See Listing 7 for an ontological representation of Figure 15.

XOR-Split

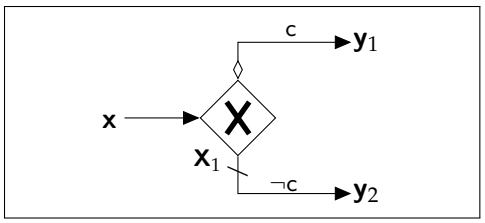

Figure 16 BPMN representation of X_1

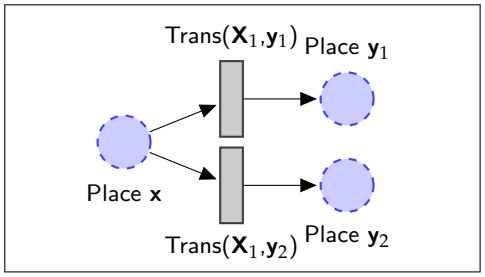

Figure 17 PN representation of X_1

Description: For XOR-Split gateways, we model conditions in the outgoing flows as silent transitions that have a common place as input. Thus, these silent transitions will compete for a single token, and the choice as to which one will fire will be non-deterministic. See Listing 8 for an ontological representation of Figure 17.

XOR-Join

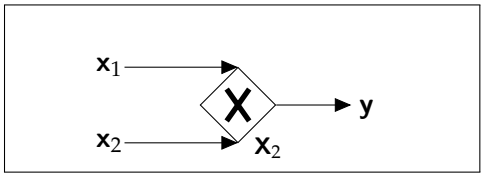

Figure 18 BPMN representation of X_2

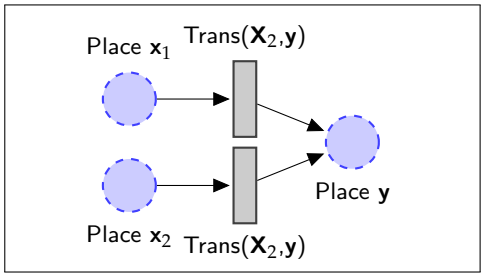

Figure 19 PN representation of X_2

Description: For XOR-Join gateways, we model each incoming flow as silent transition that have a common place as output. See Listing 9 for an ontological representation of Figure 19.

Event-Split

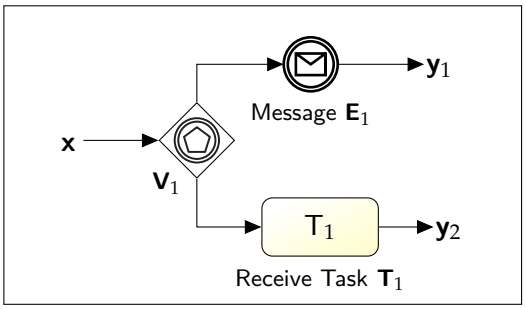

Figure 20 BPMN representation of $\mathbf{V}_1$

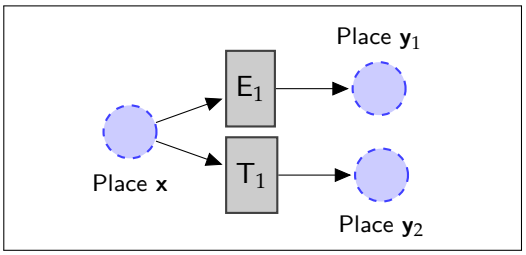

Figure 21 PN representation of $\mathbf{V}_1$

Description: For XOR-Join gateways, we model each incoming flow as silent transition that have a common place as output. See Listing 10 for an ontological representation of Figure 21.

OR-Split

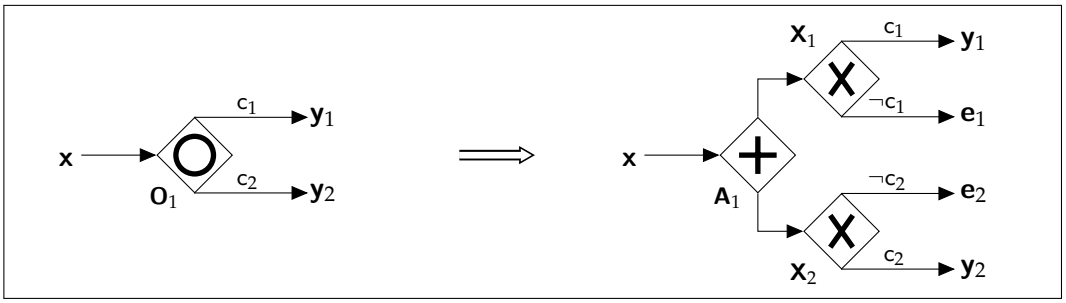

Figure 22 BPMN representation of $\mathbf{O}_1$

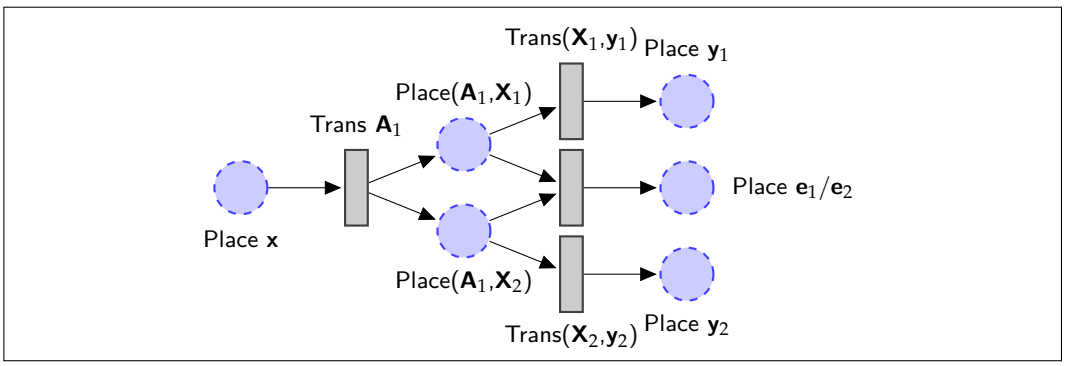

Figure 23 PN representation of $\mathbf{O}_1$

Description: We transform every OR-Split gateway into an equal representation consisting only of a combination of AND-Split and XOR-Split gateways following guidelines proposed by [22]. We subsequently translate the resulting *OR gateway free* process into its respective Petri net representation.

Activity Looping and Multiple Instances

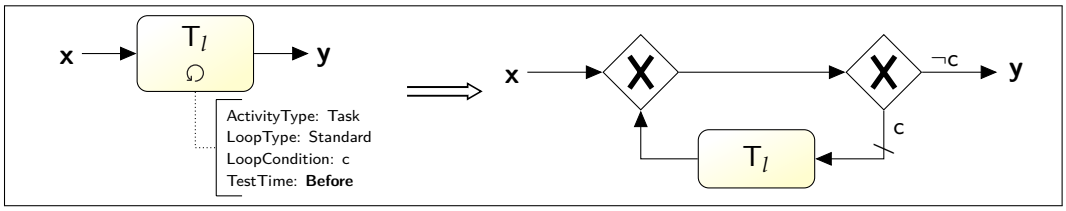

Figure 24 "while-do" loop

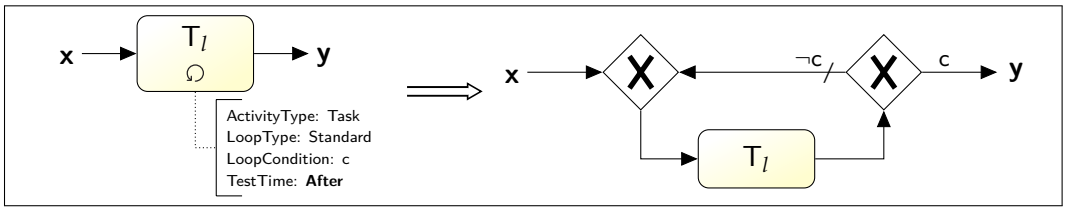

Figure 25 "do-until" loop

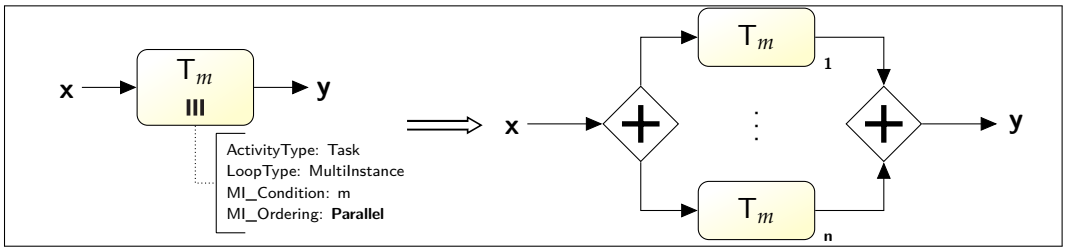

Figure 26 Parallel multi-instance activity where **n** is known at design time

Description: Repeated activities are either represented as "while-do" or "do-until" loops using XOR gateways. A multi-instance activity can be replaced by n identical copies of the activity enclosed between an AND-Split and an AND-Join. Once replaced, they are translated into their corresponding Petri net representation.

Subprocess

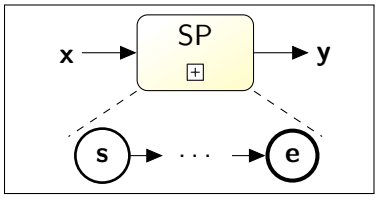

Figure 27 BPMN representation of a subprocess

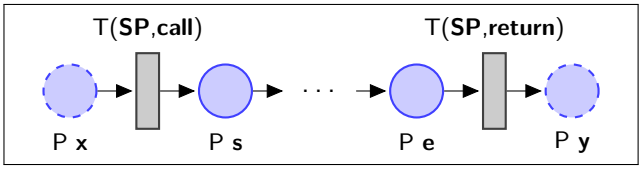

Figure 28 PN representation of a subprocess, using silent call/return transitions

Description: Each subprocess is expanded and subsequently translated into a corresponding Petri net.

Exception Handling

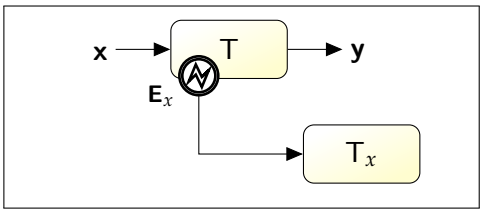

Figure 29 BPMN representation of a task with exception flow

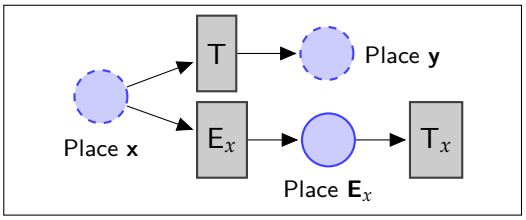

Figure 30 PN representation of a task with exception flow

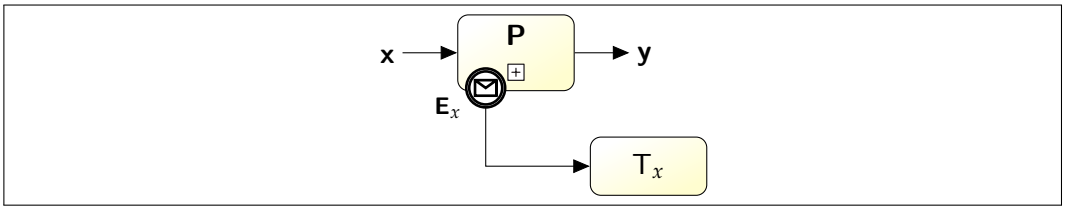

Figure 31 BPMN representation of subprocess **P** with exception flow

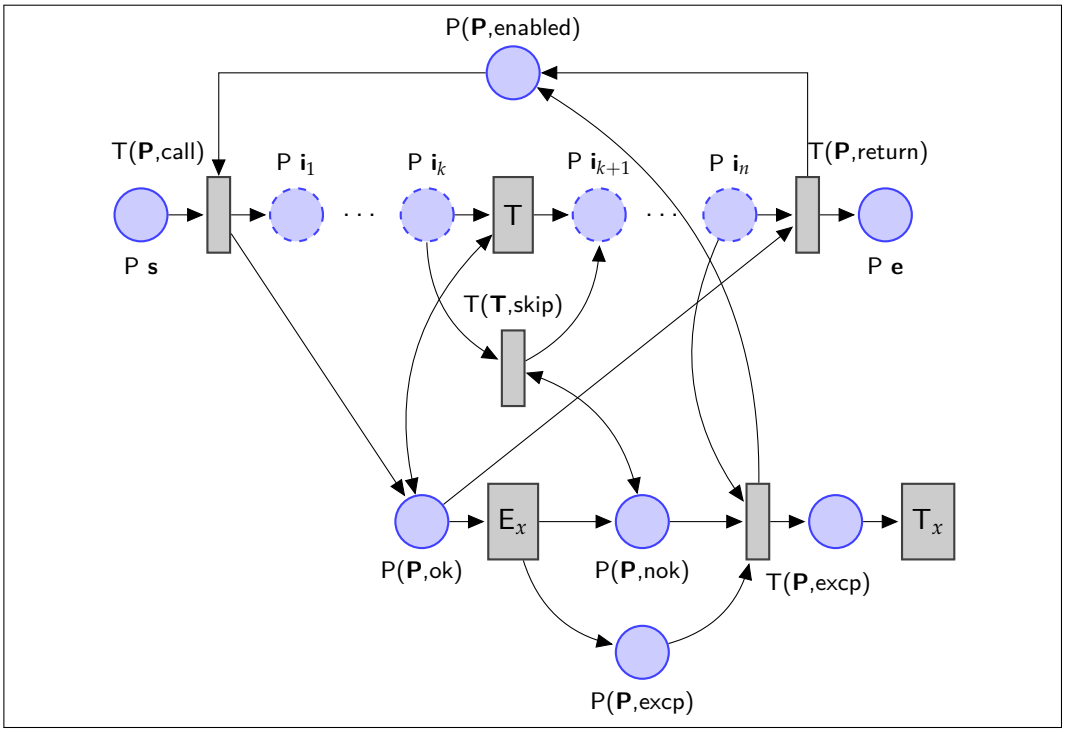

Figure 32 PN representation of subprocess **P** with exception flow

Description: Exception handling is captured by exception flows. An exception flow originates from an error event attached to the boundary of an activity. The occurrence of an exception will cancel the execution of the respective task/subprocess it is attached to under the assumption that this task/subprocess has started but is not yet completed. When the transition corresponding to the error event fires, all tokens left in the Petri net fragment corresponding to the task/subprocess need to be removed.

Message Flow

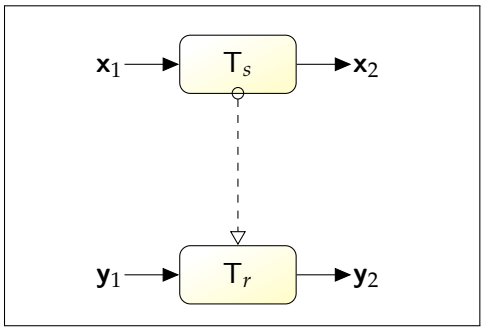

Figure 33 Message flow between tasks

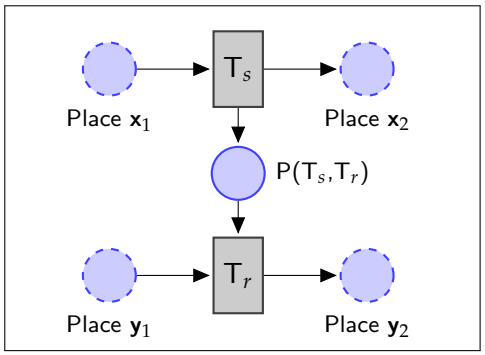

Figure 34 PN representation of T_1

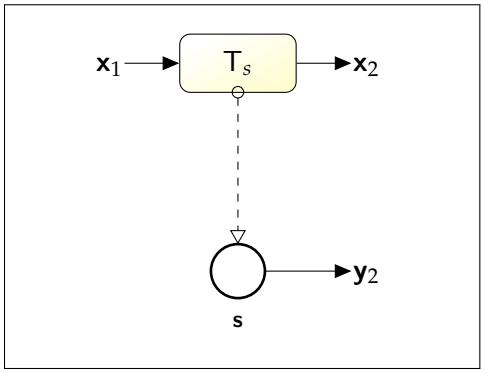

Figure 35 Message flow between task and start event

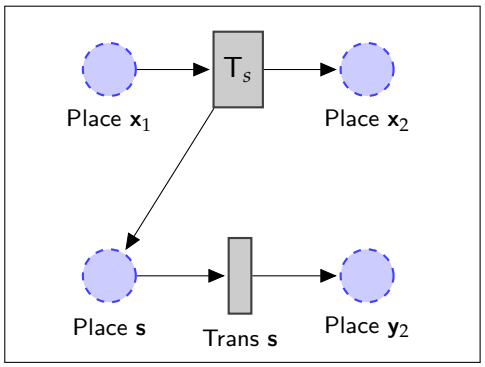

Figure 36 PN representation of T_1

Description: A message flow describes the interaction between processes and can be mapped to a place with an incoming arc from the transition modeling a send action and an outgoing arc to the transition modeling a receive action.

Data Objects

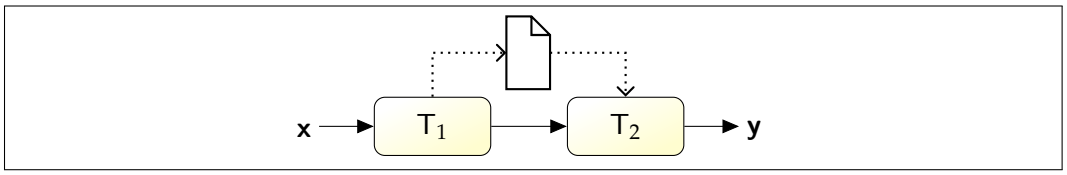

Figure 37 BPMN representation of a data flow between two tasks

Description: Each transition that represents a task can either read or write a particular data object. See Listing 11 for an ontological representation of Figure 37.

