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PISA Model Process Improvement Scheme for Automotive - Version: 3.0

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PISA Model Process Improvement Scheme for Automotive - Version: 3.0
Lami G.; Falcini F.
ISTI-TR-2024/006

Abstract
The PISA model Version 3.0 provides the automotive community with an automotive-specific standard to support organization and project benchmarking in the context of technological developments, with a focus on software-intensive ones. The current version is an extension to address innovative aspects in developments of software-intensive automotive components. The PISA model natively targets the characteristics of automotive developments by incorporating automotive development key aspects. The PISA model provides a risk-oriented evaluation model in the context of a project and organization evaluation. This approach is beneficial for all stakeholders of the automotive supply chain. The purpose of the PISA model is to evaluate performance of an automotive development project and/or benchmark an organization using an automotive specific perspective.

Automotive, Project Performance Evaluation, Process Assessment, Software Development.

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PIS A

Process Improvement Scheme

for Automotive

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0.2	Conceptual model definition of PISA Model
0.3	Engineering Process Definition
0.4	Revised draft containing system process baseline
1.0	Release for SSEC Internal Review
1.1	Insertion of a new chapter (Tour of PISA Model)
1.2	Insertion of Annex A and Annex B
2.0	Version released to CATARC
2.1	Internal version
2.2	Internal version update
2.3	Version for standardization support
2.4	Release for Second Round of Trials
3.0	General availability

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1. Introduction

1.1 Purpose

The purpose of the PISA model is to provide the automotive community with an automotive-specific standard able to support organization and project benchmarking in the context of technological developments, with a focus on software-intensive ones.

1.2 Scope

The PISA model, in the context of a development project, addresses the evaluation of:

1. System-level development
2. Hardware-level development (in a broad sense)
3. Software-level development.

1.3 Glossary

acceptance test: test of a system or functional unit usually performed by the purchaser on hi333s premise after installation with the participation of the vendor to ensure that the contractual requirements are met. [ISO/IEC/IEEE 24765]

Q-CLASS: integrated and risk-oriented indicator to evaluate the performance of an automotive development project according to the PISA model.

assessment: examination of a product, process, or set of processes to assess compliance with specifications, standards, contractual agreements, or other criteria.

baseline: formally approved version of a configuration item, regardless of media, formally designated and fixed at a specific time during the configuration item's life cycle [IEEE 15288]

code inspection: meeting at which software code is presented to project personnel, managers, users, customers, or other interested parties for comment or approval. [ISO/IEC/IEEE 24765]

configuration item: work product or aggregation of work products that is designated for configuration management and treated as a single entity in the configuration management process.

deliverable: item to be provided to an acquirer or other designated recipient as specified in an agreement process. [IEEE 730]

document: uniquely identified unit of information for human use, such as a report, specification, manual or book, in printed or electronic form. [ISO/IEC/IEEE15289]

documentation: collection of documents on a given subject [ISO/IEC/IEEE 24765]

error: difference between a computed, observed, or measured value or condition and the true, specified, or theoretically correct value or condition. [ISO/IEC/IEEE 24765]

failure:
termination of the ability of a system to perform a required function or its inability to perform within previously specified limits. [ISO/IEC 15026]

fault: defect in a system or a representation of a system that if executed/activated could potentially result in an error. [ISO/IEC 15026]

formal notation: specification written in a formal notation, often for use in proof of correctness. [ISO/IEC/IEEE 24765]

formal verification: verification conducted in accordance with verification plans and procedures that have been reviewed and approved by a customer, user, or designated level of management.

functional requirement: statement that identifies what results a product or process shall produce. [ISO/IEC/IEEE 24765]

inspection: a static analysis technique that relies on visual examination of development products to detect errors, violations of development standards, and other problems. [ISO/IEC/IEEE 24765]

integration: process of combining software components, hardware components, or both into an overall system. [ISO/IEC/IEEE 24765]

integration testing: testing in which software components, hardware components, or both are combined and tested to evaluate the interaction among them. [IEEE 1012]

interface: shared boundary between two functional units, defined by various characteristics pertaining to the functions, physical signal exchanges, and other characteristics. [ISO/IEC 2382]

life-cycle: evolution of a system, product, service, project or other human made entity from conception through retirement [ISO/IEC 12207]

management: system of controls and processes required to achieve the strategic objectives set by the organization's governing body. [ISO/IEC/IEEE 24765]

metric: quantitative measure of the degree to which a system, component, or process possesses a given attribute [ISO/IEC/IEEE 24765]

non-functional requirement: requirement that describes not what the product will do but how the product will do it.

organizational unit: identified part of an organization that deploys one or more processes that operate within a coherent set of business goals and which forms the basis for the scope of a process assessment. [ISO/IEC 33001]

process: set of interrelated or interacting activities that transforms inputs into outputs [IEEE 730]

process assessment: disciplined evaluation of an organizational unit's processes against a process assessment model [ISO/IEC 33001]

project: endeavor with defined start and finish criteria undertaken to create a product or service in accordance with specified resources and requirements. [ISO/IEC/IEEE 15939]

quality: degree to which the system satisfies the stated and implied needs of its various stakeholders, and thus provides value [ISO/IEC 25010]

quality assurance: part of quality management focused on providing confidence that quality requirements will be fulfilled [ISO/IEC TS 24748]

quality management: coordinated activities to direct and control an organization with regard to quality [ISO/IEC TS 24748]

quality model: defined set of characteristics and of relationships between them, which provides a framework for specifying quality requirements and evaluating quality [ISO/IEC 25000]

regression testing: selective retesting of a system or item to verify that modifications have not caused unintended effects and that the system or item still complies with specified requirements. [Automotive SPICE]

release: particular version of a configuration item that is made available for a specific purpose [IEEE 828]

requirement: a property or capability that must be achieved or possessed by a system, system item, product, or service to satisfy a contract, standard, specification or other formally imposed documents. [Automotive SPICE]

risk: function of the probability of occurrence of a given threat and the potential adverse consequences of that threat's occurrence [ISO/IEC 25010]

software: all or part of the programs, procedures, rules, and associated documentation of an information processing system [IEEE 828]

software component: logically separable part of a program.

software quality assurance: a set of activities that assess adherence to, and the Q-CLASS of the software processes used to develop and modify software products. SQA also determines the degree to which the desired results from software quality control are being obtained [PMBOK]

software unit: atomic-level software component of the software architecture that can be subjected to standalone testing [ISO/IEC TS 24748]

specification: information item that identifies, in a complete, precise, and verifiable manner, the requirements, design, behavior, or other expected characteristics of a system, service, or process [ISO/IEC/IEEE 15289]

system: combination of interacting elements organized to achieve one or more stated purposes [ISO/IEC/IEEE 15939]

system architecture: fundamental concepts or properties of a system in its environment embodied in its elements, relationships, and in the principles of its design and evolution [ISO/IEC/IEEE 24765]

system element: a member of a set of elements that constitutes a system. A system element is a discrete part of a system that can be implemented to fulfil specified requirements. A system element can be hardware, software, data, humans, processes (e.g., processes for providing service to users), procedures (e.g., operator instructions), facilities, materials, and naturally occurring entities (e.g., water, organisms, minerals), or any combination. [ISO/IEC 15288:2015]

technological readiness: extent to which a technological support aligned with the state-of-the-art and compatible with the organization’s means is provided

test case: set of test inputs, execution conditions, and expected results developed for a particular objective, such as to exercise a particular program path or to verify compliance with a specific requirement [IEEE 1012]

traceability: degree to which a relationship can be established between two or more products of the development process, especially products having a predecessor-successor or master-subordinate relationship to one another [ISO/IEC 19506]

validation: confirmation, through the provision of objective evidence, that the requirements for a specific intended use or application have been fulfilled [ISO/IEC 25000]

verification: confirmation, through the provision of objective evidence, that specified requirements have been fulfilled [ISO/IEC 25000]

walk-through: static analysis technique in which a designer or programmer leads members of the development team and other interested parties through a family of documentation or code, and the participants ask questions and make comments about possible errors, violation of development standards, and other problems [ISO/IEC/IEEE 24765]

work-breakdown structure (WBS): deliverable-oriented hierarchical decomposition of the work to be executed by the project team to accomplish the project objectives and create the required deliverables [ISO/IEC TR 29110]

work-product: artifact associated with the execution of a process [ISO/IEC TR 29110]

1.4 Acronyms

AIAG: Automotive Industry Action Group

APQP: Advanced Product Quality Planning

ASAM Association for Standardization of Automation and Measuring Systems

AUTOSAR: Automotive Open System Architecture

BOM: Bill of Material

CCB: Change (or Configuration) Control Board

DFMA: Design for Manufacturing and Assembly

DNN: Deep Neural Network

DV: Design Validation

E/E: Electric and Electronic

ECU: Electronic Control Unit

EoL: End of Line

FMEA: Failure Mode and Effect Analysis

HIL: Hardware-In-the-Loop

HSI: Hardware Software Interface

IEC: International Electro-Technical Commission

ISO: International Standardization Organization

IEEE: Institute of Electrical and Electronic Engineers

MISRA: Motor Industry Software Reliability Association

OEM: Original Equipment Manufacturer

PIL: Processor-In-the-Loop

PMBOK: Project Management Body of Knowledge

PPAP: Production Parts Approval Process

PV: Production Validation

QA: Quality Assurance

QMS: Quality Management System

SAE: Society of Automotive Engineers

SIL: Software-In-the-Loop

SPICE: Software Process improvement and Capability Determination

VDA: Verband der Automobilindustrie

V&V: Verification and Validation

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2. PISA model Key Concepts

2.1 Overview

The PISA model natively targets the characteristics of automotive developments by incorporating automotive development key aspects.

The PISA model provides a risk-oriented evaluation model in the context of a project and organization evaluation. This approach is beneficial for all actors of the automotive supply chain.

2.2 Definition of an Automotive Quality Standard

The purpose of the PISA model is to evaluate performance of an automotive development project and/or benchmark an organization using an automotive specific perspective.

2.3 Architecture of PISA model

The three pillars the PISA model is based on are:

1. Processes Scope
2. Qualification Class
3. Evaluation and Rating System

2.3.1 Processes Scope

The PISA model encompasses processes at technical and managerial levels that incorporate the backbone of a typical automotive development project structure. The processes belonging to the the PISA model are twenty-two (22) in total.

They are divided into four (4) Process Families:

- Three (3) technical process families: System Engineering, Hardware Engineering, and Software Engineering
- One (1) coordination process family: Management.

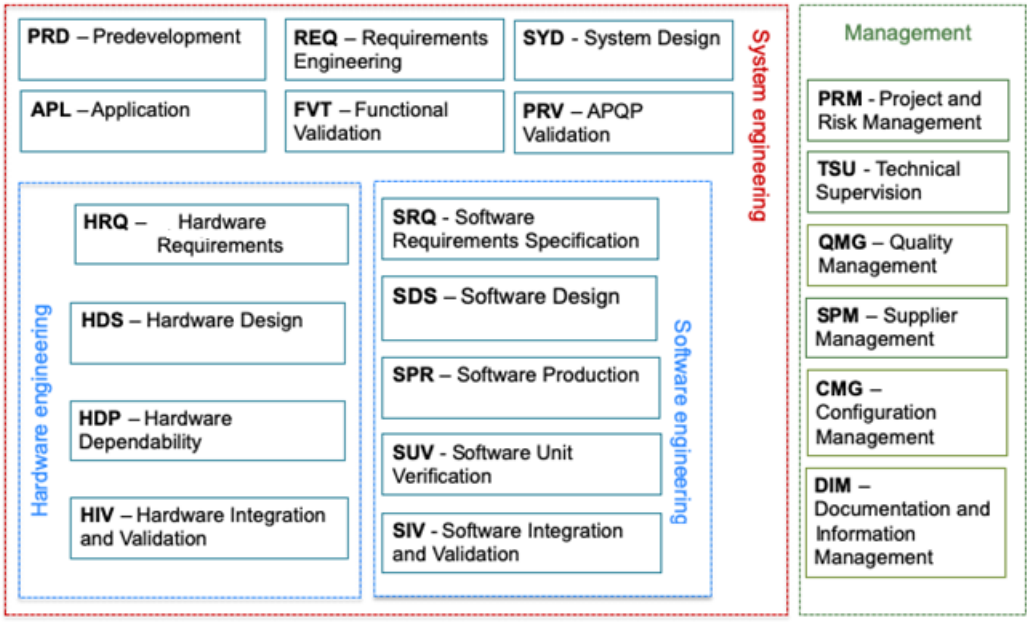


Figure 1: PISA model process scope

As shown above, the the PISA model is composed of the following processes:

1) System Engineering Family processes address the product view – the processes belonging to this family are:

PRD - Pre-development: it pertains to the early setup of the overall system architecture; this process acknowledges the fact that in the automotive market crucial design decisions are often taken during the bidding phases of the project. It is also linked to APQP Phase 1 [1].

REQ – Requirements Engineering: it pertains to the definition, documentation and management of requirements for development at system and sub-system level.

SYD – System Design: it pertains to a more detailed definition of the system design with strong focus on interfaces and system calibration aspects. Such a level of design takes into account automotive design drivers such as “design for manufacturing”.

APL – Application: it pertains to product and calibration development, transfer of technical requirements to engineering functions, and also direct interfacing with customers and suppliers.

FVL – Functional Validation: it pertains to the verification of the conformance of the developed system to functional specifications.

PRV – Advanced Product Quality Planning (APQP) Validation: it pertains to the confirmation that the organization can produce products that meet customer requirements in a cost-effective and repeatable way. It corresponds to APQP Phase 4 [1], with specific focus on product validation.

2) Hardware Engineering Family processes address the diverse hardware development according to the automotive industry best practices – the processes belonging to this family are:

HRQ – Hardware Requirements: it pertains to the definition and management of hardware requirements.

HDS – Hardware Design: it pertains to the definition of HW design.

HDP – Hardware Dependability: it pertains to the performance of hardware design verification as well as the performance of dependability analysis.

HIV – Hardware Integration and Validation: it pertains to the integration and validation activities of the hardware.

3) Software Engineering Family processes address the development of software as well as the integration of software components; the processes belonging to this family are:

SRQ – Software Requirements Specification: it pertains to the definition, documentation and maintenance of requirements for software development.

SDS – Software Design: it pertains to the definition of the software architectural design following a multi-level and multi-perspective approach.

SPR – Software Production: it pertains to the deployment of best practices for the implementation of the software design.

SUV – Software Units Verification: it pertains to the deployment of verification activities to ensure correctness of software units. The verification of the robustness of software units with respect to typical vulnerabilities is pivotal for this process.

SIV – Software Integration and Validation: it pertains to the verification and validation of software sub-system(s) from a functional and performance point of views.

4) Management Family processes provide lean requirements targeting management needs of the automotive engineering developments; the processes belonging to this family are:

PRM – Project and risk management: it pertains to management of projects according to management best practices tailored for the automotive. Insight on program management is also included.

TSU – Technical Supervision: it pertains to the management of technical and operative aspects of project activities.

QMG – Quality Management: it pertains to the deployment of an adequate quality management. It also pertains to improvement initiatives.

SPM – Supply Management: it pertains to the management of bespoken technical supply as well as third-party one in the project context.

CMG – Configuration and Release Management: it pertains to the deployment of configuration management at system, hardware and software levels.

DIM – Documentation and Information Management: it pertains to the deployment of a structured and effective documentation/information management.

2.4 Evaluation and Rating System at Project Level

The PISA model contains a rating system which provides rules for the rating of the following items according to a bottom-up view:

- **Requirement** - belonging to one of the following three classes:
  1. Process
  2. Governance
  3. Technological
- **Process** (for the applicable processes)
- **Process Family** (composed of several processes)
- **Project**

The following table describes the possible ratings an item can achieve and the associated semantics.

Table 1: Ratings definition

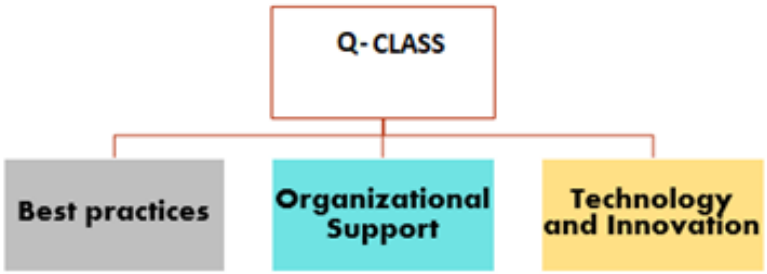
Requirement/Process/Process Family/Project Rating Scheme	
Ratings	**Semantics**
FULL	The item is deployed adequately, and related objectives are not at risk. Improvement opportunities are limited in scope and criticality.
SUFFICIENT	The item is deployed satisfactorily, and related objectives are largely not at risk. Improvement opportunities are present.
INCOMPLETE	The item is deployed nearly satisfactorily and related objectives are exposed to noteworthy risk. Significant improvement opportunities are present.
POOR	The item objectives are at high risk. Improvement opportunities are important and require immediate improvement action items.

A detailed description of the PISA Model Rating System is provided in ANNEX A.

2.5 Organizational Qualification Class

The Organizational Qualification Class is a PISA model concept introduced to allow the benchmarking of an organization (Organizational Qualification Level) by means of an integrated indicator: the **PISA model Class** or for simplicity **Q-CLASS**.

The Q-CLASS indicator combines three quality scopes, as shown by Figure 2.



- Figure 2: Q-CLASS Conceptual Foundation

Q-CLASS indicator overcomes the process capability evaluation (which is a mono-dimensional approach) by integrating:

- Automotive state of the art practices
- Organizational adequacy
- Technological readiness.

The Qualification Levels (Q-CLASS levels) range from A the highest class to D which is the lowest one (Figure 3)

The ratings are:

- **A** rating is associated with a Full Compliance with the PISA model
- **B** rating is associated with a Sufficient Compliance with the PISA model
- **C** rating is associated with an Incomplete Compliance with the PISA model
- **D** rating is associated with a Weak or Poor Compliance with the PISA model.

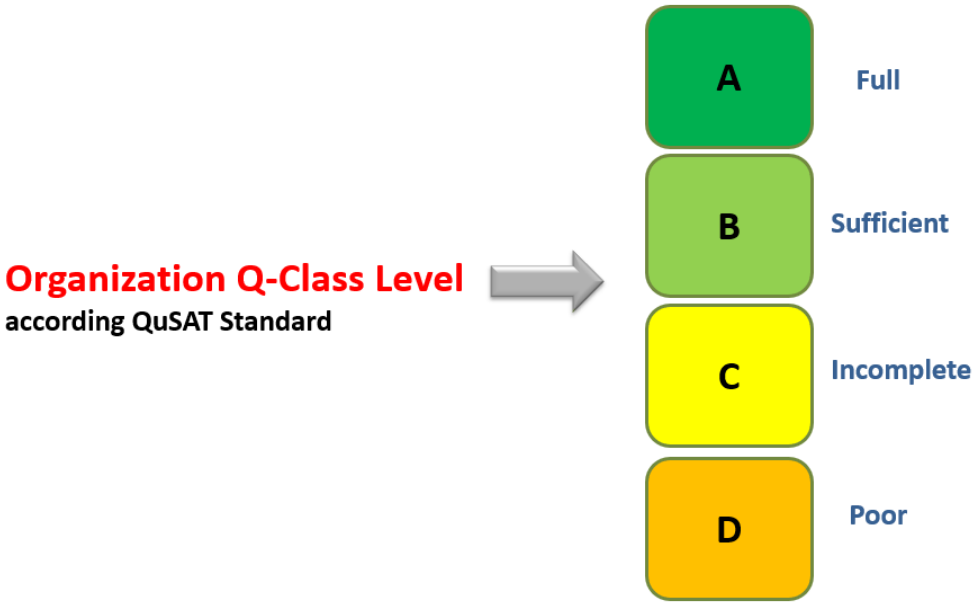


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Figure 3: The Q-CLASS Rating System (RS)

Table 2. indicates the criteria to determine the Organization achieves the Organizational Qualification Class [Q-CLASS]. Such criteria are based on two factors:

1. **Project rating**
2. **Project representativeness** of organization business.

Table 2 - Criteria for Organization Qualification Class determination

Organization Qualification Class (Q-CLASS) Rating Scheme			
Project Rating	**Project Representativeness**		
	High	**Medium**	**Low**
Full	**A**	**A**	**B**
Sufficient	**B**	**B**	**C**
Incomplete	**C**	**C**	**D**
Poor	**D**	**D**	**D**

The Project Representativeness rating with respect the Organizational Business is given as follows:

- Project Representativeness is High (H) if the project under evaluation is highly representative of the current business line and/or business objectives.
- Project Representativeness is Medium (M) if the project under evaluation is representative of the current business line and/or business objectives.
- Project Representativeness is Low (L) if the project under evaluation is partially representative of the current business line and/or business objectives.

Figure 4 shows the conceptual path towards the organization qualification level that is based on the assessment result on one or more project (one project can be sufficient).

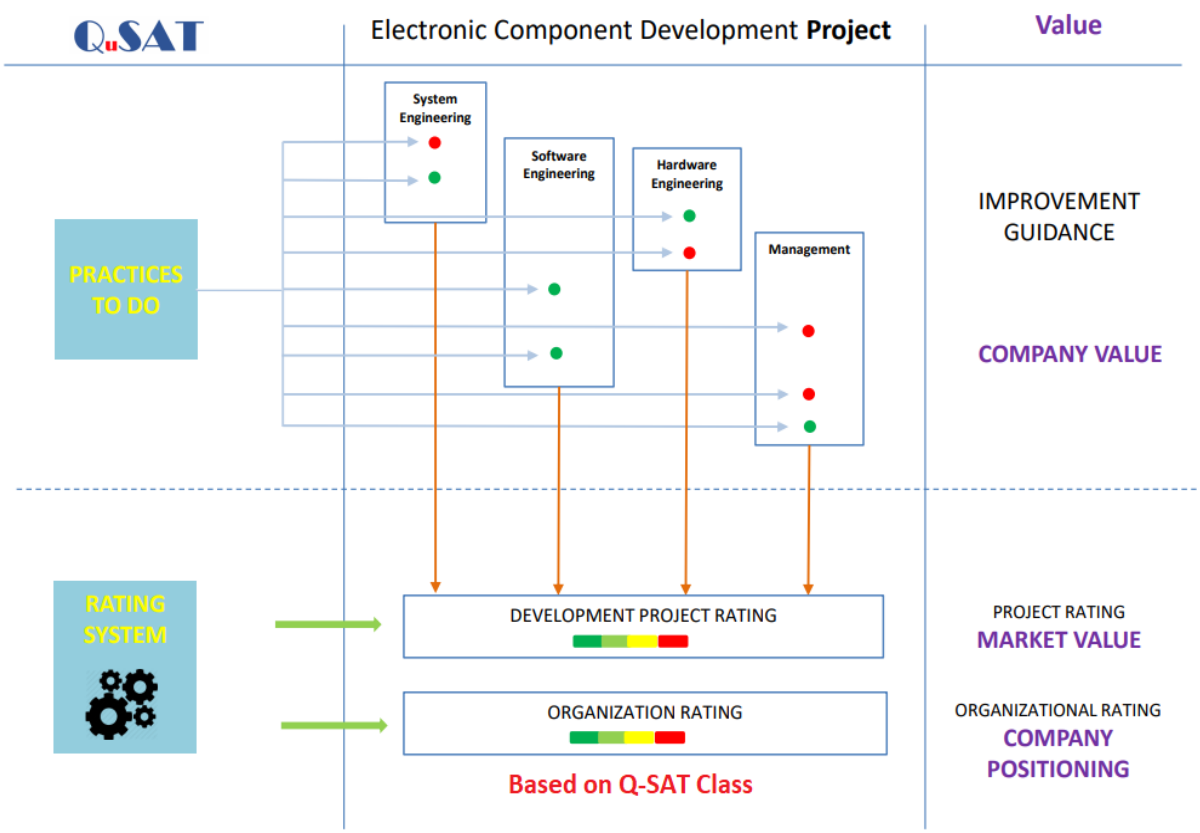

Figure 4: The Q-CLASS Rating System (RS)

The aggregation of process ratings determines the relevant process family rating (family rating level).

Finally, the combination of the process families ratings determines the project rating (as shown in Section 2.3) and thus the Q-SAT Class of the organization according to the scheme in Table 2.

3. Processes of the PISA model

3.1 Process Structure and Requirements

The PISA model process definition structure is composed of the following fields:

1. Process Name
2. Context of the Process: general information on the process and on its context of use.
3. Input Work products
4. Requirements: definition of practices to be performed by the process. Each Process requirement is classified as High Priority and Low Priority according to potential added-value criteria, as explained below.
5. Output Work Products and related content outline

The PISA model requirements are divided into three categories:

a. Process Requirements (best practices)
b. Governance Requirements (organizational support)
c. Technological Requirements (technology readiness)

Structure of a PISA model requirement:

<PROC_ID-REQ_ID>	Normative PISA model requirements
Q-clause	
Elaboration	Guidelines for Practitioners
Improvement Guidance	
Tailoring Guidance	
Notes	

4. System Engineering Family Processes

System engineering is a multi-disciplinary methodology for the design, development, technical management and operations of a system. In the context of PISA model, Automotive system engineering addresses the system throughout its life cycle, including requirement, specification, design, implementation, verification, and validation of systems.

The elements of an automotive system are heterogeneous as they may include hardware, software, mechanical, optical, acoustic, radio frequency sub-systems.