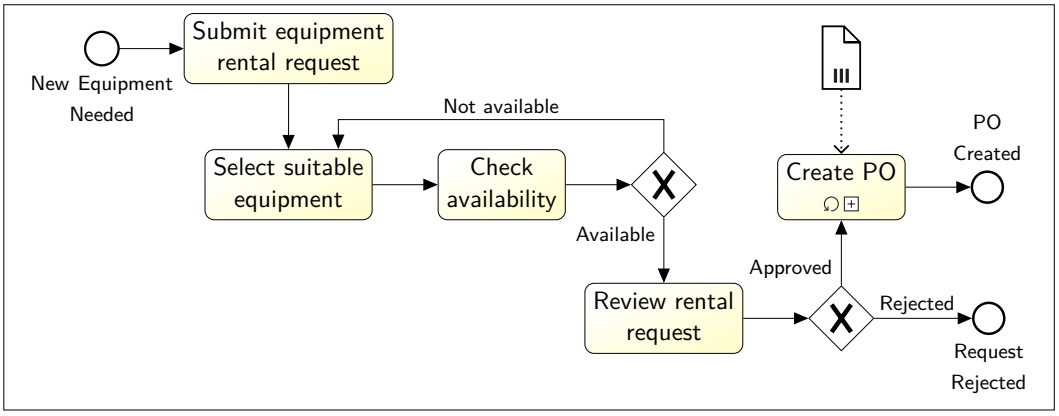

Figure 38 Sample Process using tikz

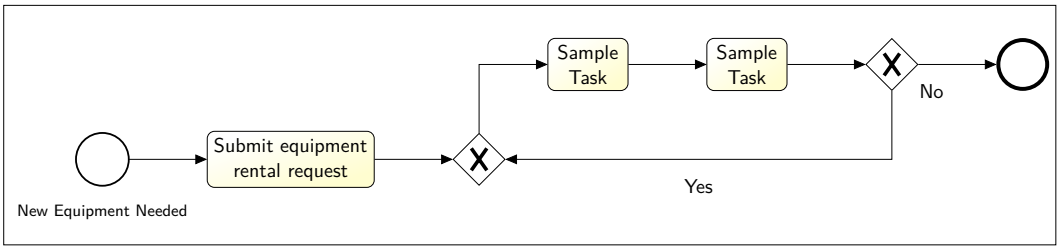

Figure 39 Sample Process in using tikz

4.3 Representing Regulations and Policies

In today's businesses, organizations have to deal with an increasing number of constraints that stem from various compliance sources, such as Sarbanes-Oxley (SOX), Basel II, EU Directive 2008/30/EC, and others. Such normative laws and requirements induce organizations to establish internal control systems, assess the organization's processes, and insure that business processes used within the company are compliant with stated laws and regulations. Violations might lead to penalties, scandals and loss of business reputation [20]. Since compliance requirements as well as processes evolve over time, it is necessary to establish automated approaches guaranteeing the compliant behavior of process models.

In order to implement such automated approaches several issues must be addressed, such as:

- expressing compliance requirements in a machine-processable manner
- process models that have to be validated must be identified
- need of an appropriate formalism for automatically checking compliance rules against process models

- users should get useful feedback in case of violation [1]

In general, there are at least two people involved in every process. On the one hand a business expert who is responsible for the definition and the management of the business processes in an organization while taking compliance constraints in account, and on the other hand a compliance expert who is responsible for refining, internalizing, specifying, and managing compliance requirements stemming from internal and external sources. Both, business expert and compliance expert are in a close cooperation [9].

4.3.1 Norms and Regulations in the Railway Domain

In the railway domain, processes have to be compliant to European Norms 50126, 50128, and 50129. As a first step, we focused on the investigation of norm **EN50126**. EN50126 constitutes the basis of norms EN50128/EN50129 and defines the specification and demonstration of reliability, availability, maintainability and safety (RAMS, cf. Figure 40) [2].

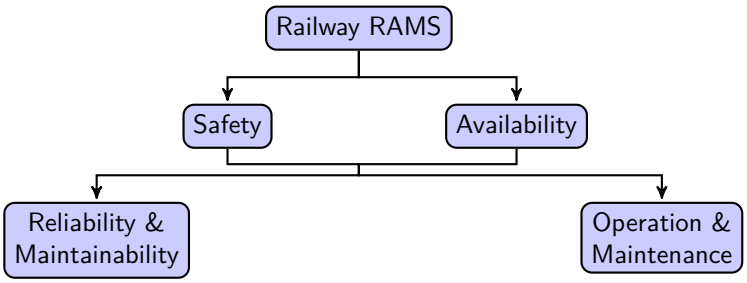

Figure 40 Reliability, Availability, Maintainability, and Safety (RAMS).

EN50126 defines a process which is based on a specified system lifecycle and respective tasks for managing RAMS. It allows to control conflicts between RAMS' elements and their management. Furthermore, the norm mentions normative references, the railway RAMS, a management for railway RAMS, the RAMS lifecycle, and five informative annexes.

Each phase in the RAMS lifecycle illustrates objectives, requirements, deliverables, verification, and validation activities which have to be undertaken.

It consists of 14 phases, namely:

Concept phase: This phase should create a level of understanding of the system which is sufficient to perform all subsequent RAMS lifecycle tasks;

[2] For a more detailed discussion on compliance rules related to EN50126 see [11]

System definition and application conditions phase: In this phase a mission profile as well as the boundaries of the system should be defined, application conditions which influence the system characteristics shall be established, the definition of the scope of system hazard analysis as well as the establishment of the RAMS policy and the safety plan;

Risk analysis phase: The tasks of this phase are the identification of hazards associated with the system and the identification of events leading to hazards. Furthermore, the determination of risks which can be associated with hazards and a process for on-going risk management shall be established;

System requirements phase: In this phase of the process lifecycle the overall RAMS requirements for the system and the overall demonstration and acceptance criteria for RAMS shall be specified and the RAM program for controlling RAM tasks during specific lifecycle phases should be established;

Apportionment of system requirements phase: The objectives of this phase are to split the RAMS requirements into designated sub-systems, components and external facilities, and define their acceptance criteria;

Design and implementation phase: In this phase it is important to create sub-systems and components which conform to RAMS requirements and show that those components and sub-systems conform to the RAMS requirements.

Manufacturing phase: The first point of this phase is to implement a manufacturing process which produces RAMS-validated sub-systems and components, after that RAMS-centered process assurance arrangements, sub-system and components RAMS support arrangements shall be established;

Installation phase: This phase describes the installation of sub-systems and components important for the system and initiate system support arrangements;

System validation phase: The objectives of this phase conclude the validation of sub-systems, components and external risk measures comply with RAMS requirements, after that, put them into operation, prepare and accept the application specific safety case and provide it for data acquisition and assessment;

System acceptance phase: This phase has to main points; the first one is to assess compliance of sub-systems, components and external risk reduction measures with the RAMS requirements and after that allow the system for entry into service;

Operation and maintenance phase: The main points in this phase of the lifecycle shall be to operate within specified limits, maintain and support all sub-systems, components as well as external risk reduction measures to make sure that compliance with system RAMS requirements is maintained;

Performance monitoring phase: The objective in this phase of the lifecycle is to maintain confidence in the RAMS performance of the system;

Modification and retrofit phase: The purpose of this phase is to control system modification and retrofit tasks to maintain system RAMS requirements;

Decommissioning and disposal phase: In this phase of the system lifecycle the system decommissioning and disposal tasks shall be controlled.

4.3.2 Identifying Compliance Rules of EN50126

After having extracted the 276 rules of 14 phases of the RAMS process lifecycle, their components have to be determined. We defined nine different components:

Type of rule: Rules are classified as being either of type: required input, activity, possible activity, conditions to repeat, inclusion, or statement of importance;

Quality attributes: Those are the elements which contribute to the fulfilment of RAMS;

Subjects: The performers of certain activities;

Objects: Objects include inputs and outputs, as well as information, data, systems etc.;

Strictness: This column indicates the strictness of a compliance rule (i.e. can, may, shall, should or must be performed);

Events/Conditions: Events/Conditions might occur in the business process lifecycle, e.g. errors or shortfalls;

Consequence: The consequence column is the implication of the before mentioned events or conditions;

Activity: This column describes all activities that occur in the respective lifecycle phase and is a supplement to the "type of rule"-component;

Inclusion: Like the "activity"-component, the "inclusion"-component is only a supplement to the "type of rule"-component and provides information about the content of objects and/or activities;

Each extracted rule is identified by an ID, a page reference, an indication of the respective phase of the RAMS process lifecycle the rule belongs to, as well as the original text of the rule. Furthermore, the components of each rule have been determined, namely its respective type, quality attributes, subjects and objects, strictness, events and conditions, consequences, and the rules activities and inclusions. All extracted rules can be found in Appendix B.

4.3.3 Representing and Validating Compliance Rules in RDF

While we heavily relied on already existing vocabularies for modeling process and organizational knowledge, we are exploring new approaches for representing and automatically validating access control policies, compliance rules, and regulations. More particularly, we are investigating how recent advancements in the area of constraint checking for RDF, i.e. Shapes Constraint Language (SHACL), can be utilized for realizing such an approach.

As an example, Listing 1 illustrates how a before-scope presence compliance rule, which checks whether a certain activity will be executed before another, could be realized using SHACL.

```
ex:xPlace a pn:Place . ex:a1Transition a pn:Transition . ex:y1Place a pn:Place .

ex:y2Place a pn:Place ;
  sh:nodeShape [
    a sh:Shape ;
    sh:constraint [
      a ex:BeforeScopeConstraint ;
      ex:precedingActivity ex:xPlace ;
    ] ;
  ] .

ex:arc1 a pn:Arc ;
  pn:typeArc pn:normal ;
  pn:multiplicity "1"^^xsd:int ;
  pn:fromNode ex:xPlace ;
  pn:toNode ex:a1Transition .

ex:arc2 a pn:Arc ;
  pn:typeArc pn:normal ;
  pn:multiplicity "1"^^xsd:int ;
  pn:fromNode ex:a1Transition ;
  pn:toNode ex:y1Place, ex:y2Place .

ex:BeforeScopeConstraint
  a sh:ConstraintTemplate ;
  rdfs:subClassOf sh:TemplateConstraint ;
  rdfs:label "BeforeScope constraint" ;
  rdfs:comment "BeforeScope presence rule requires that the execution
                of an activity B is preceded by the execution of an activity A." ;
  sh:labelTemplate "Execution of B must be preceded by execution of A" ;
```

```
  sh:argument [
    sh:predicate ex:precedingActivity ;
    sh:valueClass pn:Place ;
    rdfs:label "precedingActivity" ;
    rdfs:comment "The preceding activity to check." ;
  ] ;
  sh:message "Execution of activity {?subject} is not preceded
              by execution of activity {?object}." ;
  sh:sparql """
    SELECT ?subject ?object
    WHERE {
      {
        ?arc pn:toNode $this .
        ?arc pn:fromNode ?tmpNode .
        FILTER NOT EXISTS {?tmpNode (^pn:toNode/pn:fromNode)* $precedingActivity.}
      }
      UNION
      {
        FILTER NOT EXISTS {?arc pn:toNode $this .}
      }
      BIND($this AS ?subject) .
      BIND($precedingActivity AS ?object) .
    }
    """ ;
.
```

Listing 1 Modeling the before-scope presence compliance rule using SHACL

As a next step, we will define generic mapping rules for translating e.g. compliance rules identified Appendix B into respective SHACL constraints.

5 Further Work

Next steps within this WP primarily revolve around the completion of remaining steps to be carried out according to Section 2.1. Furthermore, we will investigate new approaches for representing and automatically validating access control policies, compliance rules, and regulations as briefly discussed in Section 4.3.3. Latter results will also be considered for publication in venues such as:

Journals

- Journal on Data Semantics (JDS)
- Information and Software Technology (INFSOF)

- Journal of Web Semantics (JWS)
- Semantic Web Journal (SWJ)
- Journal on Information Systems (JIS)

Conferences

- International Semantic Web Conference (ISWC)
- Extended Semantic Web Conference (ESWC)
- International Conference on Business Process Management (BPM)
- International Conference on Legal Knowledge and Information Systems (JURIX)
- International Conference on Knowledge Engineering and Knowledge Management (EKAW)
- International Conference on Artificial Intelligence and Law (ICAIL)
- International Conference on Semantic Systems (SEMANTiCS)
- Conference on Advanced Information Systems Engineering (CAiSE)
- International Conference on Service Oriented Computing (ICSOC)
- Conference on Ontologies, DataBases, and Applications of Semantics for Large Scale Information Systems (ODBASE)

The present document will be updated as soon as respective advancements were made.

A Listings

Start Event

```
ex:net1 a pn:Net ;
        pn:name "Start Event PN"^^xsd:string ;
        pn:element ex:page1 .

ex:page1 a pn:Page ;
        pn:element ex:sPlace, ex:arc1, ex:sTransition,
                   ex:arc2, ex:yPlace .

ex:sPlace a pn:Place ;
        pn:name "Place s"^^xsd:string ;
        pn:initialMarking [
                a pn:Token;
                pn:valueToken "1"^^xsd:int ;
        ] .

ex:sTransition a pn:Transition .
```

```
ex:yPlace a pn:Place .

ex:arc1 a pn:Arc ;
        pn:typeArc pn:normal ;
        pn:multiplicity "1"^^xsd:int ;
        pn:fromNode ex:sPlace ;
        pn:toNode ex:sTransition .

ex:arc2 a pn:Arc ;
        pn:typeArc pn:normal ;
        pn:multiplicity "1"^^xsd:int ;
        pn:fromNode ex:sTransition ;
        pn:toNode ex:yPlace .
```

Listing 2 PNMLO representation of **s**

End Event

```
ex:net1 a pn:Net ;
        pn:name "End Event PN"^^xsd:string ;
        pn:element ex:page1 .

ex:page1 a pn:Page ;
        pn:element ex:xPlace, ex:arc1, ex:eTransition,
                   ex:arc2, ex:ePlace .

ex:xPlace a pn:Place .

ex:eTransition a pn:Transition .

ex:ePlace a pn:Place ;
        pn:name "Place e"^^xsd:string .

ex:arc1 a pn:Arc ;
        pn:typeArc pn:normal ;
        pn:multiplicity "1"^^xsd:int ;
        pn:fromNode ex:xPlace ;
        pn:toNode ex:eTransition .

ex:arc2 a pn:Arc ;
        pn:typeArc pn:normal ;
        pn:multiplicity "1"^^xsd:int ;
```

```
        pn:fromNode ex:eTransition ;
        pn:toNode ex:ePlace .
```

Listing 3 PNMLO representation of **e**

Intermediate Event

```
ex:net1 a pn:Net ;
        pn:name "Intermediate Event PN"^^xsd:string ;
        pn:element ex:page1 .

ex:page1 a pn:Page ;
        pn:element ex:xPlace, ex:arc1,
                ex:e1Transition, ex:arc2, ex:yPlace .

ex:xPlace a pn:Place .

ex:e1Transition a pn:Transition ;
        pn:name "Transition E1"^^xsd:string .

ex:yPlace a pn:Place .

ex:arc1 a pn:Arc ;
        pn:typeArc pn:normal ;
        pn:multiplicity "1"^^xsd:int ;
        pn:fromNode ex:xPlace ;
        pn:toNode ex:e1Transition .

ex:arc2 a pn:Arc ;
        pn:typeArc pn:normal ;
        pn:multiplicity "1"^^xsd:int ;
        pn:fromNode ex:e1Transition ;
        pn:toNode ex:yPlace .
```

Listing 4 PNMLO representation of $\mathbf{E}_1$

Task

```
ex:net1 a pn:Net ;
        pn:name "Task PN"^^xsd:string ;
        pn:element ex:page1 .

ex:page1 a pn:Page ;
```

```
        pn:element ex:xPlace, ex:arc1,
                        ex:t1Transition, ex:arc2, ex:yPlace .

ex:xPlace a pn:Place .

ex:t1Transition a pn:Transition ;
        pn:name "Transition T1"^^xsd:string .

ex:yPlace a pn:Place .

ex:arc1 a pn:Arc ;
        pn:typeArc pn:normal ;
        pn:multiplicity "1"^^xsd:int ;
        pn:fromNode ex:xPlace ;
        pn:toNode ex:t1Transition .

ex:arc2 a pn:Arc ;
        pn:typeArc pn:normal ;
        pn:multiplicity "1"^^xsd:int ;
        pn:fromNode ex:t1Transition ;
        pn:toNode ex:yPlace .
```

Listing 5 PNMLO representation of $\mathbf{T}_1$

AND-Split

```
ex:net1 a pn:Net ;
        pn:name "AND−Split PN"^^xsd:string ;
        pn:element ex:page1 .

ex:page1 a pn:Page ;
        pn:element ex:xPlace, ex:arc1, ex:a1Transition,
                        ex:arc2, ex:y1Place, ex:y2Place .

ex:xPlace a pn:Place .

ex:a1Transition a pn:Transition .

ex:y1Place a pn:Place .
ex:y2Place a pn:Place .

ex:arc1 a pn:Arc ;
        pn:typeArc pn:normal ;
```

```
        pn:multiplicity "1"^^xsd:int ;
        pn:fromNode ex:xPlace ;
        pn:toNode ex:a1Transition .

ex:arc2 a pn:Arc ;
        pn:typeArc pn:normal ;
        pn:multiplicity "1"^^xsd:int ;
        pn:fromNode ex:a1Transition ;
        pn:toNode ex:y1Place, ex:y2Place .
```

Listing 6 PNMLO representation of $\mathbf{A}_1$

AND-Join

```
ex:net1 a pn:Net ;
        pn:name "AND−Join PN"^^xsd:string ;
        pn:element ex:page1 .

ex:page1 a pn:Page ;
        pn:element ex:yPlace, ex:arc1, ex:a2Transition,
                   ex:arc2, ex:x1Place, ex:x2Place .

ex:x1Place a pn:Place .
ex:x2Place a pn:Place .

ex:a2Transition a pn:Transition .

ex:yPlace a pn:Place .

ex:arc1 a pn:Arc ;
        pn:typeArc pn:normal ;
        pn:multiplicity "1"^^xsd:int ;
        pn:fromNode ex:x1Place, ex:x2Place ;
        pn:toNode ex:a2Transition .

ex:arc2 a pn:Arc ;
        pn:typeArc pn:normal ;
        pn:multiplicity "1"^^xsd:int ;
        pn:fromNode ex:a2Transition ;
        pn:toNode ex:yPlace .
```

Listing 7 PNMLO representation of $\mathbf{A}_2$

XOR-Split

```
ex:net1 a pn:Net ;
        pn:name "XOR−Split PN"^^xsd:string ;
        pn:element ex:page1 .

ex:page1 a pn:Page ;
        pn:element ex:xPlace, ex:arc1, ex:x1y1Transition,
                   ex:arc2, ex:x1y2Transition, ex:arc3,
                ex:y1Place, ex:y2Place .

ex:xPlace a pn:Place .

ex:x1y1Transition a pn:Transition .
ex:x1y2Transition a pn:Transition .

ex:y1Place a pn:Place .
ex:y2Place a pn:Place .

ex:arc1 a pn:Arc ;
        pn:typeArc pn:normal ;
        pn:multiplicity "1"^^xsd:int ;
        pn:fromNode ex:xPlace ;
        pn:toNode ex:x1y1Transition, ex:x1y2Transition .

ex:arc2 a pn:Arc ;
        pn:typeArc pn:normal ;
        pn:multiplicity "1"^^xsd:int ;
        pn:fromNode ex:x1y1Transition ;
        pn:toNode ex:y1Place .

ex:arc3 a pn:Arc ;
        pn:typeArc pn:normal ;
        pn:multiplicity "1"^^xsd:int ;
        pn:fromNode ex:x1y2Transition ;
        pn:toNode ex:y2Place .
```