Reference automotive system engineering goals are:

- Well-defined and possibly standardized system function
- Tailored efficient validation
- Harmonized architecture for vehicle and automotive systems
- System and technology roadmap to fit future needs
- Platform approaches

REFERENCE AUTOMOTIVE LIFECYCLE:

From a development lifecycle perspective, automotive system engineering typically targets the following system maturity stages:

- Pre-development: Initial phase featuring key commercial and technical steps for the project scope definition
- A Sample or Proto A: the system is developed starting from high-level requirements to prove the concept, assess feasibility, and resources.
- B Sample: the system engineering process is re-iterated to reach a consolidated design.
- C Sample: Final implementation. The system is developed by means of process tooling. Hardware shall be the expected final one.

TRACEABILITY TO IATF 16949:

The system-engineering family processes of the PISA model target the following IATF 16949 requirements:

- Section 8.2: Requirements for products and services
- Section 8.3: Design and development planning

The processes belonging to the System Engineering Technical Family are:

- PRD – Predevelopment
- REQ – Requirements Engineering
- SYD – System Design
- APL - Application
- FVL – Functional Validation
- PRV – APQP Validation

4.1 PRD – Predevelopment

Context of the process:

The Predevelopment process initiates the system development by defining the Technical Concept of the product. Technical Concept defines scope and directions for the technical solution to be adopted by the project.

Successfully understanding and defining the system objectives including its operational environment are keys to capturing the stakeholder expectations, which will be translated into quality requirements and operational efficiencies over the life cycle of the project.

The Predevelopment process, in fact, aims at identifying the reference technical choices and it is key for the project success.

This process usually gets started during the preparatory phases of the project (e.g. bidding) to reach its activity peak in the initial technical project activities.

Input Work Products:

- Availability of customer or stakeholder needs (APQP: Voice of the Customer)
- Customer documentation
- Regulations
- Standards

Additional relevant inputs are:

- Project documentation of similar developments
- State of the art for the specific development

Process Requirements:

PRD-PR1	Develop technical concept of the product.
Q-clause	As the project activities start, a technical concept of the product shall be developed to provide a documented technical, economic, and strategic view of the system to be developed.
Elaboration	Technical concept is high-level design with strong focus on architectural and functional aspects of the system. It addresses also initial technological and cost evaluations. This activity also supports feasibility evaluations. Market analysis is also an important element of this requirement. Particular attention shall be paid to functional safety and cyber-security aspects of the system, if any. Reuse of consolidated design experiences shall be taken into account during the system design, at all levels of design. LINKS TO APQP Requirement(s): Team Feasibility Commitment and Management Support, Design Goals, Preliminary Bill of Material
Improvement Guidance	1. Focus on functional aspects and key system elements. 2. Pictorial approach is usable in this context as no formal methodology is strictly necessary. 3. Joint work with customer or internal stakeholder, if needed. Functional analysis is a useful technique to identify, partition and describe all the main functions of a system. Accordingly, functional analysis shall: ● provide the identification of the functions of the system ● identify the functions required to be performed in the different operational scenarios. The level of detail in performing functional analysis shall be determined by design maturity and it normally increases during the project life cycle. This refinement process applies at each level of decomposition: the derived functions become the set of high-level functions and so on. In the high-level functional analysis particular attention shall be paid to functional safety aspects, if any.
Tailoring Guidance	Tailoring opportunities may arise from: - Carry over projects - Development within a consolidated product family - Consolidated design patterns
Notes	The results of this activity shall be refined by the system design process.

Governance Requirements:

PRD-GR1	Exploit organizational data and/or lessons learned in the context of project initiation.
Q-clause	Organization data shall be reused to conduct and effective preliminary analysis of the project and to maximize the success opportunities.
Elaboration	Exploitation of organization projects database provides effective support for this requirement. Organization project data may include: - Bill of materials - Design from similar projects - Validation outcomes - Project cost reports - Lessons learned
Improvement Guidance	Qualitative data such as lessons learned gathered in the corporate QMS (Quality Management System) can be exploited.
Tailoring Guidance	Relevant professional experience of involved stakeholders may be applied.
Notes	-

Technological Requirements:

No specific info since this process activities are mainly intellectual (although some prototyping capabilities may apply).

Refer to MG1-TR1 for technological requirements linked to the managerial aspect of the technical solution identification.

Output Work Products:

PRD-OWP1	Technical Product Concept
Expected Contents	Content includes: - Preliminary product architecture - Main technical solution and evaluations of alternatives (notes on including innovation opportunities) - Data on main parts of the system to support technical, logistic and costs evaluations - Preliminary development timeline - Functional safety considerations, if applicable - Cyber-security considerations, if applicable - Production Process considerations - Quality and reliability goals
Notes	Related requirements: **PRD-PR1, PRD-GR1, PRD-GR2**

PRD-OWP2	Preliminary BoM
Expected Contents	Content includes: - Data on main parts of the system (to support technical, logistic and costs evaluations)
Notes	Related requirements: **PRD-PR1, PRD-GR1** Availability of preliminary BoM can be deferred, depending on project needs.

PRD-OWP3	List of Open Points
Expected Contents	Content includes: - Open issues and related analysis - Support to elicit requirements - Support to document and track technical issues to closure
Notes	Related requirements: **PRD-PR1, PRD-GR1** This work-product shall be kept in use during the whole development. Risks at initiative level can also be associated with this work-product.

4.2 REQ – Requirements Engineering

Context of the process:

Requirements Engineering process aims at defining, maintaining, and managing project requirements at system level.

The requirements specification and requirements management stages make up a dynamic workflow. Such a workflow spans from new ideas, features,

and related requirements definition to system specifications.

Requirement engineering is a stepwise process that encompasses the following main steps:

1. Identification of system requirements from Customer or from internal sources
2. Analysis of project constraints
3. Specification of system requirements
4. Trace system requirements to customer requirements
5. Review of system requirements specification

Input Work Products:

- Customer needs and/or requests
- Customer documentation
- Applicable standards/norms

Additional relevant inputs are:

- Project documentation of similar developments

Process Requirements:

<table>
<tr><td>REQ-PR1</td><td>Specify functional requirements of the system.</td></tr>
<tr><td>Q-clause</td><td>The functional requirements of the system shall be developed in a documented format in accordance with the timing project needs.</td></tr>
<tr><td>Elaboration</td><td>System requirements analysis process aims at identifying, analyzing (focus on feasibility, soundness, and testability) and tracking system requirements to allow a full control of the development in terms of content and validation.
Special categories of functional requirements, if applicable, include:
● Functional safety requirements
● Cyber-security requirements
System Requirements analysis often starts during the commercial offer.
The default system requirements analysis process typically follows the pattern shown in this table below:
<table>
<tr><th>Project Phase</th><th>Requirements Engineering Approach</th></tr>
<tr><td>Predevelopment</td><td>NO</td></tr>
<tr><td>A (Prototyping)</td><td>YES (Analysis)</td></tr>
<tr><td>B (Product Engineering)</td><td>YES</td></tr>
<tr><td>C (Process Engineering)</td><td>YES (Change management)</td></tr>
</table>
<table>
<tr><td>YES (Analysis)</td><td>Focus on analysis of customer requirements in terms of feasibility</td></tr>
<tr><td>YES</td><td>Full analysis and documental specification</td></tr>
<tr><td>YES (Change management)</td><td>Focus on technical management on requirements</td></tr>
</table>
Requirements shall be associated to a specific release according to the system release plan. In fact, of particular importance are the following attributes in requirement:
Target Release - system release where the requirement is planned to be implemented
Allocation - indication of the architectural elements at system level where the requirement is allocated
Functional safety requirements and cyber-security requirements, if any, shall expressed according to this process requirement.
The language used must be clear, exact, and in enough detail to limit as much as possible different interpretations.
Care must be taken in using clear, unambiguous phraseology and punctuation. A misplaced comma can have several ramifications. Often requirements are written in a vague manner when the author is not sure of what is required.
When appropriate, documented review(s) shall be performed.
LINKS TO APQP Requirement(s): Engineering Specification
LINKS TO ISO 26262 Requirement(s): ISO 26262-4:2018, Clause 6.4</td></tr>
<tr><td>Improvement Guidance</td><td>Manage, possibly, requirements in a centralized database/document
Involve the project team in the analysis
Do not expect tools to replace a good analysis phase
Group requirements by feature</td></tr>
</table>

	Set focus of the requirements analysis also on the validation aspects Set up a detailed roadmap for implementation Push for receiving customer requirements in electronic and manageable format
Tailoring Guidance	Requirements can be expressed in shape of a functional model (for instance HMI prototype). The system requirements specification document may be replaced by the customer specification enriched with the detailed analysis outcomes such as target release info and allocation to relevant system architectural elements.
Notes	Functional requirements explain what must be done by identifying the necessary tasks, actions or activities that must be accomplished.

REQ-PR2	Specify non-functional requirements of the system.
Q-clause	The non-functional requirements of the system shall be developed in a documented format to the project team in accordance with the timing project needs.
Elaboration	Typical categories of non-functional requirements include, but are not limited to: ● performance requirements ● technical requirements ● interface requirements ● configuration and calibration requirements ● design-constraint requirements ● production requirements, ● quality requirements, ● environmental requirements ● physical requirements ● operational requirements, For general elaboration on requirements specification, see REQ-PR1.
	LINKS TO APQP Requirement(s): Engineering Specification LINKS TO ISO 26262 Requirement(s): ISO 26262-4:2018, Clause 6.4
Improvement Guidance	Minimize the number of non-functional requirements Due to the often-large number of Customer documents to be analyzed, it is important to map each Customer document on a reference person (that supposedly has the necessary skills).
Tailoring Guidance	See REQ-PR1
Notes	Non-functional requirements are requirements that specify criteria that can be used to judge the operation of a system, rather than specific behaviors.

Governance Requirements:

REQ-GR1	Involve project teams and relevant parties in requirement development
Q-clause	Requirements engineering activities, with reference to the review phase, shall be conducted by a cross functional team to achieve a comprehensive analysis.
Elaboration	This requirement is instrumental at conducting an in-depth, holistic review of project requirements (ref. DIM process). The cross functional team is under the supervision of the project manager.
Improvement Guidance	Rely only on decision by consensus as decision making process for technical aspects.
Tailoring Guidance	Support of questionnaires may be applied.
Notes	A cross-functional team is a group of people with different functional expertise working toward a common goal. Members may also come from outside an organization (in particular, from suppliers, key customers, or consultants). Cross-functional teams often function as self-directed teams assigned to a specific task that calls for the input and expertise of different departments.

REQ-GR2	Perform requirement change management
Q-clause	Requirements changes shall be documented, analyzed and approved as appropriate.
Elaboration	There are essentially three types of requirements that come out of the change management: – New requirement(s) – Changed requirement(s) – Deleted requirement(s) Output of the requirements change management process shall be documented in the System Requirement Specification and in the change log as appropriate. Changes shall be tracked to closure according to a defined workflow. It is responsibility of the project management function to monitor that the Change Requests implementation proceed as planned and to make timely adjustments when necessary. Responsibility for software requirement changes approval shall be assigned. The change approval shall be notified to the persons involved in the implementation of the change. The approval shall be based on explicit estimation of the impact of the implementation of the change that takes into account: ● the technical impact, ● the cost of implementation, ● the availability of necessary skills and technology. For CCB composition, roles, and workflow shall be defined in the project plan.

	LINKS TO APQP Requirement(s): Drawing and Specification Changes LINKS TO ISO 26262 Requirement(s): ISO 26262-4:2018, Clause 6.4, ISO 26262-8:2018 Clause 8.4
Improvement Guidance	Centralize management of change requests. Involve project team in change request analysis. Perform analysis in terms of feasibility, costs, schedule, resources needed, potential impact on the rest of system functionality, validation and production aspects.
Tailoring Guidance	In the case of minor requirement changes, the estimation of the impact of their implementation may be implicit. In case of small-setting project, the project leader can be main component of the board.
Notes	Major requirement corrective changes are those impacting either on design or software detailed design, or interface specifications it is a major corrective change. Otherwise, it is a minor corrective change. The change control board is constituted of project stakeholders or their representatives. The authority of the change control board may vary from project to project, but decisions reached by the change control board are accepted as final and binding. CCB meets regularly during project evolution.

Technological Requirements:

REQ-TR1	Requirements management dedicated support
Q-clause	Effective Requirements Development and Management tool(s) shall be deployed as appropriate.
Elaboration	The market offers a variety of tools and solutions, from open source to commercial full-fledged suites, able to address all needs.
Improvement Guidance	Do no tailor process on tool but do vice-versa.
Tailoring Guidance	Small and very small enterprise contexts may consider standard productivity tools such as electronic spreadsheets.
Notes	Open-source technology is relatively lacking in this area of the development flow.

Output Work Products:

REQ-OWP1	Project system requirements specification
Expected Contents	It may include specification of requirements at the following areas: - Functional - Functional Safety (if relevant) - Cyber-security (if relevant) - Performance - Interface - Validation - Design constraints - Quality - Regulatory - Production - EoL (End of Line) - Operational Its format can be documental or a database.
Related Requirements	**REQ-PR1, REQ-PR2**

REQ-OWP2	Standard list
Expected Contents	It may include at minimum: - List of standards, regulations applicable to the project - Version - Internal reference person - Status
Related Requirements	**REQ-PR2**

REQ-OWP3	Traceability data
Expected Contents	Forward and Backward traceability to internal and external customer input.
Related Requirements	**REQ-PR1, REQ-PR2**

REQ-OWP4	Review report of project requirements at system level
Expected Contents	Its content includes: - Reviewers - Review summary results - Requirements review criteria - Review findings
Notes	**REQ-TR1, REQ-TR2**

REQ-OWP5	Change request register
Expected Contents	Its content includes: - List of CRs and related processing flow - Approval - Status
Notes	**REQ-GR1, REQ-GR2, REQ-TR1**

4.3 SYD – System Design

Context of the process:

System Design process is key to provide the foundation of the technical solution of the project. It serves as a trigger for the software, hardware and mechanical engineering developments. System design typically provides the architectural view of the system that gets refined by specific engineering disciplines.

In general, the system design describes all system elements, their architectural relationships to each other, and interfaces. For each system element, the associated system requirements must be known.

ECU calibration is the process of defining, adjusting, and optimizing ECU's control algorithms and parameters according to performance requirements of vehicles (i.e. emission performance requirements and others).

Input Work Products:

- Project Requirements
- Technical Product Concept

Additional relevant inputs are:

- System Design specifications of similar projects
- Configurations and calibrations of similar projects
- Design patterns
- Technological state of the art

Process Requirements:

SYD-PR1	Develop design at system-level.
Q-clause	Design at system level that fits the project requirements with the target operational environment shall be developed.
Elaboration	Key elements to be provided are: - Overview of the structure of the system as a whole (architectural view) with a strong focus on the HW sub-system(s). In fact, the overall system can be pictorially modeled by one or several "block diagrams" illustrating the system elements, their interrelationships and event/data flows. - Hierarchical decomposition of the system into sub-systems provides the support for using different technical and physical principles in the design of the architecture sub-systems. - Partitioning of system elements - Allocation of system requirements to the system elements - Support to the necessary networking capabilities - Support to the necessary diagnostic capabilities - Operating modes of the system - Response time of the system. The above architectural design topics are integrated with the interface descriptions that are fundamental aspects of the architectural design. The HW-SW interfaces are a key aspect to address. Include system variants description in the design as appropriate. System design activities can require prototyping in order to explore technical solutions as well as potential issues. DFMA (Design for Manufacturing and Assembly) principles shall be applied during the development of the system design as appropriate. LINKS TO ISO 26262 Requirement(s): ISO 26262-4:2018, Clause 7.4 LINKS TO APQP Requirement(s): Engineering specification
Improvement Guidance	Balance the design abstraction level among different sub-systems. Semi-formal specification language (e.g. SysML) can be used.
Tailoring Guidance	In case of a safety-critical development, the system design activity shall address also the technical safety concept development.
Notes	Reuse opportunities may arise from: - Carry over projects - Development within a consolidated product family - Consolidated design patterns

SYD-PR2	Conduct FMEA

Q-clause	FMEA at functional level or design level shall be developed as appropriate.
Elaboration	The objective of this requirement is to perform a failure analysis aimed ensuring that robust design principles are adopted during the design phase of the system. LINKS TO ISO 26262 Requirement(s): ISO 26262-4:2018, Clause 7.4.3 LINKS TO APQP Requirement(s): DFMEA
Improvement Guidance	The use of the FMECA technique is recommended.
Tailoring Guidance	Depth of FMEA analysis can be tuned according to project needs. ETA (Event Tree Analysis) can be used as alternative of FMEA.
Notes	Relevant guidance for FMEA (FMECA) is provided by SAE and VDA.

Governance Requirements:

SYD-GR1	Design Review Gate
Q-clause	A set of design reviews shall be conducted along the project to make sure that the design is correct.
Elaboration	A system design Review is a formal review conducted to ensure that system requirements have been completely and properly identified and that a mutual understanding between the customer and supplier exists. Plan at least for: - Preliminary design review - Critical design review The review techniques that can be considered are: - Walkthrough - Inspection The availability of prototypes can be instrumental to conduct effective and timely design reviews. LINKS TO ISO 26262 Requirement(s): ISO 26262-4:2018, Clause 6.4.9 LINKS TO APQP Requirement(s): Design verification, design review, Team Feasibility Commitment and Management Support
Improvement Guidance	Exploitation of simulation, testing of prototypes is recommended.
Tailoring Guidance	No specific info
Notes	Verification of a product shows proof of compliance with requirements—that the product can meet each “shall” statement as proven though performance of a test, analysis, inspection, or demonstration (or combination of these). Validation of a product shows that the product accomplishes the intended purpose in the intended environment—that it meets the expectations of the customer and other stakeholders as shown through performance of a test, analysis, inspection, or demonstration.

Technological Requirements:

SYD-TR1	Prototyping and simulation support
Q-clause	Prototyping and simulation shall be deployed, as appropriate, to facilitate a fitting and robust design.
Elaboration	The development of prototypes is strongly beneficial to explore technical solutions and minimize the risks of project failures - especially during proto A phase.
Improvement Guidance	Dedicated team and facility can be allocated to this activity.
Tailoring Guidance	Prototyping support can be performed by third-party.
Notes	As the current state of the art provides mature support for simulation in a wide range of technologies, simulation tools may offer substantial benefits.

Output Work Products:

SYD-OWP1	System Design
Expected Contents	Its content includes: - Hierarchical breakdown and definition of the system elements - Function descriptions - Operating modes of the system - Safety measures, if needed (e.g. TSC)
Notes	**SYD-PR1, SYD-PR4, SYD-GR1**

SYD-OWP2	System Interfaces Specification
Expected Contents	Its content includes: - External interfaces - Internal interfaces o Focus on Hardware Software Interfaces specifications
Notes	It can be combined with system design specification. **SYD-PR1, SYD-GR1**

SYD-OWP3	System FMEA
Expected Contents	Its content includes: - Failure mode analysis of system functions - Impact analysis on external environment
Notes	**SYD-PR2, SYD-GR1**

SYD-OWP3	System Design Review report
Expected Contents	Its content includes: - Reviewers - Review summary results - Design review criteria - Review findings
Notes	**SYD-PR1, SYD-GR1**

4.4 APL – Application

Context of the process:

Application process is key to provide the foundation of the technical tuning of the system.

ECU calibration is the process of defining, adjusting, and optimizing ECU's control algorithms and parameters according to performance requirements of vehicles (i.e. emission performance requirements and others).

Configuration controls the software building process so that the expected code is selected from existing code variants already defined in the code base. This is typically done with a tool. This means that the software configuration is performed before, or as part of, the software build. The configuration is dependent both on the ECU hardware, the signal database and what SWCs that are allocated to a particular ECU.

Software calibration means to change the value of certain system parameters, typically via SW at the manufacturing or on the aftermarket but also within the development process. Within the software component access to these calibration parameters are read-only but they can be changed with a calibration tool that communicates with the ECU. Examples of calibration data: variant coding (for instance country code, left-hand/right-hand steering), calibration parameters (for instance value for low idle speed, engine characteristic diagrams) and parameters that are possible to change for bodybuilders (e.g. fuel tank size).

Input Work Products:

- Project Requirements
- System Design

Additional relevant inputs are:

- Configurations and calibrations of similar projects
- Technological state of the art

Process Requirements:

APL-PR1	Determine calibration and configuration needs of the system.
Q-clause	Calibration and configuration parameters shall be identified in accordance with the system functions and the operating environment. Default values shall be determined. Calibration design shall be refined during the project life as more detailed design of the project is developed
Elaboration	ECUs in all domains (for instance Powertrain, Chassis, Body) often have plentiful calibration and configuration parameters. Correct calibration data is equally important as high-quality software code. The development of calibration and configuration data starts at system design level and it is iterated on different levels of detail throughout the development process to get the final ones. Focus on parameters that have an impact of functional safety aspects of the system shall be applied (if any). Adjustments of calibration and configuration parameter values during the project shall be addressed as appropriate. LINKS TO ISO 26262 Requirement(s): ISO 26262-4:2018, Clause 6.4 LINKS TO APQP Requirement(s): Engineering specification
Improvement Guidance	Calibration tasks are often conducted in a work-split between OEM, ECU-suppliers and engineering companies.
Tailoring Guidance	Consider reuse of calibration data for carry-over projects.
Notes	Typical calibration systems are currently based on ASAM standard architecture.

APL-PR2	Calibration Tuning
Q-clause	Calibration parameters values shall be fine-tuned in accordance with the analytical and/or experimental studies.
Elaboration	Numerical optimization methods such as gradient methods can be applied to the theoretical and statistical models to obtain optimal control parameters.
Improvement Guidance	-
Tailoring Guidance	Despite the theoretical models, unknown parameters exist and they have to be estimated through real experiments.
Notes	Resident engineer role is often involved.

APL-PR3	Calibration Settings Test
Q-clause	Calibration parameters values shall be verified and tested in accordance with the project requirements.
Elaboration	Even if all components have to undergo several steps of testing and evaluation during the development process, it cannot be assured that all vehicles leaving the production line have identical systems.
Improvement Guidance	Representative test environments are expected to be used.
Tailoring Guidance	-
Notes	Resident engineer role is often involved.

Governance Requirements:

APL-GR1	Establish Application Resources
Q-clause	Dedicated roles, responsibilities and support shall be deployed for the project within the organization as appropriate.
Elaboration	-
Improvement Guidance	-
Tailoring Guidance	Need for application activities may be minimal in certain contexts.
Notes	-

Technological Requirements:

APL-TR1	Calibration data tool support.
Q-clause	Calibration tools shall be deployed, as appropriate, to facilitate effective calibration.
Elaboration	To manage complex calibration tasks, calibrators require solutions that combine human expertise with best practice optimization methods and easy data handling.
Improvement Guidance	“In field calibration testing” has to be supported.
Tailoring Guidance	Project may not require this support according to project characteristics.
Notes	

Output Work Products:

APL-OWP1	Configuration Data Specification
Expected Contents	Its content includes: - Configuration data (purpose, range, default, actuals, variants, measure unit) This output shall be developed and baselined during the all project as appropriate.
Notes	**APL-PR1, APL-PR2, APL-GR1, APL-TR1**

APL-OWP2	Calibration Data Specification
Expected Contents	Its content includes: - Calibration data spec (purpose, range, default, actuals, variants, measure unit) This output shall be developed and baselined during the all project as appropriate.
Notes	**APL-PR1, APL-PR2, APL-GR1, APL-TR1**

APL-OWP3	Calibration Data Test Report
Expected Contents	Its content includes: - Test results - Test logs .
Notes	**APL-PR3, APL-GR1, APL-TR1**

4.5 FVL – Functional Validation

Context of the process:

Functional Validation process determines whether the development has satisfied the documented project system requirements and related assumptions.

Input Work Products:

- Integrated system
- System Requirements
- Traceability Data (system design-system requirements)
- System Design

Additional relevant inputs are:

- Tests required by customers, if any
- Technologies designs
- Applicable norms and standards

Process Requirements:

FVL-PR1	System Integration Verification
Q-clause	The integration of the system under test (SUT) shall be verified.
Elaboration	System Integration Verification ensures the quality of complex systems composed by several sub-systems. The verification of the integration at system level is typically conducted along two main directives: - Dedicated functional tests with focus on the system internal interfaces - Dedicated verifications (visual inspections, assembly tests, dimensional checks, …) The reference objective is to possibly map 100% of identified system interfaces. LINKS TO ISO 26262 Requirement(s): ISO 26262-4:2018, Clause 8.4 LINKS TO APQP Requirement(s): Product & Process Validation
Improvement Guidance	- Special focus on testing critical hardware-software interfaces.
Tailoring Guidance	System Integration testing can focus on selected interfaces by providing technical rationale.
Notes	The default system integration path follows two main directions: 1. Mechanics - Electronic Hardware 2. Electronic Hardware – Software The integration testing shall reflect the integration path to be performed by the project.

FVL-PR2	Validation specification.
Q-clause	Validation specification shall be developed to target project system requirements.
Elaboration	Design of the test-cases, according to the defined policy, to be performed and of the related test benches. Focus on: ● repeatability ● pass/fail criteria ● automatic or semi-automatic execution, if applicable The test cases are meant to cover all the system requirements that apply to the project and applicability attribute (what tests have to be executed for a certain version) must be filled in advance. Emphasis on the functional safety tests (if applicable). The validation specification shall be formally reviewed using a walkthrough technique. LINKS TO ISO 26262 Requirement(s): ISO 26262-4:2018, Clause 9 LINKS TO APQP Requirement(s): Product & Process Validation

Improvement Guidance	1. Avoid duplication with the other levels of testing 2. Consider the application of fault injection testing techniques
Tailoring Guidance	If the project has an ASIL the test related to technical Functional Safety requirements shall be well marked as safety critical.
Notes	Validation activities are linked to the release planning.