Listing 8 PNMLO representation of $\mathbf{X}_1$

XOR-Join

```
ex:net1 a pn:Net ;
        pn:name "XOR-Join PN"^^xsd:string ;
        pn:element ex:page1 .

ex:page1 a pn:Page ;
        pn:element ex:yPlace, ex:arc1, ex:x1yTransition,
                   ex:arc2, ex:x1yTransition, ex:arc3,
                   ex:x1Place, ex:arc4, ex:x2Place .

ex:x1Place a pn:Place .
ex:x2Place a pn:Place .

ex:x1yTransition a pn:Transition .
ex:x2yTransition a pn:Transition .

ex:yPlace a pn:Place .

ex:arc1 a pn:Arc ;
        pn:typeArc pn:normal ;
        pn:multiplicity "1"^^xsd:int ;
        pn:fromNode ex:x1Place ;
        pn:toNode ex:x1yTransition .

ex:arc2 a pn:Arc ;
        pn:typeArc pn:normal ;
        pn:multiplicity "1"^^xsd:int ;
        pn:fromNode ex:x2Place ;
        pn:toNode ex:x2yTransition .

ex:arc3 a pn:Arc ;
        pn:typeArc pn:normal ;
        pn:multiplicity "1"^^xsd:int ;
        pn:fromNode ex:x1yTransition ;
        pn:toNode ex:yPlace .

ex:arc4 a pn:Arc ;
        pn:typeArc pn:normal ;
        pn:multiplicity "1"^^xsd:int ;
        pn:fromNode ex:x2yTransition ;
        pn:toNode ex:yPlace .
```

Listing 9 PNMLO representation of $\mathbf{X}_2$

Event-Split

```
ex:net1 a pn:Net ;
        pn:name "Intermediate Event PN"^^xsd:string ;
        pn:element ex:page1 .

ex:page1 a pn:Page ;
        pn:element ex:xPlace, ex:arc1, ex:e1Transition,
                   ex:arc2, ex:t1Transition, ex:arc3,
                ex:y1Place, ex:y2Place .

ex:xPlace a pn:Place .

ex:e1Transition a pn:Transition ;
        pn:name "Transition E1"^^xsd:string .

ex:t1Transition a pn:Transition ;
        pn:name "Transition T1"^^xsd:string .

ex:y1Place a pn:Place .
ex:y2Place a pn:Place .

ex:arc1 a pn:Arc ;
        pn:typeArc pn:normal ;
        pn:multiplicity "1"^^xsd:int ;
        pn:fromNode ex:xPlace ;
        pn:toNode ex:e1Transition , ex:t1Transition .

ex:arc2 a pn:Arc ;
        pn:typeArc pn:normal ;
        pn:multiplicity "1"^^xsd:int ;
        pn:fromNode ex:e1Transition ;
        pn:toNode ex:y1Place .

ex:arc3 a pn:Arc ;
        pn:typeArc pn:normal ;
        pn:multiplicity "1"^^xsd:int ;
        pn:fromNode ex:t1Transition ;
        pn:toNode ex:y2Place .
```

Listing 10 PNMLO representation of $\mathbf{V}_1$

Data Objects

```
ex:net1 a pn:Net ;
        pn:name "DataObject PN"^^xsd:string ;
        pn:element ex:page1 .

ex:page1 a pn:Page ;
        pn:element ex:xPlace, ex:arc1, ex:arc4,
                        ex:t1Transition, ex:arc2, ex:xyPlace,
                            ex:t2Transition, ex:arc3, ex:yPlace .

bp:DataObject1 a bp:DataObject .

ex:xPlace a pn:Place .

ex:t1Transition a pn:Transition ;
        pn:name "Transition T1"^^xsd:string ;
        bp:writes bp:DataObject1 .

ex:xyPlace a pn:Place .

ex:t2Transition a pn:Transition ;
        pn:name "Transition T2"^^xsd:string ;
        bp:reads bp:DataObject1 .

ex:yPlace a pn:Place .

ex:arc1 a pn:Arc ;
        pn:typeArc pn:normal ;
        pn:multiplicity "1"^^xsd:int ;
        pn:fromNode ex:xPlace ;
        pn:toNode ex:t1Transition .

ex:arc2 a pn:Arc ;
        pn:typeArc pn:normal ;
        pn:multiplicity "1"^^xsd:int ;
        pn:fromNode ex:t1Transition ;
        pn:toNode ex:xyPlace .

ex:arc3 a pn:Arc ;
        pn:typeArc pn:normal ;
        pn:multiplicity "1"^^xsd:int ;
        pn:fromNode ex:xyPlace ;
```

```
        pn:toNode ex:t2Transition .

ex:arc4 a pn:Arc ;
        pn:typeArc pn:normal ;
        pn:multiplicity "1"^^xsd:int ;
        pn:fromNode ex:t2Transition ;
        pn:toNode ex:yPlace .
```

Listing 11 PNMLO representation of a data flow between two tasks

B Extracted Compliance Rules of EN50216

This section includes extracted rules and requirements of the European Norm 50126 [11]. Each rule is identified by an ID, a page reference, an indication of the respective phase of the RAMS process lifecycle the rule belongs to, as well as the original text of the rule. Furthermore, the components of each rule have been determined, namely its respective type, quality attributes, subjects and objects, strictness, events and conditions, consequences, and the rules activities and inclusions.

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1	34	Concept	The input to this phase shall include all relevant information, and where appropriate, data, necessary to meet the requirements of the phase, for example the scope and purpose statements for the project.	required input	completeness	-	information, data, requirements	shall	-	-	check completeness of input	-	the required input can be described by using the **data perspective** of the eCRG language
2	34	Concept	Requirement 1 of this phase shall be to acquire, in the context of RAMS performance, an understanding of: a) the scope, context and purpose of the system.	activity	RAMS performance	-	scope of system, context of system, purpose of system	shall	-	-	understand scope, understand context, understand purpose of system	-	before skipping to phase 2 of the process lifecycle, certain requirements of phase 1 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
3	34	Concept	Requirement 1 of this phase shall be to acquire, in the context of RAMS performance, an understanding of: b) the environment of the system, including: — physical issues; — potential system interface issues; — social issues; — political issues; — legislative issues; — economical issues.	activity	RAMS performance	-	environment of the system	shall	-	-	understand environment	environment includes physical issues; potential system interface issues; social issues; political issues; legislative issues; economical issues	before skipping to phase 2 of the process lifecycle, certain requirements of phase 1 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
4	34	Concept	Requirement 1 of this phase shall be to acquire, in the context of RAMS performance, an understanding of: c) the general RAMS implications of the system.	activity	RAMS performance	-	system	shall	-	-	understand RAMS implications	-	before skipping to phase 2 of the process lifecycle, certain requirements of phase 1 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
5	35	Concept	Requirement 2 of this phase shall be to review: a) the RAMS implications of any financial analysis of the system.	activity	RAMS implications	-	financial analysis	shall	-	-	review RAMS implications of financial analysis	-	before skipping to phase 2 of the process lifecycle, certain requirements of phase 1 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
6	35	Concept	Requirement 2 of this phase shall be to review: b) the RAMS implications of any system feasibility studies.	activity	RAMS implications	-	system feasibility studies	shall	-	-	review RAMS implications of feasibility study	-	before skipping to phase 2 of the process lifecycle, certain requirements of phase 1 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language

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7	35	Concept	Requirement 3 of this phase shall be to identify sources of hazards which could affect the RAMS performance of the system, including: — interaction with other systems; — interaction with humans.	activity	RAMS performance	-	sources of hazards	shall	-	-	identify sources of hazard	interaction with other systems, interactions with humans	before skipping to phase 2 of the process lifecycle, certain requirements of phase 1 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
8	35	Concept	Requirement 4 of this phase shall be to obtain information about: a) previous RAMS requirements and past RAMS performance of similar and-or related systems.	activity	RAMS performance	-	similar or related systems	shall	-	-	review RAMS requirements and performance of similar or related systems	-	before skipping to phase 2 of the process lifecycle, certain requirements of phase 1 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
9	35	Concept	Requirement 4 of this phase shall be to obtain information about: b) identified sources of hazards to RAMS performance.	activity	RAMS performance	-	sources of hazards	shall	-	-	identify sources of hazard	-	before skipping to phase 2 of the process lifecycle, certain requirements of phase 1 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
10	35	Concept	Requirement 4 of this phase shall be to obtain information about: c) current Railway Authority Safety Policy and Targets.	activity	-	-	railway authority safety policy & targets	shall	-	-	identify authority safety policy and targets	-	before skipping to phase 2 of the process lifecycle, certain requirements of phase 1 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
11	35	Concept	Requirement 4 of this phase shall be to obtain information about: d) safety legislation.	activity	-	-	safety legislation	shall	-	-	identify safety legislation	-	before skipping to phase 2 of the process lifecycle, certain requirements of phase 1 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
12	35	Concept	Requirement 5 of this phase shall be to define the scope of the management requirements for subsequent system lifecycle RAMS tasks.	activity	-	-	scope of management requirements	shall	-	-	define scope of management requirements	-	before skipping to phase 2 of the process lifecycle, certain requirements of phase 1 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
13	35	Concept	The results from this phase shall be documented, along with any assumptions and justifications made during the phase.	activity	-	-	deliverables	shall	-	-	document results	including any assumptions and justifications made during the phase	before skipping to phase 2 of the process lifecycle, certain requirements of phase 1 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language

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14	35	Concept	The deliverables shall include a management structure adequate to implement the RAMS requirements of lifecycle phases 2, 3 & 4.	activity	adequate	-	deliverables (documents)	shall	-	-	define management structure	-	before skipping to phase 2 of the process lifecycle, certain requirements of phase 1 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
15	35	Concept	The deliverables from this phase are a key input to subsequent lifecycle phases.	statement of importance	-	-	deliverables (documents), key input	-	-	-	-	-	-
16	35	Concept	The following verification tasks shall be undertaken within this phase: a) assessment of the adequacy of the information, and where appropriate, data and other statistics, used as input to RAMS tasks within this phase.	activity	adequacy of the information, (data, statistics)	-	-	shall	-	-	assess adequacy of information , (data, statistics)	-	before skipping to phase 2 of the process lifecycle, certain requirements of phase 1 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
17	35	Concept	The following verification tasks shall be undertaken within this phase: b) assessment of the adequacy of the system environment statement defined under Requirement 1.	activity	adequacy of the system environment statement	-	-	shall	-	-	assess adequacy of system environment statement	-	before skipping to phase 2 of the process lifecycle, certain requirements of phase 1 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
18	35	Concept	The following verification tasks shall be undertaken within this phase: c) assessment of the completeness of the hazard source listing defined under Requirement 3.	activity	completeness of the hazard source listing	-	-	shall	-	-	assess completeness of hazard source list	-	before skipping to phase 2 of the process lifecycle, certain requirements of phase 1 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
19	35	Concept	The following verification tasks shall be undertaken within this phase: d) assessment of the adequacy of the methods, tools and techniques used within the phase.	activity	adequacy of the methods, tools and techniques	-	-	shall	-	-	assess adequacy of methods, tools, techniques	-	before skipping to phase 2 of the process lifecycle, certain requirements of phase 1 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
20	35	Concept	The following verification tasks shall be undertaken within this phase: e) assessment of the competence of all personnel undertaking tasks within the phase.	activity	competence of all personnel (undertaking tasks within the phase)	-	-	shall	-	-	assessment competence of personnel	-	before skipping to phase 2 of the process lifecycle, certain requirements of phase 1 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language

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21	36	System definition and application conditions	The input to this phase shall include all relevant information, and where appropriate, data, necessary to meet the requirements of the phase, including the deliverables of phase 1.	required input	completeness	-	information, data, requirements, deliverables phase 1	shall	-	-	check completeness of input	-	the required input can be described by using the **data perspective** of the eCRG language
22	36	System definition and application conditions	Requirement 1 of this phase shall be to define: a) the system mission profile, including: — performance requirements; — RAMS targets; — long term operating strategy and conditions; — long term maintenance strategy and conditions; — system life considerations, including lifecycle costing issues; — logistic considerations.	activity	-	-	system mission profile	shall	-	-	define system mission profile	mission profile includes — performance requirements; — RAMS targets; — long term operating strategy and conditions; — long term maintenance strategy and conditions; — system life considerations, including lifecycle costing issues; — logistic considerations	before skipping to phase 3 of the process lifecycle, certain requirements of phase 2 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
23	36	System definition and application conditions	Requirement 1 of this phase shall be to define: b) the system boundary, including: — interfaces with physical environment; — interfaces with other technological systems; — interfaces with humans; — interfaces with other Railway Authorities.	activity	-	-	system boundary	shall	-	-	define system boundaries	system boundaries include — interfaces with physical environment; — interfaces with other technological systems; — interfaces with humans; — interfaces with other Railway Authorities	before skipping to phase 3 of the process lifecycle, certain requirements of phase 2 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
24	36	System definition and application conditions	Requirement 1 of this phase shall be to define: c) the scope of application conditions influencing the system, including: — constraints imposed by existing infrastructure; — system operating conditions; — system maintenance conditions; — logistic support considerations; — review of past experience data for similar systems.	activity	-	-	scope of application conditions	shall	-	-	define scope of application conditions	conditions include — constraints imposed by existing infrastructure; — system operating conditions; — system maintenance conditions; — logistic support considerations; — review of past experience data for similar systems.	before skipping to phase 3 of the process lifecycle, certain requirements of phase 2 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language

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25	36	System definition and application conditions	Requirement 1 of this phase shall be to define: d) the scope of the system hazard analysis, including the identification of: — hazards inherent within the process to be controlled; — environmental hazards; security hazards; — the influence of external events; — the boundaries of the system to be analysed; — the influence on RAMS of existing infrastructure constraints.	activity	-	-	scope of system hazard analysis	shall	-	-	define scope of system hazard analysis	analysis includes identification of: — hazards inherent within the process to be controlled; — environmental hazards; security hazards; — the influence of external events; — the boundaries of the system to be analysed; — the influence on RAMS of existing infrastructure constraints.	before skipping to phase 3 of the process lifecycle, certain requirements of phase 2 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
26	36	System definition and application conditions	Requirement 2 of this phase shall be to perform: a) preliminary RAM analysis to support targets.	activity	support targets (Sinnfälligkeit der Ziele überprüfen)	-	preliminary RAM analysis	shall	-	-	perform preliminary RAMS analysis	-	before skipping to phase 3 of the process lifecycle, certain requirements of phase 2 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
27	36	System definition and application conditions	Requirement 2 of this phase shall be to perform: b) preliminary hazard identification to: — identify sub-systems associated with identified hazards; — identify types of accident initiating events that need to be considered, including component failure, procedural faults, human error and dependent failure mechanisms; — define initial risk tolerability criteria.	activity	-	-	hazard	shall	-	-	perform preliminary hazard identification	hazard identification to: — identify sub-systems associated with identified hazards; — identify types of accident initiating events that need to be considered, including component failure, procedural faults, human error and dependent failure mechanisms; — define initial risk tolerability criteria.	before skipping to phase 3 of the process lifecycle, certain requirements of phase 2 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
28	36	System definition and application conditions	Requirement 3 of this phase shall be to establish the general RAMS policy for the system, including requirements of safety concept and the Railway Authority's' policy for resolving any conflicts arising between "availability" and "safety".	activity	availability, safety	-	general RAMS policy, system	shall	-	-	establish RAMS policy	requirements of safety concept and the Railway Authority's' policy for resolving any conflicts arising between "availability" and "safety".	before skipping to phase 3 of the process lifecycle, certain requirements of phase 2 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language

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29	36 37	System definition and application conditions	Requirement 4 of this phase shall be to establish the Safety Plan for the system. The Safety Plan shall be agreed by the Railway Authority and the railway support industry for the system under consideration and shall be implemented, reviewed and maintained throughout the lifecycle of the system. The Safety Plan should include: a) the policy and strategy for achieving safety.	activity	safety	railway authority, railway support	safety plan (for the system), policy & strategy (for achieving safety)	shall	-	-	1) establish Safety Plan 2) get agreement of authority 3) get agreement of railway support industry 4) implementation 5) review 6) maintenance	including the policy and strategy for achieving safety	before skipping to phase 3 of the process lifecycle, certain requirements of phase 2 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language; the railway authority and the railway support as subjects can be modeled by using the **resource perspective** of the eCRG language
30	37	System definition and application conditions	The Safety Plan should include: b) the scope of the plan,	inclusion	-	-	scope of the plan	should	-	-	-	including the scope of the plan	-
31	37	System definition and application conditions	The Safety Plan should include: c) a description of the system.	inclusion	-	-	system description	should	-	-	-	including a description of the system	-
32	37	System definition and application conditions	The Safety Plan should include: d) details of roles, responsibilities, competencies and relationships of bodies undertaking tasks within the lifecycle.	inclusion	-	-	details of roles, responsibilities, competencies and relationships of bodies undertaking tasks	should	-	-	-	including details of —roles, —responsibilities, —competencies and —relationships of bodies undertaking tasks within the lifecycle	-
33	37	System definition and application conditions	The Safety Plan should include: e) description of the system lifecycle and safety tasks to be undertaken within the lifecycle along with any dependencies.	inclusion	-	-	system lifecycle description, safety tasks, dependencies	should	-	-	-	including a description of - the system lifecycle and - safety tasks to be undertaken within the lifecycle along with any dependencies	-

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34	37	System definition and application conditions	The Safety Plan should include: f) the safety analysis, engineering and assessment processes to be applied during the lifecycle, including processes for: — ensuring an appropriate degree of personnel independence in tasks, commensurate with the risk of the system; — hazard identification and analysis; — risk assessment and on-going risk management; — risk tolerability criteria; — the establishment and on-going review of the adequacy of the safety requirements; — system design; — verification and validation; — safety assessment, to achieve compliance between system requirements and realization; — safety audit, to achieve compliance of the management process with the safety plan; — safety assessment to achieve compliance between sub-system and system safety analysis.	inclusion	-	-	safety analysis, engineering and assessment processes	should	-	-	1) safety analysis 2) engineering processes 3) assessment processes	including processes for: — ensuring an appropriate degree of personnel independence in tasks, commensurate with the risk of the system; — hazard identification and analysis; — risk assessment and on-going risk management; — risk tolerability criteria; — the establishment and on-going review of the adequacy of the safety requirements; — system design; — verification and validation; — safety assessment, to achieve compliance between system requirements and realization; — safety audit, to achieve compliance of the management process with the safety plan; — safety assessment to achieve compliance between sub-system and system safety analysis.	-
35	37	System definition and application conditions	The Safety Plan should include: g) details of all safety related deliverables from the lifecycle, including: — documentation; — hardware; — software.	inclusion	-	-	details (of all safety related deliverables)	should	-	-	-	including: — documentation; — hardware; — software.	-
36	37	System definition and application conditions	The Safety Plan should include: h) a process to prepare system Safety Cases.	inclusion	-	-	process (to prepare system Safety Cases(	should	-	-	-	including a process to prepare system Safety Cases	-
37	37	System definition and application conditions	The Safety Plan should include: i) a process for the safety approval of the system.	inclusion	-	-	process (for the safety approval of the system)	should	-	-	-	including a process for the safety approval of the system	-
38	37	System definition and application conditions	The Safety Plan should include: j) a process for safety approval of system modifications.	inclusion	-	-	process (for safety approval of system modifications)	should	-	-	-	including a process for safety approval of system modifications.	-

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39	37	System definition and application conditions	The Safety Plan should include: k) a process for analysing operation and maintenance performance to ensure realized safety is compliant with requirements.	inclusion	-	-	process (for analysing operation and maintenance performance)	should	-	-	-	including a process for - analysing operation performance and - maintenance perdormance to ensure realized safety is compliant with requirements.	-
40	37	System definition and application conditions	The Safety Plan should include: l) a process for the maintenance of safety-related documentation, including a Hazard Log.	inclusion	-	-	process (for the maintenance of safety-related documentation), Hazard Log	should	-	-	-	including: - a process for the maintenance of safety-related documentation including: - a hazard log	-
41	37	System definition and application conditions	The Safety Plan should include: m) interfaces with other related programmes and plans.	inclusion	-	-	interfaces with other related programmes interfaces with plans	should	-	-	-	including: interfaces with other related programmes and plans	-
42	37	System definition and application conditions	The Safety Plan should include: n) constraints and assumptions made in the plan.	inclusion	-	-	constraints, assumptions (made in the plan)	should	-	-	-	including: - constraints and assumptions made in the plan	-
43	37	System definition and application conditions	The Safety Plan should include: o) subcontractor management arrangements.	inclusion	-	-	subcontractor management arrangements	should	-	-	-	including: - subcontractor management arrangements	-
44	37	System definition and application conditions	The Safety Plan should include: p) requirements for periodic safety audit, safety assessment and safety review, throughout the lifecycle and appropriate to the safety relevance of the system under consideration, including any personnel independence requirements.	inclusion	-	-	requirements (for periodic safety audit, safety assessment and safety review),	should	-	-	-	including: requirements for periodic - safety audit - safety assessment - safety review throughout the lifecycle and appropriate to the safety relevance of the system under consideration, including: - any personnel independence requirements.	-
45	37	System definition and application conditions	The results of this phase shall be documented, along with any assumptions and justifications made during the phase.	activity	-	-	deliverables	shall	-	-	document results	including: any assumptions and justifications made during the phase	before skipping to phase 3 of the process lifecycle, certain requirements of phase 2 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
46	37	System definition and application conditions	The deliverables shall include the RAMS Policy for the system.	inclusion	-	-	deliverables (documents), RAMS policy for the system	shall	-	-	-	including: - RAMS policy for the system	-

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47	37	System definition and application conditions	The deliverables shall include the Safety Plan for the system.	inclusion	-	-	deliverables (documents), safety plan for the system	shall	-	-	-	including: - the safety plan for the system	-
48	37	System definition and application conditions	The deliverables from this phase form a key input to subsequent lifecycle phases.	statement of importance	-	-	deliverables (documents), key input	-	-	-	-	-	-
49	37	System definition and application conditions	The following verification tasks shall be undertaken within this phase: a) assessment of the adequacy of the information, and where appropriate, data and other statistics, used as input to tasks within this phase.	activity	adequacy of the information, (data, statistics)	-	-	shall	-	-	assess adequacy of information, (data, statistics)	-	before skipping to phase 3 of the process lifecycle, certain requirements of phase 2 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
50	38	System definition and application conditions	The following verification tasks shall be undertaken within this phase: b) RAMS aspects of the phase 2 deliverables shall be verified against the phase 1 deliverables, in particular, the RAMS Policy shall be assessed for compliance against the system requirements defined in phase 1.	activity	compliance	-	RAMS policy, system requirements	shall	-	-	1) verify RAMS aspects of phase 2 deliverables against phase 1 deliverables 2) assess RAMS policy for compliance against the system requirements defined in phase 1	-	before skipping to phase 3 of the process lifecycle, certain requirements of phase 2 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
51	38	System definition and application conditions	The following verification tasks shall be undertaken within this phase: c) the completeness of the RAM analysis and hazard identification process shall be assessed for completeness.	activity	completeness	-	RAM analysis, hazard identification process	shall	-	-	assess 1) completeness of RAM analysis and 2) hazard identification process for completeness	-	before skipping to phase 3 of the process lifecycle, certain requirements of phase 2 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
52	38	System definition and application conditions	The following verification tasks shall be undertaken within this phase: d) assessment of the adequacy of the Safety Plan, including a review of the adequacy of any data sources included within the Safety Plan.	activity	adequacy of the safety plan	-	-	shall	-	-	assess adequacy of safety plan	including: - a review of the adequacy of any data sources included within the safety plan	before skipping to phase 3 of the process lifecycle, certain requirements of phase 2 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language

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53	38	System definition and application conditions	The following verification tasks shall be undertaken within this phase: e) assessment of the adequacy of the methods, tools and techniques used within the phase.	activity	adequacy of the methods, tools and techniques	-	-	shall	-	-	assess adequacy of: - methods - tools - techniques used within the phase	-	before skipping to phase 3 of the process lifecycle, certain requirements of phase 2 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
54	38	System definition and application conditions	The following verification tasks shall be undertaken within this phase: f) assessment of the competence of all personnel undertaking tasks within the phase.	activity	competence of all personnel (undertaking tasks within the phase)	-	-	shall	-	-	assess competence of personnel	-	before skipping to phase 3 of the process lifecycle, certain requirements of phase 2 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
55	38	System definition and application conditions	Any errors or shortfall may require the re-application of some or all of the activities of one or more previous lifecycle phases.	conditions to repeat	-	-	-	may	errors/shortfall	re-application of some/all activities of one/more lifecycle phases.	-	-	-
56	38	Risk analysis	The input to this phase shall include all relevant information, and where appropriate, data, necessary to meet the requirements of the phase and in particular, the deliverables produced in phase 2.	required input	completeness	-	information, data, requirements, deliverables phase 2	shall	-	-	check completeness of input	-	the required input can be described by using the **data perspective** of the eCRG language

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57	38	Risk analysis	Requirement 1 of this phase shall be to: a) Systematically identify and prioritize all reasonably foreseeable hazards associated with the system in its application environment, including hazards arising from: — system normal operation; — system fault conditions; — system emergency operation; — system misuse; — system interfaces; — system functionality; — system operation, maintenance and support issues; — system disposal considerations; — human factors; — occupational health issues; — mechanical environment; — electrical environment; — natural environment to cover such matters as snow, floods, storms, rain, landslides, etc.	activity	-	-	hazard, system, application environment	shall	-	-	systematically - identify - prioritize all reasonably foreseeable hazards	including hazards arising from: — system normal operation; — system fault conditions; — system emergency operation; — system misuse; — system interfaces; — system functionality; — system operation, maintenance and support issues; — system disposal considerations; — human factors; — occupational health issues; — mechanical environment; — electrical environment; — natural environment to cover such matters as snow, floods, storms, rain, landslides, etc.	before skipping to phase 4 of the process lifecycle, certain requirements of phase 3 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
58	38	Risk analysis	Requirement 1 of this phase shall be to: b) identify the sequence of events leading to hazards.	activity	-	-	hazards	shall	sequence of events	hazards	identify the sequence of events leading to hazards	-	before skipping to phase 4 of the process lifecycle, certain requirements of phase 3 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
59	38	Risk analysis	Requirement 1 of this phase shall be to: c) evaluate the frequency of occurrence of each hazard. (Table 2)	activity	-	-	hazards	shall	occurrence of each hazard	-	evaluate the frequency of occurrence of each hazard	-	before skipping to phase 4 of the process lifecycle, certain requirements of phase 3 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
60	38	Risk analysis	Requirement 1 of this phase shall be to: d) evaluate the likely severity of the consequences of each hazard. (Table 3)	activity	-	-	hazards	shall	-	-	evaluate the likely severity of the consequences of each hazard	-	before skipping to phase 4 of the process lifecycle, certain requirements of phase 3 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language

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61	38	Risk analysis	Requirement 1 of this phase shall be to: e) evaluate the risk to the system for each hazard.	activity	-	-	system risk, hazard	shall	-	-	evaluate the risk to the system for each hazard	-	before skipping to phase 4 of the process lifecycle, certain requirements of phase 3 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
62	39	Risk analysis	Requirement 2 of this phase shall be to determine and classify the acceptability of the risk associated with each identified hazard, having considered the risk in terms of any conflicts with availability and lifecycle cost requirements of the system.	activity	acceptability, availability	-	system risk, hazard, confilct, lifecycle cost requirements	shall	-	-	1) determine the acceptability of the risk associated with each identified hazard 2) classify the acceptability of the risk associated with each identified hazard	including: the consideration of the risk in terms of any conflicts with availability and lifecycle cost requirements of the system	before skipping to phase 4 of the process lifecycle, certain requirements of phase 3 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
63	39	Risk analysis	Requirement 3 of this phase shall be to establish a Hazard Log as the basis for on-going risk management. The Hazard Log shall be updated, whenever a change to any identified hazard occurs or a new hazard is identified, throughout the lifecycle. Hazard Log shall include details of: a) the aim and purpose of the Hazard Log;	activity	-	-	hazard log, risk management	shall	change to any identified hazard occurs, new hazard is identified	hazard log shall be updated	establish a hazard log	including the - aim and - purpose of the hazard log	before skipping to phase 4 of the process lifecycle, certain requirements of phase 3 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
64	39	Risk analysis	Hazard Log shall include details of: b) each hazardous event and contributing components;	inclusion	-	-	each hazardous event, components	shall	-	-	-	including: each hazardous event and contributing components	-
65	39	Risk analysis	Hazard Log shall include details of: c) likely consequences and frequencies of the sequence of events associated with each hazard;	inclusion	-	-	consequences frequencies, hazard	shall	-	-	-	including: - likely consequences and frequencies of the sequence of events associated with each hazard;	-
66	39	Risk analysis	Hazard Log shall include details of: d) the risk of each hazard;	inclusion	-	-	risk of each hazard	shall	-	-	-	inclduding: the risk ok each hazard	-
67	39	Risk analysis	Hazard Log shall include details of: e) risk tolerability criteria for the application;	inclusion	tolerability	-	risk tolerability criteria (for the application)	shall	-	-	-	including: risk tolerability criteria for the application	-

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68	39	Risk analysis	Hazard Log shall include details of: f) the measures taken to reduce risks to a tolerable level, or remove, the risk for each hazardous event;	inclusion	-	-	measures (to reduce risks to a tolerable level, remove risk)	shall	-	-	-	including: - measures to reduce risks to a tolerable level - measures to remove the risk for each hazardous event	-
69	39	Risk analysis	Hazard Log shall include details of: g) a process to review risk tolerability;	inclusion	-	-	process (to review risk tolerability)	shall	-	-	-	including: - a process to review risk tolerability	-
70	39	Risk analysis	Hazard Log shall include details of: h) a process to review the effectiveness of risk reduction measures;	inclusion	effectiveness	-	process (to review the effectiveness of risk reduction measures)	shall	-	-	-	including: a process to review the effectiveness of risk reduction measures	-
71	39	Risk analysis	Hazard Log shall include details of: i) a process for on-going risk and accident reporting;	inclusion	-	-	process (for on-going risk and accident reporting)	shall	-	-	-	including: a process for - on-going risk reporting and - accident reporting	-
72	39	Risk analysis	Hazard Log shall include details of: j) a process for management of the Hazard Log;	inclusion	-	-	process (for hazard log management)	shall	-	-	-	including: a poricess for hazard log management	-
73	39	Risk analysis	Hazard Log shall include details of: k) the limits of any analysis carried out;	inclusion	-	-	limits (of carried out analysis)	shall	-	-	-	including: the limits of any analysis carried out	-
74	39	Risk analysis	Hazard Log shall include details of: l) any assumptions made during the analysis;	inclusion	-	-	assumptions	shall	-	-	-	including: any assumptions made during the analysis	-
75	39	Risk analysis	Hazard Log shall include details of: m) any confidence limits applying to data used within the analysis;	inclusion	-	-	confidence limits (applying to data)	shall	-	-	-	including: any confidence limits applying to data used within the analysis	-
76	39	Risk analysis	Hazard Log shall include details of: n) the methods, tool and techniques used;	inclusion	-	-	methods, tool and techniques	shall	-	-	-	including: — methods — tool — techniques used	-
77	39	Risk analysis	Hazard Log shall include details of: o) the personnel, and their competencies, involved in the process;	inclusion	-	-	personnel	shall	-	-	-	including: - the personnel, and - their competencies, involved in the process	-

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78	39	Risk analysis	The results of this phase shall be documented, along with any assumptions and justifications made during the phase.	activity	-	-	deliverables	shall	-	-	document results	including any assumptions and justifications made during the phase	before skipping to phase 4 of the process lifecycle, certain requirements of phase 3 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
79	39	Risk analysis	The results of the risk analysis shall be recorded within the Hazard Log.	activity	-	-	deliverables (documents), hazard log	shall	-	-	record risk analysis results	-	before skipping to phase 4 of the process lifecycle, certain requirements of phase 3 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
80	39	Risk analysis	The deliverables from this phase form a key input to subsequent lifecycle phases.	statement of importance	-	-	deliverables (documents), key input	-	-	-	-	-	-
81	39	Risk analysis	The following verification tasks shall be undertaken within this phase: a) assessment of the adequacy of the information, and where appropriate, data and other statistics, used as input to tasks within this phase;	activity	adequacy of the information, (data, statistics)	-	-	shall	-	-	assess adequacy of information , (data, statistics)	-	before skipping to phase 4 of the process lifecycle, certain requirements of phase 3 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
82	39	Risk analysis	The following verification tasks shall be undertaken within this phase: b) the phase 3 deliverables shall be verified against the phase 2 deliverables;	activity	-	-	deliverables	shall	-	-	verify phase 3 deliverables against phase 2 deliverables	-	before skipping to phase 4 of the process lifecycle, certain requirements of phase 3 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
83	39	Risk analysis	The following verification tasks shall be undertaken within this phase: c) assessment of the completeness of the risk assessment;	activity	completeness of the risk assessment	-	-	shall	-	-	assess completeness of the risk assessment	-	before skipping to phase 4 of the process lifecycle, certain requirements of phase 3 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
84	39	Risk analysis	The following verification tasks shall be undertaken within this phase: d) assessment of the risk acceptability classification;	activity	risk acceptability classification	-	-	shall	-	-	assess risk acceptability classification	-	before skipping to phase 4 of the process lifecycle, certain requirements of phase 3 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language

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85	39	Risk analysis	The following verification tasks shall be undertaken within this phase: e) assessment of the suitability of the hazard log process for the system under consideration;	activity	suitability of the hazard log process	-	-	shall	-	-	assess suitability of hazard log process	-	before skipping to phase 4 of the process lifecycle, certain requirements of phase 3 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
86	39	Risk analysis	The following verification tasks shall be undertaken within this phase: f) assessment of the adequacy of the methods, tools and techniques used within the phase;	activity	adequacy of the methods, tools and techniques	-	-	shall	-	-	assess adequacy of -methods, -tools, -techniques	-	before skipping to phase 4 of the process lifecycle, certain requirements of phase 3 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
87	39	Risk analysis	The following verification tasks shall be undertaken within this phase: g) assessment of the competence of all personnel undertaking tasks within the phase.	activity	competence of all personnel (undertaking tasks within the phase)	-	-	shall	-	-	assess competence of personnel	-	before skipping to phase 4 of the process lifecycle, certain requirements of phase 3 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
88	39	Risk analysis	Any errors or shortfall may require the re-application of some or all of the activities of one or more previous lifecycle phases.	conditions to repeat	-	-	-	may	errors/shortfalls	re-application of some/all activities of one/more lifecycle phases.	-	-	-
89	40	System requirements	The input to this phase shall include all relevant information, and where appropriate, data, necessary to meet the requirements of the phase and in particular, the deliverables of phase 2 and phase 3.	required input	completeness	-	information, data, requirements, deliverables phase 2,3	shall	-	-	check completeness of input	-	the required input can be described by using the **data perspective** of the eCRG language

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90	40	System requirements	Requirement 1 of this phase shall be to specify (with reference to 6.2.3.1) the overall RAMS requirements for the total system. The RAMS Requirements, for the system under consideration, shall include: — definition of the system and boundaries; — mission profile; — functional requirements and supporting performance requirements, including safety functional requirements and safety integrity requirements for each safety function; — logistic support requirements; — interfaces; — application environment; — tolerable risk levels for identified hazards; — external measures necessary to achieve the requirements; — system support requirements; — details of the limits of the analysis; — details of any assumptions made.	activity	-	-	RAMS requirements	shall	-	-	specify the overall RAMS requirements for the total system	including: — definition of the system and boundaries; — mission profile; — functional requirements and supporting performance requirements, including safety functional requirements and safety integrity requirements for each safety function; — logistic support requirements; — interfaces; — application environment; — tolerable risk levels for identified hazards; — external measures necessary to achieve the requirements; — system support requirements; — details of the limits of the analysis; — details of any assumptions made.	before skipping to phase 5 of the process lifecycle, certain requirements of phase 4 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language

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91	40	System requirements	Requirement 2 of this phase shall be to specify (with reference to 6.2.3.3) the overall requirements for achieving compliance with RAMS requirements for the system, including: — acceptance criteria for the overall RAMS requirements; — demonstration and acceptance process for the overall RAMS requirements facilitated by the system RAMS validation plan, which should include: — a description of the system; — the RAMS validation principles to be applied to the system; — the RAMS tests and analysis to be carried out for the validation including details of the required environment, tools, facilities etc.; — the validation management structure including requirements for personnel,' independence; i — details of the validation program (sequence and schedule); — procedures for dealing with non-compliance.	activity	compliance	-	requirements, RAMS requirements	shall	-	-	specify the overall requirements for achieving compliance with RAMS requirements for the system	including: — acceptance criteria for the overall RAMS requirements; — demonstration and acceptance process for the overall RAMS requirements facilitated by the system RAMS validation plan, which should include: — a description of the system; — the RAMS validation principles to be applied to the system; — the RAMS tests and analysis to be carried out for the validation including details of the required environment, tools, facilities etc.; — the validation management structure including requirements for personnel,' independence; i — details of the validation program (sequence and schedule); — procedures for dealing with non-compliance.	before skipping to phase 5 of the process lifecycle, certain requirements of phase 4 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language