FVL-PR3	Validation execution and reporting
Q-clause	Validation testing shall be performed according to the defined policy.
Elaboration	Validation testing execution is to be performed according to the defined policy [FVL-GR1]. Execution logs shall be generated and maintained. LINKS TO ISO 26262 Requirement(s): ISO 26262-4:2018, Clause 9 LINKS TO APQP Requirement(s): Product & Process Validation
Improvement Guidance	The order and sequence of the test execution can be defined according to project needs or technical constraints.
Tailoring Guidance	Witnessing technique is acceptable in case of technical difficulties in registering test logs.
Notes	-

Governance Requirements:

<table>
<tr><td>FVL-GR1</td><td>Determine validation scheme</td></tr>
<tr><td>Q-clause</td><td>A policy and related operative guidance for the Validation shall be defined and documented.</td></tr>
<tr><td>Elaboration</td><td>Taking into account the typical phases of system development in automotive projects, the default system process is to be applied according to this table below:
<table>
<tr><th>Project Phase</th><th>Requirements Engineering Approach</th></tr>
<tr><td>Predevelopment</td><td>NO</td></tr>
<tr><td>A (Prototyping)</td><td>YES (Analysis)</td></tr>
<tr><td>B (Product Engineering)</td><td>YES</td></tr>
<tr><td>C (Process Engineering)</td><td>YES (Change management)</td></tr>
</table>
<table>
<tr><td>YES (Analysis)</td><td>Focus on analysis of customer requirements in terms of feasibility</td></tr>
<tr><td>YES</td><td>Full analysis and documental specification</td></tr>
<tr><td>YES (Change management)</td><td>Focus on technical management on requirements</td></tr>
</table>
Definition of the system testing scheme for the several project phases in accordance with project and quality objectives. The strategies should take into account the following main testing types:

- Functional Testing: testing activity performed to determine that System Under Test behaves correctly (as it is supposed to do)
- Functional Safety Testing: testing activity performed to determine that System Under Test behaves correctly in terms of safety objectives
- HMI Testing: testing performed to determine that Human Machine Interface of System Under Test behaves correctly (as it is supposed to do)
- Interface Testing: testing performed to determine that System Under Test behaves correctly with respect to external interfaces [Applicable if there are specific I/F requirements].
- Installation/Upgrade testing: testing activity that focuses on what customers will need to do to install and set up the new System successfully (or upgrade successfully an already installed System).
- Stability Testing: testing activity performed to determine that System Under Test is able to work under normal workload for a long time.
- Performance Testing: testing activity performed to determine how the System Under Test performs in terms of responsiveness and stability under a particular workload.
- Stress Testing: testing activity performed to determine how the System Under Test performs in terms of responsiveness and stability under an excessive workload.
Reference technique to consider include:
1. Nominal behavior testing
2. Negative testing</td></tr>
</table>

	3. Error guessing 4. Fault injection In addition, (but very important) definition of the regression policy for the several project phases in accordance with project and quality objectives to be provided. Default regression policy is full regression.
Improvement Guidance	1. Involve designers in the policy definition in order to reach better validation effectiveness.
Tailoring Guidance	Tailoring notes for Regression System Validation Strategy (re-run of previously executed test cases to detect and track new bugs): Selective approach is allowed on the basis of previously passed tests, impact analysis and schedule. A subset of test cases will be always repeated at every system test execution in order to provide confidence that the main system functionalities work correctly; such a subset is identified in the System Test Plan document in a chapter called “Sanity check test cases”
Notes	Validation policy shall also address the approach adopted for the verification of system integration.

FVL-GR3	Ensure suitable and sufficient validation resources
Q-clause	Sufficient validation resources shall be available on time.
Elaboration	As validation is a time-consuming activity and it also requires complex test benches, it is key to address these project needs in a timely way.
Improvement Guidance	A dedicated role for validation activities management is often useful.
Tailoring Guidance	Establish a database of qualified laboratories to be hired if needed.
Notes	Particularly useful for a successful implementation of the system integration testing and the validation is the factual interaction of the different development areas such as hardware, mechanics, software development, and test departments.

Technological Requirements:

FVL-TR1	Automation support for Validation
Q-clause	Automation validation means shall be deployed, as appropriate, in the context of integration testing and validation.
Elaboration	Automated testing facilitates and improves regression testing with increased coverage and reduced costs as a result.
Improvement Guidance	-
Tailoring Guidance	-
Notes	HIL (Hardware-In-the-Loop) is a technique used for testing control systems under simulation of the physical environment it is normally integrated in. In an automotive context, the HIL simulator is used to model a part of or the entire vehicle.

Output Work Products:

FVL-OWP1	Integration Report
Expected Contents	Its content includes: - Summary results - List of performed tests - Identification of the integrated system
Notes	**FVL-PR1, FVL-GR1**

FVL-OWP2	Validation Scheme
Expected Contents	Its content includes: - Test environment - Test tools - Test techniques - Test risks - Regression policy - Test resources - Set of tests to perform
Notes	**FVL-GR2, FVL-GR3, FVL-TR1, FVL-TR2**

FVL-OWP3	Validation Specification
Expected Contents	Its content includes: - Test settings - Test procedures - Pass/fail criteria - Test chains
Notes	**FVL-PR2, FVL-TR1, FVL-TR2**

FVL-OWP4	Validation Report
Expected Contents	Its content includes: - Summary results - Test results - Link to logs
Notes	**FVL-PR3, FVL-TR1**

FVL-OWP5	Review report of validation specification
Expected Contents	Its content includes: - Reviewers - Review summary results - Design review criteria - Review findings
Notes	**FVL-PR2, FVL-GR1**

FVL-OWP6	Traceability data
Expected Contents	Its content includes: - Link to system requirements - Link to system interfaces
Notes	**FVL-PR2**

4.6 PRV – APQP (Advanced Product Quality Planning) Validation

Context of the process:

APQP (Advanced Product Quality Planning) is a structured approach to product and process design. This framework is a standardized set of quality requirements that enable suppliers to design a product that satisfies the customer.

APQP consists of five phases:

- Plan and Define Program
- Product Design and Development
- Process Design and Development
- Product and Process Validation
- Feedback, Assessment & Corrective Action

This process focusses on key elements of APQP, that are Design Validation and Production Validation Testing.

Input Work Products:

- System Design
- Design Validation (DV) Norms
- Production Validation (PV) Norms
- System Requirements

Additional relevant inputs are:

- Configuration and Calibration Data
- User Manual

Process Requirements:

PRV-PR1	Develop DV (Design Validation) plan
Q-clause	Design Validation plan shall be developed in accordance with customer and regulatory requirements.
Elaboration	Typical DV tests include, but are not limited to: - Durability - EMC - Dynamic shocks - Thermal shocks - Dusts - Electric Plan for the availability of sufficient number of samples to conduct DV activities. LINKS TO ISO 26262 Requirement(s): ISO 26262-4:2018, Clause 9 LINKS TO APQP Requirement(s): Production Validation Testing
Improvement Guidance	DV plan is linked to DFMEA.
Tailoring Guidance	Design Validation shall be planned according to relevant standards, e.g. VDA, OEM-specific.
Notes	The Design Verification Plan format can vary greatly from company to company based upon individual preferences and business requirements. The core information is generally the same regardless of the format used.

PRV-PR2	Perform and report DV tests
Q-clause	DV activities shall be conducted as planned and reporting shall be produced.
Elaboration	Key elements of reporting are: - Summary of results - Tester identification - Traceability to test - Log availability including test settings - Sample identification LINKS TO ISO 26262 Requirement(s): ISO 26262-4:2018, Clause 9 LINKS TO APQP Requirement(s): Production Validation Testing
Improvement Guidance	DV plan is linked to DFMEA.
Tailoring Guidance	Design changes during DV execution are acceptable only if impact is minimal and analysis is documented.
Notes	-

PRV-PR3	Develop PV (Process Validation) plan
Q-clause	Production Validation plan shall be developed in accordance with customer and regulatory requirements.
Elaboration	Typical PV tests include, but are not limited to: - Durability - Vibration - Thermal shocks - Plan for the availability of sufficient number of samples to conduct PV activities LINKS TO ISO 26262 Requirement(s): ISO 26262-4:2018, Clause 9 LINKS TO APQP Requirement(s): Production Validation Testing
Improvement Guidance	PV plan is linked to PFMEA.
Tailoring Guidance	No specific info
Notes	.

PRV-PR4	Perform and report PV tests
Q-clause	PV activities shall be conducted as planned and accurate reporting shall be produced.
Elaboration	Key elements of reporting are: - Summary of results - Tester identification - Traceability to test - Log availability including test settings - Sample identification LINKS TO ISO 26262 Requirement(s): ISO 26262-4:2018, Clause 9 LINKS TO APQP Requirement(s): Production Validation Testing
Improvement Guidance	-
Tailoring Guidance	-
Notes	-

PRV-PR5	End of Line Testing Support
Q-clause	Technical support to setup effective End of Line testing shall be provided.
Elaboration	End-of-line testing is responsible ensuring the overall functionality of the product during the manufacturing process. Project team shall actively support the design of End of Line testing stations.
Improvement Guidance	-
Tailoring Guidance	-
Notes	-

Governance Requirements:

PRV-GR1	Approved laboratories
Q-clause	The use of accredited facilities for DV/PV activities shall be assured, as appropriate.
Elaboration	-
Improvement Guidance	-
Tailoring Guidance	-
Notes	Accreditation of facilities follows National Accreditation schemes

Technological Requirements:

PRV-TR1	Automation support for DV and PV
Q-clause	Automated validation means in the context of DV and PV testing shall be deployed, as appropriate
Elaboration	DV and PV testing are strongly linked to the need of automated or semi-automated environments, especially for the collection of results and test data. Automated testing facilitates and improves regression testing with increased coverage and reduced costs as a result.
Improvement Guidance	-
Tailoring Guidance	-
Notes	Automation support typically includes a database facility to store test results and convenient management of large set of information.

Output Work Products:

PRV-OWP1	DV Plan
Expected Contents	According to customer or regulatory requests (e.g. VDA, SAE).
Notes	**FVL-PR1**

PRV-OWP2	PV Plan
Expected Contents	According to customer or regulatory requests (e.g. VDA, SAE).
Notes	**FVL-PR3, FVL-TR1**

PRV-OWP3	Test Report(s)
Expected Contents	Its content includes: - Summary results - Test results - Link to logs
Notes	DV Report PV Report **FVL-PR2, FVL-PR4, FVL-TR1, FVL-GR2**

5. Hardware Engineering Family Processes

In the context of PISA model, Automotive hardware engineering addresses the related development throughout the project lifecycle, including requirement, specification, design, verification, and validation of these sub-systems.

This family is relevant for the following areas of development:

- E/E (including semiconductors)
- Mechanics
- Optics
- Acoustics
- Thermal
- Fluid-dynamics.

Implementation, that is sample productions, is out of scope of the version of the PISA model.

TRACEABILITY TO IATF 16949:

The system-engineering family processes of the PISA model target the following IATF 16949 requirements:

- Section 8.2: Requirements for products and services
- Section 8.3: Design and development planning
- Section 8.4: Control of externally provided processes, products and services

The processes belonging to the Hardware Engineering Technical Family are:

- HRQ – Hardware Requirements
- HDS – Hardware Design
- HVP – Hardware Verification and Dependability
- HIV – Hardware Integration and Validation

5.1 HRQ – Hardware Requirements

Context of the process:

Hardware requirements process is a key in the context of automotive hardware developments because it addresses the way functions shall be addressed at hardware level.

Input Work Products:

- System Requirements
- System Design (including interface specification)

Additional relevant inputs are:

- Software requirements specification
- Software design

Process Requirements:

HRQ-PR1	Hardware Requirements Specification
Q-clause	Hardware requirements shall be developed in accordance to system requirements and system design.
Elaboration	Hardware requirements specification activity converts the relevant system requirements (also considering the system design) into a stable and usable HW requirements specification that: - drives the design, development and testing of the HW sub-system(s). - supports change management. HW requirements shall include, at least, the following requirement types: - functional - performance - technical - interface - quality (reliability, environmental...) - safety (if relevant) - security (if relevant) - production process (if relevant) - It is key to associate requirements to a specific HW maturity level or release version in order to properly support to the project release plan. Traceability is needed to link HW requirements with system requirements. LINKS TO ISO 26262 Requirement(s): ISO 26262-5:2018, Clause 6.4 LINKS TO APQP Requirement(s): Engineering specification
Improvement Guidance	-
Tailoring Guidance	It is acceptable that some hardware requirements are expressed at system level
Notes	

HW1-PR2	Review hardware requirements specification
Q-clause	Hardware requirements specification shall be reviewed to find out possible defects.
Elaboration	Hardware requirement specification review shall address both any single requirements and requirement specification. Review of single requirements shall aim at finding lacks in terms of non-ambiguity, feasibility, testability, atomicity. Review of requirements specification shall aim at finding lacks in terms of traceability, completeness, and consistency.

	Relevant requirements defects shall be recorded. The technical impact and the cost of the correction of major hardware requirements defects shall be estimated. LINKS TO ISO 26262 Requirement(s): ISO 26262-6:2018, Clause 6.4.1, 11.2; ISO 26262-6:2018, Clause 9.4. LINKS TO APQP Requirement(s): Design Reviews
Improvement Guidance	Checklists are cost-effective, easy, flexible, maintainable means to support hardware requirements reviews.
Tailoring Guidance	Review technique (e.g. walkthrough, inspection…) shall be tailored according to project needs.
Notes	A requirements defect is considered a major defect if its correction impacts on either hardware design or interface specifications. Hardware requirements related to the reused software parts shall be reviewed as well.

Governance Requirements:

See REQ-GR1 and REQ-GR2 requirements.

Technological Requirements:

See REQ-TR1 requirement.

Output Work Products:

HRQ-OWP1	HW requirements specification
Expected Contents	Its content includes: - Reference architecture description - Requirements specification
Notes	**HRQ-PR1**

HRQ-OWP2	Requirements Review Report
Expected Contents	Its content includes findings of the review of: - Reference architecture description - Requirements specification
Notes	**HRQ-PR2**

HRQ-OWP3	Traceability data
Expected Contents	The traceability between hardware requirements and system requirements - Demonstration of complete traceability
Notes	Hardware requirements support tools implement traceability and help demonstration of completeness **HRQ-PR1**

5.2 HDS – Hardware Design

Context of the process:

Hardware Design process is a key in the context of automotive developments because it addresses the way the functions shall be addressed.

Input Work Products:

- System Requirements
- System Design (including interface specification)

Additional relevant inputs are:

- Software requirements specification
- Software design

Process Requirements:

HDS-PR1	Determine hardware architecture
Q-clause	Hardware architectural design shall be developed in order to provide a design able to support the implementation of the hardware requirements.
Elaboration	Develop HW architecture considering well trusted HW architectures patterns (and using standard hardware blocks as appropriate). Hardware safety mechanisms shall be described as appropriate (HW safety concept). HW requirements are allocated to HW blocks. LINKS TO ISO 26262 Requirement(s): ISO 26262-5:2018, Clause 7.4 LINKS TO APQP Requirement(s): Engineering specification
Improvement Guidance	Reuse of past design that proved functional and robust is a best practice. Reuse opportunities are explored considering the system concept, the hardware design, and the software high-level design. Reuse includes: - Forward reuse (for instance development for reuse) - Backward reuse (for instance. reuse of existing components as building blocks to develop new systems) An evaluation of the technical feasibility, cost-effectiveness and risks of the deployment of reuse opportunities shall be conducted and documented. In the case of backward reuse, opportunities evaluation shall address explicit criteria for selection of items to reuse. Reuse opportunities can include documentation reuse as well
Tailoring Guidance	Design may include wiring and connector aspects. The design of such sub-system(s) needs to address key attributes such as: ● Temperature class ● Strength ● Chemical stability (corrosion resistance) ● Anti-fatigue ● Flexibility ● Short-circuit endurance ● Mechanical creep resistance ● Safety ● Supply availability
Notes	Adoption of complex architectural elements such as SoC and/or ASIC can offer advantages.

HDS-PR2	Design hardware detailed design

Q-clause	Detail design shall be deployed in order to define sub-system schematics/drawings aligned with the architectural design.
Elaboration	The hardware design is an articulated process that include: - BoM Definition - Layout and netlist definition - Components and circuit dimensioning LINKS TO ISO 26262 Requirement(s): ISO 26262-5:2018, Clause 7.4 LINKS TO APQP Requirement(s): Engineering specification
Improvement Guidance	AEC-Q100/101/200 is the reference qualification standards for automotive electronics components.
Tailoring Guidance	-
Notes	-

Governance Requirements:

HDS-GR1	Co-design
Q-clause	Project shall exploit co-design or simultaneous engineering to improve the quality of the design process and project velocity.
Elaboration	The purpose is to improve and expedite the development of quality products. This approach complements or replaces the sequential series of phases where results are transmitted to the next area for execution. Dependencies between processes do not mean that processes shall be executed in a strict time sequence. On the contrary, any process may start as soon as acceptable drafts are available as input and with continuous design interactions among disciplines.
Improvement Guidance	Functional safety and cyber-security related developments are potential areas where to apply co-design principles.
Tailoring Guidance	-
Notes	Co-design is typically adopted in conjunction with concurrent engineering.

Technological Requirements:

HDS-TR1	CAD (Computer Aided Design) support
Q-clause	CAD tools shall be deployed, as appropriate.
Elaboration	Effective mechanical design shall be supported by tools aligned with the state of the art
Improvement Guidance	Integration with hardware design tools is highly beneficial.
Tailoring Guidance	-
Notes	A CAD program is a computer technology that designs a product and documents the design phase of the engineering process. CAD may facilitate the manufacturing process by transferring detailed diagrams of product's materials, processes, tolerances, and dimensions. It can be used to produce either 2D or 3D diagrams, which can then be rotated to be viewed from any angle, even from the inside looking out.

HDS-TR2	CAE (Computer Aided Engineering) support.
Q-clause	CAE shall be deployed, as appropriate, in order to converge towards a correct and robust design.
Elaboration	CAE tools shall support: - Calculation - Simulation - FEA - CFD analysis - MBD analysis - And other analysis as appropriate
Improvement Guidance	-
Tailoring Guidance	-
Notes	-

Output Work Products:

HDS-OWP1	HW architectural design
Expected Contents	Its content includes: - architecture description - block descriptions - connector(s) design
Notes	**HDS-PR1**

HDS-OWP2	HW detailed design
Expected Contents	Its content is technology dependent: - Design book includes calculations to dimension the HW elements - 2D Drawings - 3D Drawings -
Notes	**HDS-PR2, HRQ-TR1**

HDS-OWP3	HW BoM
Expected Contents	Its content includes: - primary source components - secondary source components Should be accessible to buyers
Notes	**HDS-PR1, HDS-PR2, HDS-TR1**

5.3 HVD – Hardware Verification and Dependability

Context of the process:

Hardware Verification and Dependability process is a key in the context of ensuring that hardware design is correct and provides the expected reliability level.

From an operative point of view, HW.2 and HW.3 processes are conducted with a high degree of parallelism.

Input Work Products:

- Hardware Requirements
- Hardware Design
- Hardware BoM

Additional relevant inputs are:

- System Requirements
- System Design

Process Requirements:

HVD-PR1	Review hardware design
Q-clause	A set of design reviews shall be conducted along the project to make sure that the design is correct.
Elaboration	A design Review is a peer review conducted to ensure that hardware requirements have been completely and properly identified and that a mutual understanding between the customer and supplier exists. Exploitation of simulation, testing of prototypes is welcome. LINKS TO ISO 26262 Requirement(s): ISO 26262-5:2018, Clause 7.4.4 LINKS TO APQP Requirement(s): Design verification, design review
Improvement Guidance	1. Plan at least for: - Preliminary design review - Critical design review
Tailoring Guidance	The review techniques that can be considered are: - Walkthrough - Inspection - simulation
Notes	-

HVD-PR2	Perform DFMEA on hardware sub-system
Q-clause	FMEA analysis at component level or design level shall be developed, as appropriate
Elaboration	The objective of this requirement is to make sure that a failure analysis is conducted in order to make sure that robust design principles are adopted during the design phase of the hardware. LINKS TO ISO 26262 Requirement(s): ISO 26262-5:2018, Clause 7.4 LINKS TO APQP Requirement(s): DFMEA
Improvement Guidance	1. FMEA instead of FMECA technique is not recommended.
Tailoring Guidance	ETA (Event Tree Analysis) can be used as alternative of inductive analysis. Also, FTA can be adopted.
Notes	In case of safety critical projects, FMEDA technique needs to be applied in accordance with ISO 26262

HVD-PR3	Perform HW sub-system dependability evaluation
Q-clause	The project shall make use of appropriate means in the context of relevant engineering discipline to assess the hardware sub-system dependability vs. defined objectives.
Elaboration	Dependability analysis is beneficial to overall design improvement. LINKS TO ISO 26262 Requirement(s): ISO 26262-5:2018, Clause 7.4 LINKS TO APQP Requirement(s): Design verification
Improvement Guidance	-
Tailoring Guidance	-
Notes	-

Governance Requirements:

HVD-GR1	Determine quality and reliability goals for hardware sub-system.
Q-clause	As the project or pre-project activities start, a documented view of the quality and reliability goals for the hardware sub-system shall be provided.
Elaboration	Achieving quality and reliability goals depends on fundamental knowledge of how to select and integrate elements, technologies and materials into functionally capable and dependable systems. Quality and reliability goals shall be refined along the development into measurable requirements. LINKS TO APQP Requirement(s): Reliability and Quality Goals LINKS TO ISO 26262 Requirement(s): ISO 26262-4:2018, Clause 7.4
Improvement Guidance	1. Collaborate with customer to identify quality and reliability goals. 2. Use benchmarks as appropriate.
Tailoring Guidance	-
Notes	A specific APQP requirement exists.

Technological Requirements:

HVD-TR1	HW design simulation tool support
Q-clause	The project shall make use of state-of-the-art simulations tools to perform in depth analysis for relevant aspects.
Elaboration	The exploitation of simulation tools is key to achieve high-quality.
Improvement Guidance	-
Tailoring Guidance	-
Notes	The project shall consider the use of state-of-the-art dependability tools to perform in depth analysis for dependability aspects.

Output Work Products:

HVD-OWP1	HW design review report
Expected Contents	Its content includes: - Reviewers - Review summary results - Design review criteria - Review findings
Notes	**HVD-PR1**

HVD-OWP2	HW DFMEA
Expected Contents	Its content includes: - Failure mode analysis of HW components - Impact analysis on external environment
Notes	**HVD-PR2**

HVD-OWP3	Electronic HW Dependability Evaluation Report(s)
Expected Contents	Its content includes: - Summary results - Applied approach description - Analysis details.
Notes	**HVD-PR3, HVD-TR1**

5.4 HIV – Hardware Integration and Validation

Context of the process:

Hardware Integration and Validation process is a key in the context of automotive developments because it addresses how the EE functions provided by the hardware sub-system(s) shall be integrated and validated.

From an operative point of view, HDS and HVD processes are conducted with a high degree of parallelism.

Input Work Products:

- Hardware requirements
- Hardware design

Additional relevant inputs are:

- Software requirements
- Software design
- Mechanical constraints

Process Requirements:

HIV-PR1	Validation (quality check) of the (incoming) components.
Q-clause	Inspection and/or test on components shall be conducted to verify the respect of the design.
Elaboration	External designed components shall be qualified according to a documented and approved procedure performed by the supplier.
Improvement Guidance	Testing can be performed also by virtual means.
Tailoring Guidance	-
Notes	-

HIV-PR2	Perform HW blocks characterization
Q-clause	HW tests at block level shall be performed to ensure the correctness of the design.
Elaboration	The project shall conduct testing at block level to make sure that actual behaviors of components are what expected. Back-to-back verification with modeling or simulations apply. LINKS TO ISO 26262 Requirement(s): ISO 26262-5:2018, Clause 10 LINKS TO APQP Requirement(s): -
Improvement Guidance	-
Tailoring Guidance	-
Notes	-

HIV-PR3	Hardware integration and integration verification
Q-clause	Hardware blocks shall be integrated into the hardware sub-system(s) and the related integrity shall be verified.
Elaboration	The Integration activity addresses the integration and the related integration verification of the hardware blocks. It typically includes the following steps: - Perform visual inspection - Automatic check - Smoke testing
	LINKS TO ISO 26262 Requirement(s): ISO 26262-5:2018, Clause 10 LINKS TO APQP Requirement(s): -
Improvement Guidance	-
Tailoring Guidance	Not applicable for semiconductor development.
Notes	This activity often involves incoming quality function.

HIV-PR4	Perform HW Validation
Q-clause	HW tests at sub-system level shall be performed.
Elaboration	The project shall conduct testing to validate hardware requirements according to a documented test specification (to be formally reviewed). Traceability to requirements is necessary.
	LINKS TO ISO 26262 Requirement(s): ISO 26262-5:2018, Clause 10 LINKS TO APQP Requirement(s): -
Improvement Guidance	-
Tailoring Guidance	This activity can be performed at system level.
Notes	Refer to REQ-PR1 for general notes on requirement specification.