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92	40 41	System requirements	Requirement 3 of this phase shall be to establish the detailed RAM Programme for the remaining lifecycle tasks (with reference to 6.2.3.3). The RAM Programme shall include the tasks which are judged to be the most effective to the attainment of the RAM requirements for the system under consideration. The RAM Programme shall be agreed by the Railway Authority and the railway support industry for the system under consideration and shall be implemented throughout the lifecycle of the system. Within the RAM Programme, consideration should be given to including the following tasks: a) management, including details of: — the policy and strategy for achieving RAM requirements; — the scope of the programme; — a description of the system; — the system lifecycle and RAM tasks and processes to be undertaken within the lifecycle, specifically the order of RAM tasks to ensure maximum benefit to system design; — the roles, responsibilities, competencies and relationships of organizations undertaking	activity	effectiveness	railway authority, railway support industry	RAM programme, RAM requirements, management	shall	-	-	1) establish detailed RAM programme 2) get agreement of authority 3) get agreement of railway support industry 4) implementation	RAM programme including: tasks which are judged to be the most effective to the attainment of the RAM requirements; management including: — the policy and strategy for achieving RAM requirements; — the scope of the programme; — a description of the system; — the system lifecycle and RAM tasks and processes to be undertaken within the lifecycle, specifically the order of RAM tasks to ensure maximum benefit to system design; — the roles, responsibilities, competencies and relationships of organizations undertaking tasks within the lifecycle; — A Failure Reporting Analysis and Corrective Action System (FRACAS) to be applied to the system from phase 7 of the lifecycle (by the Railway Authority and the railway support industry, as appropriate), with records including: - technical data on system; - reason for maintenance action; - type of maintenance action; - man-hours & elapsed time for	before skipping to phase 5 of the process lifecycle, certain requirements of phase 4 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language; the railway authority and the railway support industry as subjects can be modeled by using the **resource perspective** of the eCRG language

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93	41	System requirements	Requirement 3 of this phase shall be to establish the detailed RAM Programme for the remaining lifecycle tasks (with reference to 6.2.3.3). The RAM Programme shall include the tasks which are judged to be the most effective to the attainment of the RAM requirements for the system under consideration. The RAM Programme shall be agreed by the Railway Authority and the railway support industry for the system under consideration and shall be implemented throughout the lifecycle of the system. Within the RAM Programme, consideration should be given to including the following tasks: b) reliability, including: — reliability analysis and prediction, including: - functional analysis and system failure definition; - top down analysis, for example fault tree analysis and block diagram analysis; - bottom up analysis, for example Failure Modes Effects Analysis (FMEA); - common cause failure or multiple failure analysis;	activity	effectiveness, reliability	railway authority, railway support industry	RAM programme, RAM requirements	shall	-	-	1) establish detailed RAM programme 2) get agreement of authority 3) get agreement of railway support industry 4) implementation	1) including: reliability 2) including: — reliability analysis and prediction, including: - functional analysis and system failure definition; - top down analysis, for example fault tree analysis and block diagram analysis; - bottom up analysis, for example Failure Modes Effects Analysis (FMEA); - common cause failure or multiple failure analysis; - sensitivity analysis and trade-off studies; - reliability apportionment; - human machine interface analysis; - stress analysis; - worst case prediction and tolerance analysis. — reliability planning, including: - reliability design review programme; - component reliability assurance programme; - software quality/reliability assurance programme. reliability testing, including: - reliability growth testing, based on failure generation;	before skipping to phase 5 of the process lifecycle, certain requirements of phase 4 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language; the railway authority and the railway support industry as subjects can be modeled by using the **resource perspective** of the eCRG language

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94	1 & 4	System requirements	Requirement 3 of this phase shall be to establish the detailed RAM Programme for the remaining lifecycle tasks (with reference to 6.2.3.3). The RAM Programme shall include the tasks which are judged to be the most effective to the attainment of the RAM requirements for the system under consideration. The RAM Programme shall be agreed by the Railway Authority and the railway support industry for the system under consideration and shall be implemented throughout the lifecycle of the system. Within the RAM Programme, consideration should be given to including the following tasks: c) maintainability, including: — maintainability analysis and prediction, including: - maintainability analysis and verification; - maintenance task analysis; - ease-of-maintenance studies and testing; - human factors maintainability considerations. — maintainability planning, including: - maintainability design review programme;	activity	effectiveness, maintainability	railway authority, railway support industry	RAM programme, RAM requirements	shall	-	-	1) establish detailed RAM programme 2) get agreement of authority 3) get agreement of railway support industry 4) implementation	1) including: maintainability 2) including: — maintainability analysis and prediction, including: - maintainability analysis and verification; - maintenance task analysis; - ease-of-maintenance studies and testing; - human factors maintainability considerations. — maintainability planning, including: - maintainability design review programme; - establishment of the maintenance strategy; - review of reliability centred maintenance options; - software maintenance programme. ' — logistic suppon evaluation including: - definition of maintenance requirements; - definition of spares policy and support resource; - maintenance personnel and facilities; - personnel safety precautions; - system support requirements; - training programme requirements;	before skipping to phase 5 of the process lifecycle, certain requirements of phase 4 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language; the railway authority and the railway support industry as subjects can be modeled by using the **resource perspective** of the eCRG language

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95	42	System requirements	Requirement 3 of this phase shall be to establish the detailed RAM Programme for the remaining lifecycle tasks (with reference to 6.2.3.3). The RAM Programme shall include the tasks which are judged to be the most effective to the attainment of the RAM requirements for the system under consideration. The RAM Programme shall be agreed by the Railway Authority and the railway support industry for the system under consideration and shall be implemented throughout the lifecycle of the system. Within the RAM Programme, consideration should be given to including the following tasks: d) availability, including: — availability analysis; — sensitivity analysis and trade-off studies; — availability demonstration during early operation; — availability data acquisition and assessment; — data analysis for availability improvement and prediction.	activity	effectiveness, availability	railway authority, railway support industry	RAM programme, RAM requirements	shall	-	-	1) establish detailed RAM programme 2) get agreement of authority 3) get agreement of railway support industry 4) implementation	1) including: availability 2) including: — availability analysis; — sensitivity analysis and trade-off studies; — availability demonstration during early operation; — availability data acquisition and assessment; — data analysis for availability improvement and prediction.	before skipping to phase 5 of the process lifecycle, certain requirements of phase 4 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language; the railway authority and the railway support industry as subjects can be modeled by using the **resource perspective** of the eCRG language
96	42	System requirements	Requirement 4 of this phase shall be to amend the Safety Plan to ensure that all future planned tasks are consistent with the system's emergent RAMS requirements.	activity	consistency	-	safety plan, RAMS requirements	shall	-	-	amend safety plan to ensure that all future planned tasks are consistent with the systems's emergent RAMS requirements	-	before skipping to phase 5 of the process lifecycle, certain requirements of phase 4 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
97	42	System requirements	The results of this phase shall be documented, along with any assumptions and justifications made during the phase.	activity	-	-	deliverables	shall	-	-	document results	including any assumptions and justifications made during the phase	before skipping to phase 5 of the process lifecycle, certain requirements of phase 4 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language

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98	42	System requirements	The phase shall produce an updated Safety Plan and Acceptance Plan.	activity	-	-	deliverables (documents), safety plan, acceptance plan	shall	-	-	1) produce updated safety plan 2) produce acceptance plan	-	before skipping to phase 5 of the process lifecycle, certain requirements of phase 4 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
99	42	System requirements	The deliverables from this phase are an input to subsequent lifecycle phases.	statement of importance	-	-	deliverables (documents), key input	-	-	-	-	-	-
100	42	System requirements	The following verification tasks shall be undertaken within this phase: a) assessment of the adequacy of the information, and where appropriate, data and other statistics, used as input to tasks within this phase.	activity	adequacy of the information, (data, statistics)	-	-	shall	-	-	assess adequacy of information , (data, statistics)	-	before skipping to phase 5 of the process lifecycle, certain requirements of phase 4 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
101	42	System requirements	The following verification tasks shall be undertaken within this phase: b) system requirements shall be verified against the deliverables produced within phase 2 and phase 3, including lifecycle costings.	activity	-	-	deliverables, system requirements, lifecycle costs	shall	-	-	verify system requirements against deliverables produced in phase 2 and 3	including: lifecycle costs	before skipping to phase 5 of the process lifecycle, certain requirements of phase 4 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
102	42	System requirements	The following verification tasks shall be undertaken within this phase: c) safety requirements shall be verified against any safety targets and safety policies of the Railway Authority.	activity	-	-	deliverables, safety requirements, safety targets, safety policies	shall	-	-	verify safety requirements against safety targets and safety policies of railway authority	-	before skipping to phase 5 of the process lifecycle, certain requirements of phase 4 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
103	42	System requirements	The following verification tasks shall be undertaken within this phase: d) RAM requirements shall be verified against any RAM targets and RAM policies of the Railway Authority.	activity	-	-	deliverables. RAM requirements, RAM targets, RAM policies	shall	-	-	verify RAM requirements against any RAM targets and RAM polivies of the railway authority	-	before skipping to phase 5 of the process lifecycle, certain requirements of phase 4 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language

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104	42	System requirements	The following verification tasks shall be undertaken within this phase: e) assessment of the adequacy and completeness of the Acceptance Plan and the Validation Plan.	activity	adequacy of the acceptance and validation plan completeness of the acceptance and validation plan	-	-	shall	-	-	asses 1) adequacy of the acceptance and validation plan 2) completeness of the acceptance and validation plan	-	before skipping to phase 5 of the process lifecycle, certain requirements of phase 4 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
105	42	System requirements	The following verification tasks shall be undertaken within this phase: f) assessment of the adequacy of the RAM Programme, including a review of the adequacy of any data sources used.	activity	adequacy of RAM programme, adequacy of data sources used	-	-	shall	-	-	assess adequacy of RAM programme	including: a review of the adequacy of any data sources used	before skipping to phase 5 of the process lifecycle, certain requirements of phase 4 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
106	42	System requirements	The following verification tasks shall be undertaken within this phase: g) assessment of the methods, tools and techniques used within the phase.	activity	-	-	methods, tool and techniques	shall	-	-	assess - methods - tools - techniques	-	before skipping to phase 5 of the process lifecycle, certain requirements of phase 4 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
107	42	System requirements	The following verification tasks shall be undertaken within this phase: h) competence assessment of personnel undertaking tasks within the phase.	activity	competence of all personnel (undertaking tasks within the phase)	-	-	shall	-	-	assess competence of personnel	-	before skipping to phase 5 of the process lifecycle, certain requirements of phase 4 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
108	42	System requirements	Any errors or shortfall may require the re-application of some or all of the activities of one or more previous lifecycle phases.	conditions to repeat	-	-	-	may	errors/shortfalls	re-application of some/all activities of one/more lifecycle phases.	-	-	-
109	43	Apportionment of system requirements	The input to this phase shall include all relevant information, and where appropriate, data, necessary to meet the requirements of the phase and in particular, all deliverables produced in phase 4.	required input	completeness	-	information, data, requirements, deliverables phase 4	shall	-	-	check completeness of input	-	the required input can be described by using the **data perspective** of the eCRG language

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110	43	Apportionment of system requirements	Requirement 1 of this phase shall be to: a) allocate functional requirements to designated sub-systems, components and external facilities.	activity	-	-	functional requirements, designated sub-systems, components, external facilities	shall	-	-	allocate functional requirements to designated sub-systems, components and external facilities	-	before skipping to phase 6 of the process lifecycle, certain requirements of phase 5 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
111	43	Apportionment of system requirements	Requirement 1 of this phase shall be to: b) allocate safety requirements to designated sub-systems, components and external risk reduction facilities.	activity			safety requirements, designated sub-systems, components, external risk reduction facilities	shall	-	-	allocate safety requirements to designated sub-systems, components and external risk reduction facilities	-	before skipping to phase 6 of the process lifecycle, certain requirements of phase 5 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
112	43	Apportionment of system requirements	Requirement 1 of this phase shall be to: c) specify the designated sub-systems, components and external facilities to achieve complete system RAM requirements, including the impact of common cause and multiple failures.	activity	-	-	designated sub-systems, components, external facilities, RAM requirements	shall	-	-	specify the designated sub-systems, components and external facilities to achieve complete system RAM requirements	including: the impact of common cause and multiple failures	before skipping to phase 6 of the process lifecycle, certain requirements of phase 5 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
113	43	Apportionment of system requirements	Requirement 1 of this phase shall be to: d) review the RAM programme.	activity	-	-	RAM programme	shall	-	-	review RAM programme	-	before skipping to phase 6 of the process lifecycle, certain requirements of phase 5 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
114	43	Apportionment of system requirements	Requirement 2 of this phase shall be to specify requirements for compliance with sub-system, component and external facilities requirements, including: — acceptance criteria for sub-system, component and external facilities requirements; — demonstration and acceptance processes and procedures for sub-system, component and external facilities requirements.	activity	compliance	-	compliance requirements with sub-system, component, external facilities requirements	shall	-	-	specify requirements for compliance with sub-system, component and external facilities requirements	including: — acceptance criteria for sub-system, component and external facilities requirements; — demonstration and acceptance processes and procedures for sub-system, component and external facilities requirements.	before skipping to phase 6 of the process lifecycle, certain requirements of phase 5 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language

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115	43	Apportionment of system requirements	Requirement 3 of this phase shall be to review and update the Safety Plan and the Validation Plan to ensure that planned tasks are consistent with the requirements of the system following apportionment. Key areas of concern include requirements for personnel independence and the control of system interfaces where safety functionality may be compromised.	activity	-	-	safety plan, validation plan, requirements	shall	-	-	1) review safety and validation plan 2) update safety and validation plan to ensure that planned tasks are consistent with the requirements of the system following apportionment	key areas of concern include: - requirements for personnel independence - control of system interfaces where safety functionality may be compromised	before skipping to phase 6 of the process lifecycle, certain requirements of phase 5 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
116	43	Apportionment of system requirements	The results of this phase shall be documented, along with any assumptions and justifications made during the phase.	activity	-	-	deliverables	shall	-	-	document results	including any assumptions and justifications made during the phase	before skipping to phase 6 of the process lifecycle, certain requirements of phase 5 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
117	43	Apportionment of system requirements	This phase shall produce an updated Safety Plan.	activity	-	-	safety plan	shall	-	-	produce updated safety plan	-	before skipping to phase 6 of the process lifecycle, certain requirements of phase 5 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
118	43	Apportionment of system requirements	The documents resulting from this phase shall include the allocated system requirements to the designated sub-systems, components and external facilities.	activity	-	-	deliverables (documents), allocated system requirements, designated sub-systems, components, external facilities	shall	-	-	-	including: allocated system requirements to the designated sub-systems, components and external facilities.	before skipping to phase 6 of the process lifecycle, certain requirements of phase 5 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
119	43	Apportionment of system requirements	The deliverables from this phase form a key input to subsequent lifecycle phases.	statement of importance	-	-	deliverables (documents), key input	-	-	-	-	-	-
120	43	Apportionment of system requirements	The following verification tasks shall be undertaken within this phase: a) assessment of the adequacy of the information, and where appropriate, data and other statistics, used as input to tasks within this phase;	activity	adequacy of the information, (data, statistics)	-	-	shall	-	-	assess adequacy of information, (data, statistics)	-	before skipping to phase 6 of the process lifecycle, certain requirements of phase 5 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language

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121	44	Apportionment of system requirements	The following verification tasks shall be undertaken within this phase: b) verification of system, sub-system, component and external facility requirements against the deliverables produced in phase 4, and including a review of the requirements against the lifecycle cost for the system;	activity	-	-	system, sub-system, component, external facility requirements, deliverables phase 4	shall	-	-	verify system, sub-system, component and external facility requirements against the deliverables produced in phase 4,	including: a review of the requirements against the lifecycle cost for the system	before skipping to phase 6 of the process lifecycle, certain requirements of phase 5 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
122	44	Apportionment of system requirements	The following verification tasks shall be undertaken within this phase: c) the architecture for the total combination of designated sub-systems, components and external facilities shall be verified to ensure it complies with the RAMS requirements for the total system;	activity	compliance	-	designated sub-systems, components, external facilities, RAMS requirements, system	shall	-	-	verify the architecture for the total combination of designated sub-systems, components and external facilities to ensure it complies with the RAMS requirements for the total system;	-	before skipping to phase 6 of the process lifecycle, certain requirements of phase 5 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
123	44	Apportionment of system requirements	The following verification tasks shall be undertaken within this phase: d) the RAMS requirements for sub-system, component and external facilities shall be verified to ensure that they are traceable to the RAMS requirements for the system;	activity	traceability	-	designated sub-systems, components, external facilities, RAMS requirements, system	shall	-	-	verify RAMS requirements for sub-system, component and external facilities to ensure that they are traceable to the RAMS requirements for the system	-	before skipping to phase 6 of the process lifecycle, certain requirements of phase 5 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
124	44	Apportionment of system requirements	The following verification tasks shall be undertaken within this phase: e) the RAMS requirements for sub-system, component and external facilities shall be verified to ensure completeness and consistency between functions;	activity	completeness, consistency	-	RAMS requirements, sub-system, component, external facilities	shall	-	-	verify the RAMS requirements for sub-system, component and external facilities to ensure completeness and consistency between functions;	-	before skipping to phase 6 of the process lifecycle, certain requirements of phase 5 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language

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125	44	Apportionment of system requirements	The following verification tasks shall be undertaken within this phase: f) the revised Safety plan and Validation plan shall be verified to ensure its continued applicability;	activity	applicability	-	safety plan, validation plan	shall	-	-	verify revised safety and validation plan to ensure its continued applicability	-	before skipping to phase 6 of the process lifecycle, certain requirements of phase 5 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
126	44	Apportionment of system requirements	The following verification tasks shall be undertaken within this phase: g) assessment of the adequacy of the methods, tools and techniques used within the phase;	activity	adequacy of the methods, tools and techniques	-	-	shall	-	-	assess adequacy of methods, tools, techniques	-	before skipping to phase 6 of the process lifecycle, certain requirements of phase 5 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
127	44	Apportionment of system requirements	The following verification tasks shall be undertaken within this phase: h) assessment of the competence of all personnel undertaking tasks within the phase.	activity	competence of all personnel (undertaking tasks within the phase)	-	-	shall	-	-	assess competence of personnel	-	before skipping to phase 6 of the process lifecycle, certain requirements of phase 5 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
128	44	Apportionment of system requirements	Any errors or shortfall may require the re-application of some or all of the activities of one or more previous lifecycle phases.	conditions to repeat	-	-	-	may	errors/shortfalls	re-application of some/all activities of one/more lifecycle phases.	-	-	-
129	44	Design and implementation	The input to this phase shall include all relevant information, and where appropriate, data, necessary to meet the requirement, and in particular the deliverables produced in phase 4 and phase 5.	required input	completeness	-	information, data, requirements, deliverables phase 4,5	shall	-	-	check completeness of input	-	the required input can be described by using the **data perspective** of the eCRG language
130	44	Design and implementation	Requirement 1 of this phase shall be to design the sub-systems and components to meet RAMS requirements.	activity	-	-	sub-systems, components, RAMS requirements	shall	-	-	design the sub-systems and components to meet RAMS requirements	-	before skipping to phase 7 of the process lifecycle, certain requirements of phase 6 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
131	44	Design and implementation	Requirement 2 of this phase shall be to realize the design of the sub-systems and components to meet RAMS requirements.	activity	-	-	sub-systems, components, RAMS requirements	shall	-	-	realize the design of the sub-systems and components to meet RAMS requirements	-	before skipping to phase 7 of the process lifecycle, certain requirements of phase 6 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language