Governance Requirements:

HIV-GR1	Determine HW testing verification
Q-clause	A policy for the analysis, integration, verification, and validation of the hardware sub-systems shall be defined and documented.
Elaboration	Definition of the scheme for the several project phases in accordance with project and quality objectives. The scheme should take into account the following main testing types: - Functional Testing - Functional safety Testing - Interface Testing - Performance and Stress Testing Reference technique to consider include: 1. Nominal behavior testing 2. Negative testing 3. Error guessing 4. Fault injection In addition, but very important, definition of the regression policy for the several project phases in accordance with project and quality objectives. Default regression policy is full regression.
Improvement Guidance	Involve designers in the policy definition to reach better validation effectiveness.
Tailoring Guidance	Tailoring notes for Regression Strategy: Selective is allowed on the base of previously passed tests, impact analysis and schedule A subset of test cases will be always repeated at every system test execution in order to provide confidence that the main system functionalities work correctly; such a subset is identified and called “Sanity check test cases”
Notes	-

Technological Requirements:

HIV-TR1	Automation support for HW testing
Q-clause	Automation validation means shall be deployed, as appropriate
Elaboration	Automatic test equipment or automated test equipment (ATE) is any apparatus that performs tests on a device, known as the device under test (DUT), equipment under test (EUT) or unit under test (UUT), using automation to quickly perform measurements and evaluate the test results.
Improvement Guidance	Automated testing equipment and improves regression testing (rerun of previously executed test cases to uncover and track new hardware defects) with increased coverage and reduced costs as a result.
Tailoring Guidance	-
Notes	Automation has much more to offer than to simply alleviate the boredom of the would-rather-not-be testers.

Output Work Products:

HIV-OWP1	Component Quality Check Report(s)
Expected Contents	Its content includes: - Summary results - List of performed tests - Identification of the HW block and main features - Detailed test results
Notes	**HIV-PR1**

HIV-OWP2	Characterization Report(s)
Expected Contents	Its content includes: - Summary results - List of performed tests - Identification of the HW block and main features - Detailed test results
Notes	**HIV-PR1**

HIV-OWP3	HW Validation Strategy
Expected Contents	Its content includes: - Test environment - Test tools - Test techniques - Test risks - Regression policy - Test resources - Set of tests to perform
Notes	**HIV-GR2**

HIV-OWP4	HW Validation Specification
Expected Contents	Its content includes: - Test settings - Test procedures - Pass/fail criteria - Test chains
Notes	**HIV-PR3**

HIV-OWP5	HW Validation Report
Expected Contents	Its content includes: - Summary results - Test results - Link to logs

Notes	**HW4-PR3**

HIV-OWP6	Traceability data
Expected Contents	Its content includes: - Link to HW requirements (forward and backward)
Notes	**HIV-PR3**

6. Software Engineering Family Processes

In the context of PISA model, Automotive software engineering addresses the software throughout its life cycle, including requirement, specification, design, development, integration, verification and validation.

Reference automotive software engineering goals are:

- Rigorous software verification and validation
- Robust requirement handling to cope with volatility
- Vehicle network-oriented software design
- Compliance with coding standard and code analysis
- Focus on software unit verification

The processes belonging to the System Engineering Technical Family are:

- SRQ – Software Requirements
- SDS – Software Design
- SPR – Software Production
- SIV – Software Unit Verification
- SUV – Software Integration and Validation

TRACEABILITY TO IATF 16949:

The software-engineering family processes of the PISA model target the following IATF 16949 requirements:

- Section 8.2: Requirements for products and services
- Section 8.3: Design and development planning

6.1 SRQ – Software Requirements

Context of process:

Software requirements specification deals with the definition of functional and non-functional requirements for software.

Software requirements specification is key because the whole software development depends on the availability of complete and clear software requirements. For this reason, the informative content and the level of detail of requirements has to be enough for software unit development as well as for software testing.

Input Work Products

- Project requirements at system level
- System design
- HW-SW Interface specification

Process Requirements

SRQ–PR1	Determine software requirements
Q-clause	Requirements at software level shall be documented and made available to stakeholders.
Elaboration	Each software requirement shall be identified by a unique Id. Possible notations for software requirements documentation are: ● Natural language, ● Simplified natural language, ● Semiformal notation (e.g. UML, …). Each software requirement shall be classified according to as a minimum, the following criteria: ● Priority of implementation (in the case of incremental software development approach), ● Safety (in the case of existing functional safety requirements), ● Functional / Non-functional requirements. Requirement specification shall be under configuration management. LINKS TO ISO 26262 Requirement(s): ISO 26262-6:2018, Clause 6.4.1. ISO 26262-8:2018, Clause 6.4. LINKS TO APQP Requirement(s): Engineering specification
Improvement Guidance	Grouping requirements according to features supports effective communication and requirements handling. Define rules for software requirements Id. so that some relevant information is derivable by the Id. itself.
Tailoring Guidance	In the case of reuse, the software requirements related to the reused software parts may be referred rather than rewritten. In the case of platform-based development, the requirements related to the platform software may be referred rather than rewritten. Requirements can be expressed in shape of a functional model (e.g. HMI prototype). Agile Tailoring: Relevant work-products (artifacts) are: - Product backlog - Sprint Backlog - Agile estimation - EPIC/User Story The identified artifacts **address**/partially address/do not address the requirement expectations.
Notes	The way software requirements are documented may vary according to several

	factors as: skills of stakeholders; tools availability; development approach. In the case of configurable software, software requirements specification includes: ● non-functional requirements related to the specification of software configuration; ● calibration requirements for specific software releases. Software requirements shall not be necessarily specified separately with respect system requirements. In the case of adequate level of detail and informative content, a requirement specified at system level can be considered as valid at software level as well. If applicable, requirements for: - model based software - artificial intelligence (for instance DNN) software shall be documented.

SRQ-PR2	Review software requirements specification
Q-clause	Software requirements specification shall be reviewed to find out possible defects.
Elaboration	Software requirement specification review shall address both any single requirements and the whole requirement specification. Review of single software requirements shall aim at finding lacks in terms of non-ambiguity, feasibility, testability, atomicity. Review of the whole software requirement specification shall aim at finding lacks in terms of completeness, consistency, and compatibility of software requirements with the target hardware environment. To address the compatibility with the hardware target environment the following aspects are to be addressed: micro controller response time, data and voltage interfaces, environmental conditions (as temperature, EMC, …), memory (RAM/ROM, EEPROM, …) capacity limits and dynamic loads. Major software requirements defects shall be recorded. The technical impact and the cost of the correction of major software requirements defects shall be estimated. The availability of a consistent traceability between software requirements and higher-level requirements shall be part of the review. LINKS TO ISO 26262 Requirement(s): ISO 26262-6:2018, Clause 6.4.1, 11.2; ISO 26262-6:2018, Clause 9.4. LINKS TO APQP Requirement(s): Design Reviews
Improvement	Checklists are cost-effective, easy, flexible, maintainable means to support

Guidance	software requirements reviews (see SRQ-TR2).
Tailoring Guidance	Review technique (for instance walk-through, inspection…) shall be tailored according to project needs. Agile Tailoring: Relevant work-products (artifacts) are: - Definition of Ready - Backlog refinement The identified artifacts address/**partially address**/do not address the requirement expectations.
Notes	A software requirements defects is considered a major software requirement defect if its correction impacts on either software architectural design, or software detailed design, or interface specifications. Software requirements related to the reused software parts shall be reviewed as well.

Governance Requirements:

SRQ-GR1	Software requirements change management
Q-clause	Software requirements changes shall be documented, analyzed and approved as appropriate.
Elaboration	Change management workflow for software requirements shall be defined and applied. Changes shall be analyzed in order to evaluate the impact. Responsibility for software requirement changes approval shall be assigned. The change approval shall be notified to the persons involved in the implementation of the change. The approval shall be based on explicit estimation of the impact of the implementation of the change that takes into account: ● the technical impact, ● the cost of implementation, ● the availability of necessary skills and technology. Major corrective changes shall be recorded. LINKS TO ISO 26262 Requirement(s): ISO 26262-8:2018, Clause 8.4. LINKS TO APQP Requirement(s): Drawing and specification changes
Improvement Guidance	Software requirement management tool may support the change management procedure.
Tailoring Guidance	In the case of minor software requirement changes, the estimation of the impact of their implementation may be implicit. Agile Tailoring: Relevant approaches are: - Kamban Board The identified artifacts address/**partially address**/do not address the requirement expectations.
Notes	-

Technological Requirements:

SRQ-TR1	Software requirement management tool
Q-clause	Automatic tool(s) supporting requirements management, documentation, storing, traceability, and classification shall be used.
Elaboration	The software requirement management tool shall be setup to make the software requirements available to the stakeholders. Software requirements management tool shall guarantee the versioning of requirements. The tool shall guarantee the backup of requirements. The tool shall guarantee the filtering by classes of software requirements (for instance safety-related requirements, non-functional requirements, …). Guidance on the use of the tool shall be available to stakeholders.
Improvement Guidance	In order to facilitate the exchange of software requirements use the same tool or a tool that is compatible with stakeholders' tools (customer(s) and supplier(s)). Using a unique tool for issue and tasks management, requirements change management, and task management can be considered. Consider the use of a unique tool for system requirements and software requirements management.
Tailoring Guidance	Spreadsheets (e.g. MS Excel) are not acceptable software requirements management tools unless the number and complexity of software requirements is negligible. In case of a limited set of requirements (e.g. 100), standard office tools may be sufficient.
Notes	Open source technology is relatively lacking in this area of the development flow.

Output Work Products

SRQ-OWP1	Software Requirements Specification
Expected Contents	Software requirements specification shall include: ● A unique identifier for each software requirement ● A classification for each software requirement. Classification is made according to as a minimum the following criteria: ○ Priority of implementation (in the case of incremental software development approach), ○ Safety (in the case of existing functional safety requirements), ○ Functional / Non-functional requirements ● Reference to applicable standards
Notes	**SRQ-PR1**

SRQ-OWP2	Software Requirements Specification Review Report
Expected Contents	Review record includes: ● Review objectives ● Reviewers identification ● Review results
Notes	Software Requirements review tool allows the full description of defects found. **SRQ-PR2**

SRQ-OWP3	Traceability data
Expected Contents	The traceability between software requirements and system requirements Demonstration of complete traceability
Notes	Software requirements support tools implement traceability and help demonstration of completeness **SRQ-PR3**

6.2 SDS – Software Design

Context of process:

Software design process deals with the definition of software design. Unless software under development is very simple, the software design needs to be represented at different levels of details.

The number of levels of detail software design is to be provided cannot be established a priori.

The requirements of this process refer to both manual software development and automatic code creation from models.

Input Work Products:

- System Design
- Software requirements specification
- Hardware-software interface specification

Additional relevant inputs are:

- Hardware technical environment characteristics

Process Requirements:

SDS-PR1	Develop high-level software design
Q-clause	Software design shall be provided to represent the software part of the system along with its interfaces.
Elaboration	A complete architecture of software shall be elaborated and documented. Such an architecture shall contain the software components and the related interfaces and relationship. The software high-level design shall provide a complete representation of software units and their interfaces and interactions. Software high-level design shall address static aspects of software, as: ● External interfaces of the software ● Interfaces between software units/software components ● Resources usage constraints for software ● Allocation of system requirements to the system elements Software high-level design shall address dynamic aspects of software behavior, as: ● Dataflow between software units/software components ● Dataflow at software external interfaces ● Interrupts management ● SW operating modes Software design shall specify the notation to be used. Possible notations to represent software design are: - natural language - semi-formal graphical notations (as UML) - informal notations Diagnostic software components shall be Identified and specified as appropriate. Network communication management software components shall be Identified and specified as appropriate. In the case of model-based software development the first levels of model decomposition can be equated to high-level design. In case of artificial intelligence, the definition of the structure of neural network(s) such as layers and number of nodes, learning policy can be equated to high-level design. Software features or software requirements shall be allocated consistently to software units/components. LINKS TO ISO 26262 Requirement(s): ISO 26262-6:2018, Clause 6.4.1, 11.2; ISO 26262-6:2018, Clause 9.4. LINKS TO APQP Requirement(s): Engineering Drawings
Improvement Guidance	A layered representation of software design is encouraged in the case of architectural high complexity of software.

	The use of formal notations to represent software design is not to be encouraged, because their costs in terms of tool support and people training, and because the consequent sharing barriers. To address software design dynamic aspects, the use of graphical notation is profitable.
Tailoring Guidance	High-level design can be expressed as collection of separate work-product, documental and electronic. Agile Tailoring: Relevant approaches are: - Design thinking - Refactoring The identified artifacts address/**partially address**/do not address the requirement expectations. Model-based development Tailoring: Relevant work-products (artifacts) are: - High-level models - I/O signal definition - Functional model (prototype) of Feature(s) or Product The identified artifacts **address**/partially address/do not address the requirement expectations.
Notes	AUTOSAR provides a set of specifications that builds a common design methodology based on standardized exchange format.