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132	44	Design and implementation	Requirement 3 of this phase shall be to establish plans, in the context of RAMS, for future lifecycle tasks, including: — installation; — commissioning; — operation and maintenance, including definition of operation and maintenance procedures; — data acquisition and assessment during operation.	activity	-	-	plans	shall	-	-	establish plans, in the context of RAMS, for future lifecycle tasks	including: — installation; — commissioning; — operation and maintenance including: definition of operation and maintenance procedures; — data acquisition and assessment during operation	before skipping to phase 7 of the process lifecycle, certain requirements of phase 6 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
133	44 45	Design and implementation	Requirement 4 of this phase shall be to define, verify and establish a manufacturing process capable of producing RAMS-validated sub-systems and components, giving consideration to the use of: — environmental stress screening; — RAM improvement testing; — inspection and testing for RAMS-related failure modes; — implementation of requirement 4 of the safety plan (item d of 6.2.3.4).	activity	-	-	RAMS-validated sub-systems, components	shall	-	-	1) define a manufacturing process 2) verify a manufacturing process 3) establish a manufacturing process capable of producing RAMS-validated sub-systems and components	including: — environmental stress screening; — RAM improvement testing; — inspection and testing for RAMS-related failure modes; — implementation of requirement 4 of the safety plan (item d of 6.2.3.4)	before skipping to phase 7 of the process lifecycle, certain requirements of phase 6 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language

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134	45	Design and implementation	Requirement 5 of this phase shall be to: a) prepare a Generic Safety Case for the system, justifying that the system, as designed and independent of application, meets safety requirements. The Safety Case requires approval by the Railway Authority, and should include: — an overview of the system; — a summary or reference to the safety requirements, including a consideration of the SIL justifications for safety functions; — a summary of the quality and safety management controls adopted within the lifecycle; — a summary of safety assessment and safety audit tasks; — a summary of safety analysis tasks; — an overview of the safety engineering techniques employed within the system — verification of the manufacturing process; — adequacy of compliance with safety requirements, including any SIL requirements of the system; — a summary of any limitations and constraints applying to the system; — any special exemption (or	activity	-	railway authority	generic safety case, safety requirements	shall	-	-	1) prepare a Generic Safety Case for the system, justifying that the system, as designed and independent of application, meets safety requirements 2) get apporval of railway authority	including: — an overview of the system; — a summary or reference to the safety requirements, including a consideration of the SIL justifications for safety functions; — a summary of the quality and safety management controls adopted within the lifecycle; — a summary of safety assessment and safety audit tasks; — a summary of safety analysis tasks; — an overview of the safety engineering techniques employed within the system — verification of the manufacturing process; — adequacy of compliance with safety requirements, including any SIL requirements of the system; — a summary of any limitations and constraints applying to the system; — any special exemption (or specificity) imposed and justified by the contract, to the usual requirements of this Standard	before skipping to phase 7 of the process lifecycle, certain requirements of phase 6 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language: the railway authority as a subject can be modeled by using the **resource perspective** of the eCRG language

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135	45	Design and implementation	Requirement 5 of this phase shall be to: b) prepare an Application Safety Case, if appropriate at this stage, for the system. The Application Safety Case builds on the Generic Safety Case, justifying that the design of the system and its physical realization, including installation and test phases, for a specific class of application, meet safety requirements. The Application Safety Case requires approval by the Railway Authority, and should include: — all additional information necessary to justify system safety for the class of application under consideration; — any limitations or constraints relevant to the application of the system.	activity	-	railway authority	application safety case, system, generic safety case, safety requirements	shall	-	-	1) prepare an Application Safety Case, if appropriate at this stage, for the system 2) get approval of railway authority	including: — all additional information necessary to justify system safety for the class of application under consideration; — any limitations or constraints relevant to the application of the system	before skipping to phase 7 of the process lifecycle, certain requirements of phase 6 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language; the railway authority as a subject can be modeled by using the **resource perspective** of the eCRG language
136	45	Design and implementation	The results of this phase shall be documented, along with any assumptions and justifications made during the phase.	activity	-	-	deliverables	shall	-	-	document results	including any assumptions and justifications made during the phase	before skipping to phase 7 of the process lifecycle, certain requirements of phase 6 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
137	45	Design and implementation	A record of all RAMS validation tasks undertaken within the phase shall be maintained.	activity	-	-	deliverables (documents)	shall	-	-	maintain a record of all validation tasks	-	before skipping to phase 7 of the process lifecycle, certain requirements of phase 6 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
138	45	Design and implementation	Detailed plans for future lifecycle tasks, in the context of RAMS, shall be produced.	activity	-	-	plans	shall	-	-	produce detailed plans for future lifecycle tasks	-	before skipping to phase 7 of the process lifecycle, certain requirements of phase 6 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
139	45	Design and implementation	Operation and Maintenance Procedures including all the relevant information for providing spare pans, particularly safety related items, shall be produced within this phase.	activity	-	-	operation procedures, maintenance procedures, information	shall	-	-	produce operation and maintenance procedures	including all the relevant information for providing spare pans, particularly safety related items	before skipping to phase 7 of the process lifecycle, certain requirements of phase 6 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language

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140	45	Design and implementation	A Generic Safety Case shall be produced within this phase.	activity	-	-	generic safety case	shall	-	-	produce generic safety case	-	before skipping to phase 7 of the process lifecycle, certain requirements of phase 6 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
141	45	Design and implementation	An Application Safety Case may be produced within this phase.	possible activity	-	-	application safety case	may	-	-	produce an application safety case	-	before skipping to phase 7 of the process lifecycle, certain requirements of phase 6 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
142	45	Design and implementation	The deliverables from this phase form a key input to subsequent lifecycle phases.	statement of importance	-	-	deliverables (documents), key input	-	-	-	-	-	-
143	45	Design and implementation	The following verification tasks shall be undertaken within this phase: a) assessment of the adequacy of the information, and where appropriate, data and other statistics, used as input to tasks within this phase.	activity	adequacy of the information, (data, statistics)	-	-	shall	-	-	assess adequacy of information, (data, statistics)	-	before skipping to phase 7 of the process lifecycle, certain requirements of phase 6 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
144	45	Design and implementation	The following verification tasks shall be undertaken within this phase: b) verification, by analysis and test, that sub-system and component design complies with the RAMS requirements.	activity	compliance	-	sub-system, component design, RAMS requirements	shall	-	-	verify by analysis and test, that sub-system and component design complies with the RAMS requirements	-	before skipping to phase 7 of the process lifecycle, certain requirements of phase 6 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
145	46	Design and implementation	The following verification tasks shall be undertaken within this phase: c) verification, by analysis and test, that sub-systems and components realization complies with designs	activity	compliance	-	sub-systems (realization), components (realization), design	shall	-	-	verify by analysis and test, that sub-systems and components realization complies with designs	-	before skipping to phase 7 of the process lifecycle, certain requirements of phase 6 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language

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146	46	Design and implementation	The following verification tasks shall be undertaken within this phase: d) validation of sub-system and component realization to ensure that the realization complies with RAMS acceptance criteria for sub-system and components, including lifecycle requirements.	activity	compliance	-	sub-systems (realization), components (realization), lifecycle requirements, RAMS acceptance criteria	shall	-	-	validate sub-system and component realization to ensure that the realization complies with RAMS acceptance criteria for sub-system and components	including lifecycle requirements	before skipping to phase 7 of the process lifecycle, certain requirements of phase 6 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
147	46	Design and implementation	The following verification tasks shall be undertaken within this phase: e) verification, by analysis and test, that the manufacturing arrangements produce RAMS-validated sub-systems and components.	activity	-	-	manufacturing arrangements, RAMS validated sub-systems, components	shall	-	-	verify, by analysis and test, that the manufacturing arrangements produce RAMS-validated sub-systems and components	-	before skipping to phase 7 of the process lifecycle, certain requirements of phase 6 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
148	46	Design and implementation	The following verification tasks shall be undertaken within this phase: f) verification that all future lifecycle activity plans are consistent with RAMS requirements for the system, including lifecycle cost requirements.	activity	consistency	-	future lifecycle activity plans, RAMS requirements, system, lifecycle cost requirements	shall	-	-	verify, that all future lifecycle activity plans are consisten with RAMS requirements for the system	including lifecycle cost requirements	before skipping to phase 7 of the process lifecycle, certain requirements of phase 6 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
149	46	Design and implementation	The following verification tasks shall be undertaken within this phase: g) assessment of the adequacy and completeness of the generic safety case and where appropriate, the application safety case.	activity	adequacy of generic safety case, completeness of generic safety case (adequacy/completeness of application safety case)	-	-	shall	-	-	1) assess adequacy of generic safety case 2) assess completeness of the generic safety case (and where appropriate, the application safety case)	-	before skipping to phase 7 of the process lifecycle, certain requirements of phase 6 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
150	46	Design and implementation	The following verification tasks shall be undertaken within this phase: h) assessment of the adequacy of the methods, tools and techniques used within the phase.	activity	adequacy of the methods, tools and techniques	-	-	shall	-	-	assess adequacy of methods, tools, techniques	-	before skipping to phase 7 of the process lifecycle, certain requirements of phase 6 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language

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151	46	Design and implementation	The following verification tasks shall be undertaken within this phase: i) assessment of the competence of all personnel undertaking tasks within the phase.	activity	competence of all personnel (undertaking tasks within the phase)	-	-	shall	-	-	assess competence of personnel	-	before skipping to phase 7 of the process lifecycle, certain requirements of phase 6 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
152	46	Design and implementation	The following verification tasks shall be undertaken within this phase: j) ensure the continued applicability of the RAMS validation plan.	activity	applicability	-	RAMS validation plan	shall	-	-	ensure the continued applicability of the RAMS validation plan	-	before skipping to phase 7 of the process lifecycle, certain requirements of phase 6 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
153	46	Design and implementation	Any errors or shortfall may require the re-application of some or all of the activities of one or more previous lifecycle phases.	conditions to repeat	-	-	-	may	errors/shortfalls	re-application of some/all activities of one/more lifecycle phases.	-	-	-
154	46	Manufacturing	The input to this phase shall include all relevant information, and where appropriate, data, necessary to meet the requirement, and in particular the design deliverables produced in phase 6.	required input	completeness	-	information, data, requirements, design deliverables phase 6	shall	-	-	check completeness of input	-	the required input can be described by using the **data perspective** of the eCRG language
155	46	Manufacturing	Requirement 1 of this phase shall be to verify and implement the manufacturing process.	activity	-	-	manufacturing process	shall	-	-	1) verify manufacturing process 2) implement manufacturing process	-	before skipping to phase 8 of the process lifecycle, certain requirements of phase 7 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language

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156	46	Manufacturing	Requirement 2 of this phase shall be to establish sub-system and component support. arrangements, including: — preparation, verification and validation of sub-system and component RAMS support documentation; — preparation, verification and validation of operation and maintenance procedures in the context of RAMS; — preparation, verification and validation of sub-system and component training material in the context of RAMS. The above documentation, procedures and training material shall be reviewed in all subsequent phases.	activity	-	-	sub-system support, component support	shall	-	-	1) establish sub-system support 2) establish component support	including: — preparation, verification and validation of sub-system and component RAMS support documentation; — preparation, verification and validation of operation and maintenance procedures in the context of RAMS; — preparation, verification and validation of sub-system and component training material in the context of RAMS. The above documentation, procedures and training material shall be reviewed in all subsequent phases.	before skipping to phase 8 of the process lifecycle, certain requirements of phase 7 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
157	46	Manufacturing	Requirement 3 of this phase may, if appropriate, be to: a) plan manufacturing to meet requirements.	possible activity	-	-	requirements	may	-	-	plan manufacturing to meet requirements	-	before skipping to phase 8 of the process lifecycle, certain requirements of phase 7 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
158	46	Manufacturing	Requirement 3 of this phase may, if appropriate, be to: b) implement manufacturing to meet requirements.	possible activity	-	-	requirements	may	-	-	implement manufacturing to meet requirements	-	before skipping to phase 8 of the process lifecycle, certain requirements of phase 7 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
159	46	Manufacturing	Requirement 3 of this phase may, if appropriate, be to: c) implement RAMS process assurance to avoid potential RAMS-related failure modes.	possible activity	-	-	RAMS process assurance, RAMS-related failure modes	may	-	-	implement RAMS porcess assurance to avoid potential RAMS-related failure modes	-	before skipping to phase 8 of the process lifecycle, certain requirements of phase 7 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
160	47	Manufacturing	The results of this phase shall be documented, along with any assumptions and justifications made during the phase.	activity	-	-	deliverables	shall	-	-	document results	including any assumptions and justifications made during the phase	before skipping to phase 8 of the process lifecycle, certain requirements of phase 7 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language

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161	47	Manufacturing	A record of all RAMS validation tasks undertaken within the phase shall be maintained.	activity	-	-	deliverables (documents)	shall	-	-	maintain a record of all validation tasks	-	before skipping to phase 8 of the process lifecycle, certain requirements of phase 7 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
162	47	Manufacturing	The deliverables from this phase form a key input to subsequent lifecycle phases.	statement of importance	-	-	deliverables (documents), key input	-	-	-	-	-	-
163	47	Manufacturing	The following verification tasks shall be undertaken within this phase: a) assessment of the adequacy of the information, and where appropriate, data and other statistics, used as input to tasks within this phase.	activity	adequacy of the information, (data, statistics)	-	-	shall	-	-	assess adequacy of information, (data, statistics)	-	before skipping to phase 8 of the process lifecycle, certain requirements of phase 7 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
164	47	Manufacturing	The following verification tasks shall be undertaken within this phase: b) verification that RAMS support documentation is correct, adequate and consistent with lifecycle cost requirements and any target RAMS requirements defined for the system.	activity	correctness, adequacy, consistency	-	RAMS support documentation, lifecycle cost requirements, target RAMS requirements	shall	-	-	verify that RAMS support documentation is 1) correct 2) adequate 3) consistens with lifecycle cost requirements and any target RAMS requirements defined for the system	-	before skipping to phase 8 of the process lifecycle, certain requirements of phase 7 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
165	47	Manufacturing	The following verification tasks shall be undertaken within this phase: c) assessment to ensure that the products being produced manufactured comply with system requirements.	activity	compliance	-	products, system requirements	shall	-	-	assess to ensure that the products being produced manufactured comply with the system requirements	-	before skipping to phase 8 of the process lifecycle, certain requirements of phase 7 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
166	47	Manufacturing	The following verification tasks shall be undertaken within this phase: d) assessment of the adequacy of the methods, tools and techniques used within the phase.	activity	adequacy of the methods, tools and techniques	-	-	shall	-	-	assess adequacy of -methods, -tools, -techniques	-	before skipping to phase 8 of the process lifecycle, certain requirements of phase 7 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language

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167	47	Manufacturing	The following verification tasks shall be undertaken within this phase: e) assessment of the competence of all personnel undeitaking tasks within the phase.	activity	competence of all personnel (undertaking tasks within the phase)	-	-	shall	-	-	assess competence of personnel	-	before skipping to phase 8 of the process lifecycle, certain requirements of phase 7 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
168	47	Manufacturing	Any errors or shortfall may require the re-application of some or all of the activities of one or more previous lifecycle phases.	conditions to repeat	-	-	-	may	errors/shortfalls	re-application of some/all activities of one/more lifecycle phases.	-	-	-
169	47	Installation	The input to this phase shall include all relevant information, and where appropriate, data, necessary to meet the requirement, and in particular the installation Plan prepared in phase 6, the sub-systems and components manufactured in phase 7 and the RAMS support documentation prepared in phase 7.	required input	completeness	-	information, data, requirements, installation plan phase 6, sub-systems & components phase 7 & RAMS support documentation phase 7.	shall	-	-	check completeness of input	-	the required input can be described by using the **data perspective** of the eCRG language
170	47	Installation	Requirement 1 of this phase shall be to assemble and install the total combination of subsystems, components and external facilities required to form the complete system, according to the installation Plan.	activity	-	-	subsystems, components, external facilities, complete system, installation plan	shall	-	-	1) assemble 2) install the total combination of subsystems, components and external facilities required to form the complete system, according to the installation Plan	-	before skipping to phase 9 of the process lifecycle, certain requirements of phase 8 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
171	47	Installation	Requirement 2 of this phase shall be to document the installation process, including: — review plans in the context of requirement 3 of the design and implementation phase (66.3.3); — installation tasks; — action taken to resolve failures and incompatibilities.	activity	-	-	installation process	shall	-	-	document the installation process	including: — review plans in the context of requirement 3 of the design and implementation phase (66.3.3); — installation tasks; — action taken to resolve failures and incompatibilities	before skipping to phase 9 of the process lifecycle, certain requirements of phase 8 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language

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172	47	Installation	Requirement 3 of this phase shall be to review and update the Safety Plan following completion of installation to ensure that any changes to either system or procedures are recorded and effectively managed in future lifecycle tasks.	activity	-	-	safety plan, system, procedures, future lifecycle tasks	shall	-	-	1) review 2) update the safety plan following completion of installation to ensure that any changes to either system or procedures are recorded and effectively managed in future lifecycle tasks	-	before skipping to phase 9 of the process lifecycle, certain requirements of phase 8 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
173	48	Installation	Requirement 4 of this phase shall be to: a) start staff training;	activity	-	-	staff training	shall	-	-	start staff training	-	before skipping to phase 9 of the process lifecycle, certain requirements of phase 8 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
174	48	Installation	Requirement 4 of this phase shall be to: b) make support procedures available;	activity	availability	-	support procedures	shall	-	-	make support procedures available	-	before skipping to phase 9 of the process lifecycle, certain requirements of phase 8 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
175	48	Installation	Requirement 4 of this phase shall be to: c) establish spare parts provision;	activity	-	-	spare parts provision	shall	-	-	establish spare parts provision	-	before skipping to phase 9 of the process lifecycle, certain requirements of phase 8 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
176	48	Installation	Requirement 4 of this phase shall be to: d) establish tool provision.	activity	-	-	tool provision	shall	-	-	establish tool provision	-	before skipping to phase 9 of the process lifecycle, certain requirements of phase 8 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
177	48	Installation	The results of this phase shall be documented, along with any assumptions and justifications made during the phase.	activity	-	-	deliverables	shall	-	-	document results	including any assumptions and justifications made during the phase	before skipping to phase 9 of the process lifecycle, certain requirements of phase 8 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language

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178	48	Installation	A record of all RAMS validation tasks undertaken within the phase, including the installation activity, shall be maintained.	activity	-	-	deliverables (documents)	shall	-	-	maintain a record of all validation tasks	including installation activity	before skipping to phase 9 of the process lifecycle, certain requirements of phase 8 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
179	48	Installation	An updated Safety Plan shall be produced within this phase.	activity	-	-	deliverables (documents), safety plan	shall	-	-	produce an updated safety plan	-	before skipping to phase 9 of the process lifecycle, certain requirements of phase 8 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
180	48	Installation	The deliverables from this phase form a key input to subsequent lifecycle phases.	statement of importance	-	-	deliverables (documents), key input	-	-	-	-	-	-
181	48	Installation	The following verification tasks shall be undertaken within this phase: a) assessment of the adequacy of the information, and where appropriate, data and other statistics, used as input to tasks within this phase;	activity	adequacy of the information, (data, statistics)	-	-	shall	-	-	assess adequacy of information, (data, statistics)	-	before skipping to phase 9 of the process lifecycle, certain requirements of phase 8 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
182	48	Installation	The following verification tasks shall be undertaken within this phase: b) verification that the installation activity was carried out in accordance with the installation Plan;	activity	accordance	-	installation plan	shall	-	-	verify that the installation activity was carried out in accordance with the installation Plan	-	before skipping to phase 9 of the process lifecycle, certain requirements of phase 8 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
183	48	Installation	The following verification tasks shall be undertaken within this phase: c) verification, by analysis and test, that the installed system meets the RAMS requirements;	activity	-	-	system, RAMS requirements	shall	-	-	verify, by analysis and test, that the installed system meets the RAMS requirements	-	before skipping to phase 9 of the process lifecycle, certain requirements of phase 8 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
184	48	Installation	The following verification tasks shall be undertaken within this phase: d) assessment of the safety plan to ensure its continued applicability;	activity	applicability	-	safety plan	shall	-	-	assess safety plan to ensure ist continued applicability	-	before skipping to phase 9 of the process lifecycle, certain requirements of phase 8 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language

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185	48	Installation	The following verification tasks shall be undertaken within this phase: e) assessment of the adequacy and effectiveness of system support arrangements;	activity	adequacy, effectiveness	-	system support arrangements	shall	-	-	assess 1) adequacy 2) effectiveness of system support arrangements	-	before skipping to phase 9 of the process lifecycle, certain requirements of phase 8 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
186	48	Installation	The following verification tasks shall be undertaken within this phase: f) assessment of the adequacy of the methods, tools and techniques used within the phase;	activity	adequacy of the methods, tools and techniques	-	-	shall	-	-	assess adequacy of -methods, -tools, -techniques	-	before skipping to phase 9 of the process lifecycle, certain requirements of phase 8 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
187	48	Installation	The following verification tasks shall be undertaken within this phase: g) assessment of the competence of all personnel undertaking tasks within the phase.	activity	competence of all personnel (undertaking tasks within the phase)	-	-	shall	-	-	assess competence of personnel	-	before skipping to phase 9 of the process lifecycle, certain requirements of phase 8 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
188	48	Installation	Any errors or shortfall may require the re-application of some or all of the activities of one or more previous lifecycle phases.	conditions to repeat	-	-	-	may	errors/shortfalls	re-application of some/all activities of one/more lifecycle phases.	-	-	-
189	49	System validation (including safety acceptance and commissioning)	The input to this phase shall include all relevant information, and where appropriate, data, necessary to meet the requirement, and in particular the system requirements produced in phase 4, the Verification and Validation Plan produced in phase 4, the Commissioning Plan produced in phase 6 and the training material prepared in phase 7.	required input	completeness	-	information, data, requirements, system requirements phase 4, commissioning plan phase 6, training material phase 7.	shall	-	-	check completeness of input	-	the required input can be described by using the **data perspective** of the eCRG language

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190	49	System validation (including safety acceptance and commissioning)	Requirement 1 of this phase shall be to validate the total combination of sub-systems, components and external risk reduction measures according to the Validation Plan and record the validation process, including: — details of RAMS validation tasks against acceptance criteria, including RAM demonstrations and safety analysis; — details of process, tools, equipment used for validation tasks against acceptance criteria; — results of validation tasks for all acceptance criteria; — any limitations and constraints applying to the system; — action taken to resolve failures and incompatibilities.	activity	-	-	sub-systems, components, external risk reduction measures, validation plan	shall	-	-	1) validate the total combination of sub-systems, components and external risk reduction measures according to the Validation Plan 2) record the validation process	including: — details of RAMS validation tasks against acceptance criteria, including RAM demonstrations and safety analysis; — details of process, tools, equipment used for validation tasks against acceptance criteria; — results of validation tasks for all acceptance criteria; — any limitations and constraints applying to the system; — action taken to resolve failures and incompatibilities	before skipping to phase 10 of the process lifecycle, certain requirements of phase 9 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
191	49	System validation (including safety acceptance and commissioning)	Requirement 2 of this phase shall be to: a) commission the total combination of sub-systems, components and external risk reduction measures according to the Commissioning Plan and record the commissioning process, including: — commissioning tasks; — failure reporting and assessment tasks; — action taken to resolve failures and incompatibilities; — details of any limitations or constraints on the use of the system.	activity	-	-	sub-systems, components, external risk reduction measures, commissioning plan	shall	-	-	1) commission the total combination of sub-systems, components and external risk reduction measures according to the Commissioning Plan and 2) record the commissioning process	including: — commissioning tasks; — failure reporting and assessment tasks; — action taken to resolve failures and incompatibilities; — details of any limitations or constraints on the use of the system	before skipping to phase 10 of the process lifecycle, certain requirements of phase 9 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language

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192	49	System validation (including safety acceptance and commissioning)	Requirement 2 of this phase shall be to: b) undertake probationary period of operation, if required, to enable the resolution of in-service system problems. Where use is made of a probationary period of operation as part of system acceptance, consideration shall be given lo the need for system safety to be demonstrated prior to operation of the system in revenue earning service.	possible activity	-	-	in-service system problems	shall	-	-	1) undertake probationary period of operation, if required, to enable the resolution of in-service system problems 2) Where use is made of a probationary period of operation as part of system acceptance, consideration shall be given lo the need for system safety to be demonstrated prior to operation of the system in revenue earning service	-	before skipping to phase 10 of the process lifecycle, certain requirements of phase 9 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language

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193	49	System validation (including safety acceptance and commissioning)	Requirement 3 of this phase shall be to prepare an Application Safety Case for the system, if not already prepared in phase 6 (item 2 of6.6.3.5), to justify that the system, as specifically applied within this application, complies with the system safety requirements. The Application Safety Case requires approval by the Railway Authority, and should include: — an oven/iew of the system; — a summary or reference to the safety requirements, including a consideration of the SIL justifications for safety functions within the application; — a summary of the quality and safety management controls adopted within the lifecycle; — a summary of safety assessment and safety audit tasks; — a summary of safety analysis tasks; — an overview of the safety engineering techniques employed within the system; — adequacy of compliance with safety requirements for the system, including adequacy of compliance with the SIL requirements of the application including its physical realization	activity	compliance	railway authority	application safety case, application, safety requirements	shall	-	-	1) prepare an Application Safety Case for the system, if not already prepared in phase 6 2) get approval from railway authority	including: — an oven/iew of the system; — a summary or reference to the safety requirements, including a consideration of the SIL justifications for safety functions within the application; — a summary of the quality and safety management controls adopted within the lifecycle; — a summary of safety assessment and safety audit tasks; — a summary of safety analysis tasks; — an overview of the safety engineering techniques employed within the system; — adequacy of compliance with safety requirements for the system, including adequacy of compliance with the SIL requirements of the application including its physical realization within the specific application; — a summary of any limitations and constraints applying to the application	before skipping to phase 10 of the process lifecycle, certain requirements of phase 9 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language; the railway authority as a subject can be modeled by using the **resource perspective** of the eCRG language
194	49	System validation (including safety acceptance and commissioning)	Requirement 4 of this phase shall be to establish and implement a process for the acquisition and assessment of operational data as an input to a system improvement process.	activity	-	-	process, operational data, system improvement process	shall	-	-	1) establish 2) implement a process for the acquisition and assessment of operational data as an input to a system improvement process	-	before skipping to phase 10 of the process lifecycle, certain requirements of phase 9 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
195	50	System validation (including safety acceptance and commissioning)	The results of this phase shall be documented, along with any assumptions and justifications made during the phase.	activity	-	-	deliverables	shall	-	-	document results	including any assumptions and justifications made during the phase	before skipping to phase 10 of the process lifecycle, certain requirements of phase 9 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language

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196	50	System validation (including safety acceptance and commissioning)	A record of all RAMS validation tasks undertaken within the phase, including the commissioning activity, shall be maintained.	activity	-	-	deliverables (documents)	shall	-	-	maintain a record of all validation tasks	incldluding the comissioning activity	before skipping to phase 10 of the process lifecycle, certain requirements of phase 9 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
197	50	System validation (including safety acceptance and commissioning)	An Application Specific Safety Case shall be produced for the system within this phase.	activity	-	-	deliverables (documents), application specific safety case	shall	-	-	produce an Application Specific Safety Case	-	before skipping to phase 10 of the process lifecycle, certain requirements of phase 9 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
198	50	System validation (including safety acceptance and commissioning)	A record of all Acceptance Tasks undertaken within this phase shall be maintained.	activity	-	-	record of all acceptance tasks	shall	-	-	maintain a record of all validation tasks	-	before skipping to phase 10 of the process lifecycle, certain requirements of phase 9 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
199	50	System validation (including safety acceptance and commissioning)	The deliverables from this phase form a key input to subsequent lifecycle phases.	statement of importance	-	-	deliverables (documents), key input	-	-	-	-	-	-
200	50	System validation (including safety acceptance and commissioning)	The following process verification tasks shall be undertaken within this phase: a) assessment of the adequacy of the information, and where appropriate, data and other statistics, used as input to tasks within this phase.	activity	adequacy of the information, (data, statistics)	-	-	shall	-	-	assess adequacy of information, (data, statistics)	-	before skipping to phase 10 of the process lifecycle, certain requirements of phase 9 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language

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201	50	System validation (including safety acceptance and commissioning)	The following process verification tasks shall be undertaken within this phase: b) verification and validation, by analysis and test, that the installed system meets RAMS requirements. It should be noted that for some railway systems, acceptance of the Application Specific Safety Case will be required prior to installation and commissioning activities taking place.	activity	acceptance	-	system, RAMS requirements, railway systems, application specific safety case, installation activities, commissioning activities	shall	-	-	1) verification and validation, by analysis and test, that the installed system meets RAMS requirements 2) It should be noted that for some railway systems, acceptance of the Application Specific Safety Case will be required prior to installation and commissioning activities taking place	-	before skipping to phase 10 of the process lifecycle, certain requirements of phase 9 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
202	50	System validation (including safety acceptance and commissioning)	The following process verification tasks shall be undertaken within this phase: c) verification that the commissioning activity was carried out in accordance with the Commissioning Plan.	activity	accordance	-	commissioning activity, commissioning plan	shall	-	-	verify that the commissioning activity was carried out in accordance with the Commissioning Plan	-	before skipping to phase 10 of the process lifecycle, certain requirements of phase 9 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
203	50	System validation (including safety acceptance and commissioning)	The following process verification tasks shall be undertaken within this phase: d) assessment of the adequacy and effectiveness of the operational data collection system.	activity	adequacy, effectiveness	-	operational data collection system	shall	-	-	assess 1) adequacy 2) effectiveness of the operational data collection system	-	before skipping to phase 10 of the process lifecycle, certain requirements of phase 9 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
204	50	System validation (including safety acceptance and commissioning)	The following process verification tasks shall be undertaken within this phase: e) assessment of the adequacy of the methods, tools and techniques used within the phase.	activity	adequacy of the methods, tools and techniques	-	-	shall	-	-	assess the adequacy of the methods, tools and techniques used within the phase	-	before skipping to phase 10 of the process lifecycle, certain requirements of phase 9 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language

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205	50	System validation (including safety acceptance and commissioning)	The following process verification tasks shall be undertaken within this phase: f) assessment of the competence of all personnel undertaking tasks within the phase.	activity	competence of all personnel (undertaking tasks within the phase)	-	-	shall	-	-	assess competence of personnel	-	before skipping to phase 10 of the process lifecycle, certain requirements of phase 9 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
206	50	System validation (including safety acceptance and commissioning)	Any errors or shortfall may require the re-application of some or all of the activities of one or more previous lifecycle phases.	conditions to repeat	-	-	-	may	errors/shortfalls	re-application of some/all activities of one/more lifecycle phases.	-	-	-
207	50	System acceptance	The input to this phase shall include all relevant information, and where appropriate, data, necessary to meet the requirement, and in particular the system requirements prepared in phase 4, the Verification and Validation Plan and Acceptance Plan prepared in phase4 and the record of verification and validation tasks prepared in phase 9.	required input	completeness	-	information, data, requirements (system requirements prepared in phase 4, verification, validation & acceptance plan prepared in phase 4, record of verification and validation tasks prepared in phase 9)	shall	-	-	check completeness of input	-	the required input can be described by using the **data perspective** of the eCRG language
208	50	System acceptance	Requirement 1 of this phase shall be to assess all system verification and validation tasks, specifically the RAM verification and validation and the Application Specific Safety Case, in accordance with the System Acceptance Plan.	activity	accordance	-	system verification tasks, system validation tasks, RAM verification and validation and application specfic safety case, system acceptance plan	shall	-	-	assess all system verification and validation tasks, specifically the RAM verification and validation and the Application Specific Safety Case, in accordance with the System Acceptance Plan	-	before skipping to phase 11 of the process lifecycle, certain requirements of phase 10 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language

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209	51	System acceptance	Requirement 2 of this phase shall be to formally accept the system for entry into service, if appropriate.	activity	acceptance	-	system	shall	-	-	formally accept the system for entry into service, if appropriate	-	before skipping to phase 11 of the process lifecycle, certain requirements of phase 10 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
210	51	System acceptance	Requirement 3 of this phase shall be to review and update the Hazard Log to record any residual hazards identified during system validation or acceptance and to ensure that the risks from any such hazards are effectively managed.	activity	-	-	hazard log, hazards	shall	-	-	1) review 2) update Hazard Log to record any residual hazards identified during system validation or acceptance 3) ensure that the risks from any such hazards are effectively managed	-	before skipping to phase 11 of the process lifecycle, certain requirements of phase 10 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
211	51	System acceptance	The results of this phase shall be documented, along with any assumptions and justifications made during the phase.	activity	-	-	deliverables	shall	-	-	document results	including any assumptions and justifications made during the phase	before skipping to phase 11 of the process lifecycle, certain requirements of phase 10 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
212	51	System acceptance	A record of all acceptance tasks undertaken within the phase, shall be maintained.	activity	-	-	record of all acceptance tasks	shall	-	-	maintain a record of all validation tasks	-	before skipping to phase 11 of the process lifecycle, certain requirements of phase 10 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
213	51	System acceptance	An updated Hazard Log shall be produced within this phase.	activity	-	-	hazard log	shall	-	-	produce an updated hazard log	-	before skipping to phase 11 of the process lifecycle, certain requirements of phase 10 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
214	51	System acceptance	The deliverables from this phase form a key input to subsequent lifecycle phases.	statement of importance	-	-	deliverables (documents), key input	-	-	-	-	-	-

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215	51	System acceptance	The following verification tasks shall be undertaken within this phase: a) assessment of the adequacy of the information, and where appropriate, data and other statistics, used as input to tasks within this phase;	activity	adequacy of the information, (data, statistics)	-	-	shall	-	-	assess adequacy of information , (data, statistics)	-	before skipping to phase 11 of the process lifecycle, certain requirements of phase 10 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
216	51	System acceptance	The following verification tasks shall be undertaken within this phase: b) acceptance, by analysis and test, that the system meets the RAMS requirements, including lifecycle cost requirements;	activity	-	-	RAMS requirements, system, lifecycle cost requirements	shall	-	-	verify, by analysis and test, that the system meets the RAMS requirements	incldluing lifecycle cost requirements	before skipping to phase 11 of the process lifecycle, certain requirements of phase 10 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
217	51	System acceptance	The following verification tasks shall be undertaken within this phase: c) verification that the acceptance activity was carried out in accordance with the Acceptance Plan;	activity	accordance	-	acceptance activity, acceptance plan	shall	-	-	verify, that the acceptance activity was carried out in accordance with the Acceptance Plan	-	before skipping to phase 11 of the process lifecycle, certain requirements of phase 10 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
218	51	System acceptance	The following verification tasks shall be undertaken within this phase: d) assessment of the continued applicability of the revised safety plan;	activity	applicability	-	revised safety plan	shall	-	-	assess continued applicability of the revised safety plan	-	before skipping to phase 11 of the process lifecycle, certain requirements of phase 10 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
219	51	System acceptance	The following verification tasks shall be undertaken within this phase: e) assessment to ensure that any residual hazards are being managed effectively;	activity	effectiveness	-	residual hazards	shall	-	-	assess to ensure any residual hazards are being managed effectively	-	before skipping to phase 11 of the process lifecycle, certain requirements of phase 10 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
220	51	System acceptance	The following verification tasks shall be undertaken within this phase: f) assessment of the adequacy and completeness of the application specific safety case;	activity	adequacy, completeness	-	application specific safety case	shall	-	-	assess adequacy and completeness of the application specific safety case	-	before skipping to phase 11 of the process lifecycle, certain requirements of phase 10 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
221	51	System acceptance	The following verification tasks shall be undertaken within this phase: g) assessment of the adequacy of the methods, tools and techniques used within the phase;	activity	adequacy of the methods, tools and techniques	-	-	shall	-	-	assess adequacy of methods, tools, techniques	-	before skipping to phase 11 of the process lifecycle, certain requirements of phase 10 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language

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222	51	System acceptance	The following verification tasks shall be undertaken within this phase: h) assessment of the competence of all personnel undertaking tasks within the phase.	activity	competence of all personnel (undertaking tasks within the phase)	-	-	shall	-	-	assess competence of personnel	-	before skipping to phase 11 of the process lifecycle, certain requirements of phase 10 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
223	51	System acceptance	Any errors or shortfall may require the re-application of some or all of the activities of one or more previous lifecycle phases.	conditions to repeat	-	-	-	may	errors/shortfalls	re-application of some/all activities of one/more lifecycle phases.	-	-	-
224	51	Operation and maintenance	The input to this phase shall include all relevant information, and where appropriate, data, necessary to meet the requirement, and in particular the operation and maintenance procedures prepared in phase 6.	required input	completeness	-	information, data, requirements (operation & maintenance procedures prepared in phase 6)	shall	-	-	check completeness of input	-	the required input can be described by using the **data perspective** of the eCRG language
225	51	Operation and maintenance	Requirement 1 of this phase shall be to monitor implementation of the system and to implement the operation and maintenance procedures, particularly with regard to system performance and lifecycle cost issues.	activity	-	-	system, operation and maintenance procedures	shall	-	-	1) monitor implementation of the system 2) implement the operation and maintenance procedures	inclduding the regard to system perdormance and lifecycle cost issues	before skipping to phase 12 of the process lifecycle, certain requirements of phase 11 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
226	52	Operation and maintenance	Requirement 2 of this phase shall be to assure compliance with system RAMS requirements, throughout this phase, by: a) regular review and update of operation and maintenance procedures;	activity	compliance	-	system RAMS requirements	shall	-	-	assure compliance with system RAMS requirements	including: regular review and update of operation and maintenance procedures	before skipping to phase 12 of the process lifecycle, certain requirements of phase 11 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
227	52	Operation and maintenance	Requirement 2 of this phase shall be to assure compliance with system RAMS requirements, throughout this phase, by: b) regular review of system training documentation;	activity	compliance	-	system RAMS requirements	shall	-	-	assure compliance with system RAMS requirements	including: regular review of system training documentation	before skipping to phase 12 of the process lifecycle, certain requirements of phase 11 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
228	52	Operation and maintenance	Requirement 2 of this phase shall be to assure compliance with system RAMS requirements, throughout this phase, by: c) regular review and update of Hazard Log and Safety Case;	activity	compliance	-	system RAMS requirements, hazard log, safety case	shall	-	-	assure compliance with system RAMS requirements	including: regular 1) review 2) update of hazard log and safety case	before skipping to phase 12 of the process lifecycle, certain requirements of phase 11 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language

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229	52	Operation and maintenance	Requirement 2 of this phase shall be to assure compliance with system RAMS requirements, throughout this phase, by: d) effective logistic support, including spare parts, tools, calibration, competent staff, RAMS focused maintenance.	activity	compliance	-	system RAMS requirements	shall	-	-	assure compliance with system RAMS requirements by effective logistic support	including: spare parts, tools, calibration, competent staff, RAMS focused maintenance	before skipping to phase 12 of the process lifecycle, certain requirements of phase 11 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
230	52	Operation and maintenance	Requirement 2 of this phase shall be to assure compliance with system RAMS requirements, throughout this phase, by: e) maintenance of the failure reporting and corrective action system (FRACAS).	activity	compliance	-	system RAMS requirements	shall	-	-	shall be to assure compliance with system RAMS requirements, throughout this phase, by maintenance of the failure reporting and corrective action system (FRACAS	-	before skipping to phase 12 of the process lifecycle, certain requirements of phase 11 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
231	52	Operation and maintenance	A record of all RAMS tasks undertaken within the phase shall be maintained, along with any assumptions and justifications made during the phase.	activity	-	-	RAMS tasks	shall	-	-	maintain a record of all RAMS tasks	including any assumptions and justifications made during the phase	before skipping to phase 12 of the process lifecycle, certain requirements of phase 11 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
232	52	Operation and maintenance	System documentation shall be updated, as appropriate, within this phase.	possible activity	-	-	system documentation	shall	-	-	update system documentation	-	before skipping to phase 12 of the process lifecycle, certain requirements of phase 11 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
233	52	Operation and maintenance	The deliverables from this phase form a key input to subsequent lifecycle phases.	statement of importance	-	-	deliverables (documents), key input	-	-	-	-	-	-
234	52	Operation and maintenance	The following verification tasks shall be undertaken within this phase: a) assessment of the adequacy of the information, and where appropriate, data and other statistics, used as input to tasks within this phase.	activity	adequacy of the information, (data, statistics)	-	-	shall	-	-	assess adequacy of information , (data, statistics)	-	before skipping to phase 12 of the process lifecycle, certain requirements of phase 11 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language

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235	52	Operation and maintenance	The following verification tasks shall be undertaken within this phase: b) verification that changes in support arrangements are consistent with system RAMS requirements and lifecycle cost requirements.	activity	consistency	-	support arrangement, RAMS requirements, lifecycle costs	shall	-	-	1) verify that changes in support arrangements are consistent with system RAMS requirements 2) that changes in support arrangements are consistent with lifecycle cost requirements	-	before skipping to phase 12 of the process lifecycle, certain requirements of phase 11 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
236	52	Operation and maintenance	The following verification tasks shall be undertaken within this phase: c) assessment of the adequacy of the methods, tools and techniques used within the phase.	activity	adequacy of the methods, tools and techniques	-	-	shall	-	-	assess adequacy of -methods, -tools, -techniques	-	before skipping to phase 12 of the process lifecycle, certain requirements of phase 11 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
237	52	Operation and maintenance	The following verification tasks shall be undertaken within this phase: d) assessment of the competence of all personnel undertaking tasks within the phase.	activity	competence of all personnel (undertaking tasks within the phase)	-	-	shall	-	-	assess competence of personnel	-	before skipping to phase 12 of the process lifecycle, certain requirements of phase 11 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
238	52	Performance monitoring	The input to this phase shall include all relevant information, and where appropriate, data, necessary to meet the requirement, particularly system RAMS requirements and system support data.	required input	completeness	-	information, data, requirements (system RAMS requirements & system support data)	shall	-	-	check completeness of input	-	the required input can be described by using the **data perspective** of the eCRG language
239	52	Performance monitoring	Requirement 1 of this phase shall be to establish, implement and regularly review a process for: — the collection of operational performance and RAMS statistics; — the acquisition, analysis and evaluation of performance and RAMS data; — checking that the assumptions made in the safety case remain valid.	activity	-	-	process	shall	-	-	1) establish 2) implement 3) regularly review a process	including (for): — the collection of operational performance and RAMS statistics; — the acquisition, analysis and evaluation of performance and RAMS data; — checking that the assumptions made in the safety case remain valid	before skipping to phase 13 of the process lifecycle, certain requirements of phase 12 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language

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240	52	Performance monitoring	Requirement 2 of this phase shall be to analyse performance and RAMS data and statistics to influence: — new operating and maintenance procedures; — changes in logistic support for the system.	activity	performance	-	RAMS data, RAMS statistics	shall	-	-	analyse 1) performance and 2)RAMS data and 3) statistics	including (influence): — new operating and maintenance procedures; — changes in logistic support for the system	before skipping to phase 13 of the process lifecycle, certain requirements of phase 12 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
241	53	Performance monitoring	A record of all performance monitoring tasks undertaken within the phase shall be maintained, along with any assumptions and justifications made during the phase.	activity	-	-	performance monitoring tasks	shall	-	-	maintain a record of all performance monitoring tasks	including any assumptions and justifications made during the phase	before skipping to phase 13 of the process lifecycle, certain requirements of phase 12 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
242	53	Performance monitoring	System support documentation may be updated within this phase.	possible activity	-	-	system support documentation	may	-	-	update system support documentation	-	before skipping to phase 13 of the process lifecycle, certain requirements of phase 12 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
243	53	Performance monitoring	The deliverables from this phase form a key input to subsequent lifecycle phases.	statement of importance	-	-	deliverables (documents), key input	-	-	-	-	-	-
244	53	Performance monitoring	The following process verification tasks shall be undertaken within this phase: a) assessment of the adequacy of the information, and where appropriate, data and other statistics, used as input to tasks within this phase.	activity	adequacy of the information, (data, statistics)	-	-	shall	-	-	assess adequacy of information, (data, statistics)	-	before skipping to phase 13 of the process lifecycle, certain requirements of phase 12 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
245	53	Performance monitoring	The following process verification tasks shall be undertaken within this phase: b) verification that changes in support arrangements are consistent with system RAMS requirements and lifecycle cost requirements.	activity	consistency	-	support arrangement, RAMS requirements, lifecycle cost requirements	shall	-	-	verify that changes in support arrangements are consistent with system RAMS requirements and lifecycle cost requirements	-	before skipping to phase 13 of the process lifecycle, certain requirements of phase 12 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
246	53	Performance monitoring	The following process verification tasks shall be undertaken within this phase: c) assessment of the adequacy of the methods, tools and techniques used within the phase.	activity	adequacy of the methods, tools and techniques	-	-	shall	-	-	assess adequacy of -methods, -tools, -techniques	-	before skipping to phase 13 of the process lifecycle, certain requirements of phase 12 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language

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247	53	Performance monitoring	The following process verification tasks shall be undertaken within this phase: d) assessment of the competence of all personnel undertaking tasks within the phase.	activity	competence of all personnel (undertaking tasks within the phase)	-	-	shall	-	-	assess competence of personnel	-	before skipping to phase 13 of the process lifecycle, certain requirements of phase 12 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
248	53	Modification and retrofit	The input to this phase shall include all relevant information, and where appropriate, data, necessary to meet the requirement.	required input	completeness	-	information, data, requirements	shall	-	-	check completeness of input	-	the required input can be described by using the **data perspective** of the eCRG language
249	53	Modification and retrofit	Requirement 1 of this phase shall be to establish a safety plan.	activity	-	-	safety plan	shall	-	-	establish a safety plan	-	before skipping to phase 14 of the process lifecycle, certain requirements of phase 13 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
250	53	Modification and retrofit	Requirement 2 of this phase shall be to establish, implement and regularly review a process to control system modification and retrofit, in the context of RAMS, including: — control through the mandatory use of an appropriate lifecycle model for all modification and retrofitting tasks; — a requirement to establish a procedure for verifying, validating and accepting the RAMS performance of the system following modification and retrofit; — a requirement to analyse the reasons for the change; — a requirement to carry out a RAMS impact analysis of the change, including the impact on lifecycle cost requirements; — a requirement to plan the implementation and subsequent acceptance of the change; — a requirement to record modification and retrofit tasks; — a requirement to update all affected system documentation.	activity	-	-	process, RAMS	shall	-	-	1) establish 2) implement 3) regularly review a process to control system modification and retrofit, in the context of RAMS	including: — control through the mandatory use of an appropriate lifecycle model for all modification and retrofitting tasks; — a requirement to establish a procedure for verifying, validating and accepting the RAMS performance of the system following modification and retrofit; — a requirement to analyse the reasons for the change; — a requirement to carry out a RAMS impact analysis of the change, including the impact on lifecycle cost requirements; — a requirement to plan the implementation and subsequent acceptance of the change; — a requirement to record modification and retrofit tasks; — a requirement to update all affected system documentation	before skipping to phase 14 of the process lifecycle, certain requirements of phase 13 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
251	53	Modification and retrofit	The key deliverable from this phase is a validated, modified system.	statement of importance	-	-	key deliverable, validated, modified system	-	-	-	-	-	-

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252	53	Modification and retrofit	The results of this phase shall be documented, along with any assumptions and justifications made during the phase.	activity	-	-	deliverables	shall	-	-	document results	including any assumptions and justifications made during the phase	before skipping to phase 14 of the process lifecycle, certain requirements of phase 13 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
253	54	Modification and retrofit	A record of all verification, validation and acceptance tasks undertaken within the phase, shall be maintained.	activity	-	-	deliverables, verification, validation and acceptance tasks	shall	-	-	maintain a record of all verification, validation and acceptance tasks	-	before skipping to phase 14 of the process lifecycle, certain requirements of phase 13 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
254	54	Modification and retrofit	An updated Hazard Log should be produced within this phase.	activity	-	-	hazard log	should	-	-	produce an updated hazard log	-	before skipping to phase 14 of the process lifecycle, certain requirements of phase 13 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
255	54	Modification and retrofit	An updated Application Safety Case shall be produced within this phase.	activity	-	-	application safety case	shall	-	-	produce an updated application safety case	-	before skipping to phase 14 of the process lifecycle, certain requirements of phase 13 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
256	54	Modification and retrofit	All RAM related documents should be reviewed and updated where necessary.	activity	-	-	RAM related documents	should	-	-	1) review all RAM related documents 2) update al RAM related documentsl	-	before skipping to phase 14 of the process lifecycle, certain requirements of phase 13 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
257	54	Modification and retrofit	The deliverables from this phase form a key input to subsequent lifecycle phases.	statement of importance	-	-	deliverables (documents), key input	-	-	-	-	-	-
258	54	Modification and retrofit	The following process verification tasks shall be undertaken within this phase: a) assessment of the adequacy of the information, and where appropriate, data and other statistics, used as input to tasks within this phase;	activity	adequacy of the information, (data, statistics)	-	-	shall	-	-	assess adequacy of information, (data, statistics)	-	before skipping to phase 14 of the process lifecycle, certain requirements of phase 13 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language

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259	54	Modification and retrofit	The following process verification tasks shall be undertaken within this phase: b) verify and validate that any changes or modifications to the system are consistent with the RAMS requirements for the system and lifecycle cost requirements;	activity	-	-	system, RAMS requirements, lifecycle cost requirements	shall	-	-	1) verify 2) validate that any changes or modifications to the system are consistent with the RAMS requirements for the system and lifecycle cost requirements	-	before skipping to phase 14 of the process lifecycle, certain requirements of phase 13 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
260	54	Modification and retrofit	The following process verification tasks shall be undertaken within this phase: c) assessment of the adequacy and completeness of any amended system documentation, in particular, any system safety case documents;	activity	adequacy, completeness	-	amended system documentation, system safety case documents	shall	-	-	assess adequacy and completeness of any amended system documentation	including: any system safety case documents	before skipping to phase 14 of the process lifecycle, certain requirements of phase 13 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
261	54	Modification and retrofit	The following process verification tasks shall be undertaken within this phase: d) assessment of the adequacy of the methods, tools and techniques used within the phase;	activity	adequacy of the methods, tools and techniques	-	-	shall	-	-	assess adequacy of -methods, -tools, -techniques	-	before skipping to phase 14 of the process lifecycle, certain requirements of phase 13 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
262	54	Modification and retrofit	The following process verification tasks shall be undertaken within this phase: e) assessment of the competence of all personnel undertaking tasks within the phase.	activity	competence of all personnel (undertaking tasks within the phase)	-	-	shall	-	-	assess competence of personnel	-	before skipping to phase 14 of the process lifecycle, certain requirements of phase 13 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
263	54	Decommissioning and disposal	The input to this phase shall include all relevant information, and where appropriate, data, necessary to meet the requirement.	required input	completeness	-	information, data, requirements	shall	-	-	check completeness of input	-	the required input can be described by using the **data perspective** of the eCRG language
264	54	Decommissioning and disposal	Requirement 1 of this phase shall be to: a) establish the impact of decommissioning and disposal on any system or external facility associated with the system to be de-commissioned.	activity	-	-	decommissioning, disposal of system, external facility (associated with system)	shall	-	-	establish the impact of decommissioning and disposal on any system or external facility associated with the system to be de-commissioned	-	before finishing the process lifecycle, certain requirements of phase 14 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language

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265	54	Decommissioning and disposal	Requirement 1 of this phase shall be to: b) plan the decommissioning, including the establishment of procedures for: — the safe closing down of the system and any associated external facility; — the safe dismantling of the system and any associated external facmty; — the continued assurance of compliance with RAMS requirements of any systems or external facility affected by the decommissioning of the system.	activity	-	-	decommissioning	shall	-	-	plan decommissioning	including: establishment of procedures for: — the safe closing down of the system and any associated external facility; — the safe dismantling of the system and any associated external facmty; — the continued assurance of compliance with RAMS requirements of any systems or external facility affected by the decommissioning of the system.	before finishing the process lifecycle, certain requirements of phase 14 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
266	54	Decommissioning and disposal	Requirement 2 of this phase shall be to provide an analysis of RAMS llfecycle performance for input to future systems, including lifecycle costings.	activity	performance	-	(input) to future systems, lifecycle costings	shall	-	-	provide an analysis of RAMS llfecycle performance for input to future systems	including lifecycle costings	before finishing the process lifecycle, certain requirements of phase 14 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
267	54	Decommissioning and disposal	The results of this phase shall be documented, along with any assumptions and justifications made during the phase.	activity	-	-	deliverables	shall	-	-	document results	including any assumptions and justifications made during the phase	before finishing the process lifecycle, certain requirements of phase 14 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
268	54	Decommissioning and disposal	A record of all de-commissioning and disposal tasks undertaken within the phase, shall be maintained.	activity	-	-	de-commissioning and disposal tasks	shall	-	-	maintain a record of all de-commissioning and disposal tasks	-	before finishing the process lifecycle, certain requirements of phase 14 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
269	55	Decommissioning and disposal	An updated Hazard Log should be produced within this phase.	activity	-	-	hazard log	should	-	-	produce an updated hazard log	-	before finishing the process lifecycle, certain requirements of phase 14 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
270	55	Decommissioning and disposal	A Safety Plan should be established to address the de-commissioning and disposal tasks and closed out following completion of the work.	activity	-	-	safety plan, de-commissioning and disposal tasks	should	-	-	establish a safety plan	-	before finishing the process lifecycle, certain requirements of phase 14 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language

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271	55	Decommissioning and disposal	A revised Application Safety Case may be produced within this phase.	possible activity	-	-	revised application safety case	may	-	-	produce a revised application safety case	-	before finishing the process lifecycle, certain requirements of phase 14 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
272	55	Decommissioning and disposal	Updated documentation may be produced covering the continued compliance with RAMS requirements of affected associated systems during the decommissioning and disposal tasks.	possible activity	compliance	-	RAMS requirements, de-commissioning and disposal tasks	may	-	-	produce updated documentation	-	before finishing the process lifecycle, certain requirements of phase 14 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
273	55	Decommissioning and disposal	The following process verification tasks shall be undertaken within this phase: a) the adequacy of the information, and where appropriate, data and other statistics, used as input to tasks within this phase shall be assessed;	activity	adequacy of the information, (data, statistics)	-	-	shall	-	-	assess adequacy of the information, and where appropriate, data and other statistics, used as input to tasks within this phase shall be assessed	-	before finishing the process lifecycle, certain requirements of phase 14 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
274	55	Decommissioning and disposal	The following process verification tasks shall be undertaken within this phase: b) assessment of the adequacy of any documentation for systems affected by decommissioning and disposal activities;	activity	adequacy of any documentation for systems	-	systems	shall	-	-	assess adequacy of any documentation for systems affected by decommissioning and disposal activities	-	before finishing the process lifecycle, certain requirements of phase 14 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
275	55	Decommissioning and disposal	The following process verification tasks shall be undertaken within this phase: c) assessment of the adequacy of the methods, tools and techniques used within the phase;	activity	adequacy of the methods, tools and techniques	-	-	shall	-	-	assess adequacy of -methods, -tools, -techniques	-	before finishing the process lifecycle, certain requirements of phase 14 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language
276	55	Decommissioning and disposal	The following process verification tasks shall be undertaken within this phase: d) assessment of the competence of all personnel undertaking tasks within the phase.	activity	competence of all personnel (undertaking tasks within the phase)	-	-	shall	-	-	assess competence of personnel	-	before finishing the process lifecycle, certain requirements of phase 14 have to be fulfilled - this can be descriebed by using the **control flow perspective** of the eCRG language