SDS-PR2	Develop low-level software design
Q-clause	Each software unit shall be associated with a low-level design specification that is instrumental to develop or generate the software.
Elaboration	Detailed design is the process of defining the lower level components, units and interfaces of the software. Low-level software design elements shall contain the information on how develop the related code (e.g. control flow diagrams of software units, algorithm descriptions, implementation choices, …) In the case of model-based software development the lower levels of model decomposition can be equated to low-level design. In case of artificial intelligence, the detailed structure of neural network(s) such as node weights can be equated to low-level design.

	LINKS TO ISO 26262 Requirement(s): ISO 26262-6:2018, Clause 6.4.1, 11.2; ISO 26262-6:2018, Clause 9.4. LINKS TO APQP Requirement(s): Engineering Drawings
Improvement Guidance	Avoid over design specification and focus on project complexities.
Tailoring Guidance	Reverse engineering from source code is acceptable in presence of adequate coding guidelines. Agile Tailoring: Relevant artifacts are: - Detailed stories (or tasks) associated with design content - Source code commenting The identified artifacts address/**partially address**/do not address the requirement expectations. Model-based development Tailoring: Relevant work-products (artifacts) are: - Low-level models - I/O signal definition The identified artifacts **address**/partially address/do not address the requirement expectations.
Notes	-

SDS-PR5	Design review
Q-clause	A set of design reviews shall be conducted along the project to make sure that the software design is correct.
Elaboration	A software design Review is a formal review conducted to ensure that system requirements have been completely and properly identified and that a mutual understanding between the customer and supplier exists. Plan at least for: - Preliminary design review (to establish the initial baseline of the software design to ensure software is operationally effective) - Critical design review (to ensure that the software design can proceed software development and can meet stated functional and non-functional requirements within cost, schedule, and risk) The review techniques that can be considered are: - Walkthrough - Inspection Software design review is meant also to address key non-functional features such as dependability.

	Structural objectives for software design shall be established. Possible structural objectives for software design are: target values of coupling/cohesion metrics, target values of fan-in/fan-out, limited number of software unit interfaces, target number of interrupts. The availability of a consistent allocation of software requirements to the architectural elements shall part of the review. LINKS TO ISO 26262 Requirement(s): ISO 26262-4:2018, Clause 7.4.8 LINKS TO APQP Requirement(s): Design verification, design review
Improvement Guidance	Exploitation of simulation, testing of prototypes is recommended.
Tailoring Guidance	No specific info in general. Agile Tailoring: Relevant approaches are: - Sprint review - Definition of Done - Refactoring The identified artifacts address/**partially address**/do not address the requirement expectations.
Notes	Software design simulation techniques are valid means for design review.

Governance Requirements:

SDS-GR1	SW Design Pattern Support
Q-clause	Organization shall sponsor adoption of architectural patterns suitable for the missions of its projects.
Elaboration	In software engineering, a software design pattern is a general, reusable solution to a commonly occurring problem within a given context in software design. It is not a finished design that can be transformed directly into source or machine code. Design patterns are formalized best practices that the programmer can use to solve common problems when designing an application or system.
Improvement Guidance	Deployment of role of organization SW architect or CTO is supportive to the Q-clause.
Tailoring Guidance	-
Notes	-

Technological Requirements:

SDS-TR1	Automatic support for software design, modeling, and simulation
Q-clause	Suitable software modeling and automatic code generation tool chain shall be applied.
Elaboration	In the case of semi-formal graphical notation is adopted for software design specification, a supporting tool shall be selected, setup and used. Graphical specification of software design shall allow the specification of software units/components as well as all their interactions and interface data types. In the case of model-based software development, a state-of-the-art tool chain allowing model construction and automatic code generation is selected, setup and used.
Improvement Guidance	Consider that some environments for modeling, prototyping, verification and automatic code generation are able to support AUTOSAR compliance when needed.
Tailoring Guidance	-
Notes	This requirement is applicable only in the case of model-based software development approach.

Output Work Products:

SDS-OWP1	Software Architecture
Expected Contents	- Design methodology and objectives - Required software components/units including relationships and dependencies. In the case of layered software design representation, the required software components including relationships and dependencies - Dynamic behaviour of the software (at least the main phases as: Start-up, shutdown, software update, error handling and recovery, etc.). - Identification of own developed and third-party code. - Internal and external interfaces of software units (and software components, if it is case). - Format of input/output data. - Interrupts with their priorities - Allocation of software requirements
Notes	In the case of model-based software development, the expected contents are the same. **SDS-PR1, SDS-GR1, SDS-TR1**

SDS-OWP2	Software units design specification(s)
Expected Contents	Content includes: ● Software unit provided interfaces ● Software unit required interfaces ● Software unit internals design as appropriate - Control flow - Data flow - Algorithm(s) and/or mathematical aspects - Performance and timing constraints - Interrupt management - Resource management
Notes	**SDS-PR2, SW2-TR1**

SDS-OWP3	Software design review report
Expected Contents	Review record includes: ● Review objectives ● Reviewers identification ● Review results ● Demonstration of consistent allocation. ●
Notes	**SDS-PR5**

SDS-OWP4	Software Models
Expected Contents	In the case of model-driven software development, models shall be stored and maintained
Notes	**SDS-PR1, SDS-PR2, SDS-TR1**

6.3 SPR – Software Production

Context of process:

Software Production process deals with the development of source code. The process addresses software at application layer and also software at lower layers.

The requirements of this process refer to both manual software development and automatic code creation from models.

Input Work Products

- Software Detailed Design including Software Units design specification
- Hardware constraints specification
- Software requirements specification

Process Requirements

SPR-PR1	Software unit development
Q-clause	Source code of software unit shall be developed according to the low-level software design constraints and software requirements.
Elaboration	The source code of the software units developed shall be produced. Software units developed shall be consistent with the low-level software design. Consistency with software detailed design shall include the internal and external interfaces of software units (ref. SDS). Source code shall be compliant with code style guidelines in order to assure its readability and maintainability (ref. SPR-GR1). Source code style guidelines shall be applied both to source code developed manually and generated automatically. LINKS TO ISO 26262 Requirement(s): ISO 26262-6:2018, Clause 8.4.4. LINKS TO APQP Requirement(s): -
Improvement Guidance	When possible support the application of source code style guidelines with a specific setup of software development environment (both for source code developed manually and generated automatically). Software requirements implemented by a software unit can be included into the source code of that software units as comments.
Tailoring ıidance	Agile Tailoring: Relevant artifacts/approaches are: - Pair programming
Notes	The software unit source code can be developed manually or generated automatically.

SPR-PR2	Build software from software units
Q-clause	The software shall be built from software units according to a defined process.
Elaboration	- LINKS TO ISO 26262 Requirement(s): ISO 26262-6:2018, Clause 8.4.5. LINKS TO APQP Requirement(s):
Improvement Guidance	-
Tailoring Guidance	Agile Tailoring: Relevant approaches are: - Continuous Integration

	The identified artifacts **address**/partially address/do not address the requirement expectations.
Notes	-

SPR-PR3	Configuration and Calibration development
Q-clause	Configuration parameters and calibration data shall be identified, defined and implemented as per design.
Elaboration	Calibration aims at adjusting certain characteristic data of software units implementing control functionality to the HW/SW environment. Characteristic data in the source code of a software function have a significant impact on the functionality of the software. Calibration tuning shall be performed as a post-build activity Each software configuration parameters and calibration data shall be identified and maintained. Default value shall be assigned as per design.
	LINKS TO ISO 26262 Requirement(s): ISO 26262-6:2018, Clause C.4. LINKS TO APQP Requirement(s):
Improvement Guidance	Consider the use of a calibration tool in the case of relevant number of calibration parameters.
Tailoring Guidance	SPR-PR3 requirement is valid only in the case of use of calibration and configuration data.
Notes	Calibration does not aim at varying implemented functionality (as in the case of data variant coding approach)

Governance Requirements

SPR-GR1	Coding directives and objectives definition
Q-clause	Software unit related objectives shall be defined
Elaboration	Structural objectives for software units shall be established. Possible structural objectives for software units may include: cyclomatic complexity metrics, number of lines of code per function, comment density. Sub-set of MISRA C/C++/Modelling rules to apply shall be identified as appropriate.
Improvement Guidance	Other source code objectives may be: no unreachable branches, limited number of global variables.
Tailoring Guidance	Metrics target values may vary according to project-specific choices. Agile Tailoring: Relevant artifacts are: - Definition of Ready The identified artifacts address/**partially address**/do not address the requirement expectations.
Notes	The elaborations of this Governance Requirement are valid both software units developed manually and for software units derived automatically from models. (See also SUV-PR2)

Technology Requirements

SPR-TR1	Software development environment
Q-clause	Adequate software development environment and related supporting tools shall be identified, setup, and used in consistent and controlled way.
Elaboration	In the case of software units developed manually, software development environment is identified. In particular configuration set up and version of the used compiler are identified, recorded and associated to each release. In the case of model-based software development the version and the configuration parameters of each tool involved in the model-based automatic software generation is identified recorded and associated to each release.
Improvement Guidance	Use state-of-the-art tools and development environment. Agile Tailoring: Relevant approaches are: - DevOps (SAFe) The identified artifacts **address**/partially address/do not address the requirement expectations.
Tailoring Guidance	-
Notes	-

SPR-TR2	Software version management
Q-clause	Software elements and software units shall be maintained under configuration management
Elaboration	See process CMG – Configuration Management
Improvement Guidance	-
Tailoring Guidance	-
Notes	-

Output Work Products

SPR-OWP1	Software unit(s)
Expected Contents	● source code, models and data ● building instructions
Notes	It may include readme.txt file to track implementation changes and notes as appropriate **SPR-PR1, SPR-GR1, SPR-TR2**

SPR-OWP2	Configuration data
Expected Contents	● Configuration parameters of each variant/release
Notes	Configuration may apply at compile time. **SPR-PR3**

SPR-OWP2	Binary code
Expected Contents	Data file
Notes	 **SPR-PR2**

SPR-OWP3	Calibration data
Expected Contents	● Calibration parameters of each variant/release
Notes	 **SPR-PR3**

6.4 SUV – Software Unit Verification

Context of process:

Software Unit Verification process is a key in the context of automotive software developments because it aims at ensuring that the developed software units are solid building blocks to be deployed in the project.

This process addresses both static verification of code and dynamic verification (testing) of SW units – refer to Glossary for SW Unit definition.

Input Work Products:

- Software Units Design Specification
- Software Units

Additional relevant inputs are:

- Software Requirements Specification
- Software Design
- Hardware-Software Interface Specification

Process Requirements:

SUV-PR1	Perform MISRA C/C++ Check
Q-clause	Source code shall be verified in respect to MISRA C/C++ compliance.
Elaboration	MISRA C/C++ guidelines [11][12] comprise a set of coding rules conceived for the automotive software that minimize the risk of programming errors. MISRA C/C++ check shall be performed also in the case of automatic generation of source code from models. The code generated from models can be checked for MISRA C/C++ compliance and the results can be traced back to the models. Any deviation shall be documented and justified according to MISRA Compliance Guideline. Reference versions are: ● MISRA C:2012, ● MISRA C++:2008 LINKS TO ISO 26262 Requirement(s): ISO 26262-6:2018, Q-clause 9.4.4. LINKS TO APQP Requirement(s):
Improvement Guidance	MISRA C/C++ check is supported by several tools providing automatic check and advanced reporting features. Tools allow to perform checking directly on the models to maximize MISRA C:2012 compliant code.
Tailoring Guidance	If requested by customer, MISRA C/C++ check can be performed using an older version (e.g. MISRA C:2004). This requirement applies in the case of the programming language is C or C++, otherwise a specific set of coding rules is to be defined and applied. In particular for model-based development. Agile Tailoring: Relevant artifacts/approaches are: - Definition of Done - Pair programming The identified artifacts address/**partially address**/do not address the requirement expectations.
Notes	MISRA – Motor Industry Software Reliability Association For model based development MISRA has developed a set of guidelines for users of control system modeling packages. The aim of the guidelines is to provide a set of rules, in a similar fashion to the MISRA C rules, which encourage good modeling practices and avoid poorly-defined features of the

	modeling language. In light of automotive industry trends, some rules will be aimed at the use of automatic code generators in safety-related systems. The available documents are: ● MISRA AC GMG - Generic modeling design and style guidelines ● MISRA AC SLSF - Modeling design and style guidelines for the application of Simulink and Stateflow ● MISRA AC TL - Modeling style guidelines for the application of TargetLink in the context of automatic code generation ● MISRA AC AGC - Guidelines for the application of MISRA-C:2004 in the context of automatic code generation These documents are available to purchase from the MISRA webstore. In addition, an introductory document, MISRA AC INT, is available free-of-charge from the "Resources" section of the MISRA Bulletin Board. The MISRA AC documents are organized in a hierarchy representing the complete workflow of model-based development, from the generic level (MISRA AC GMG) through a graphical language (MISRA AC SLSF), an autocode generator (MISRA AC TL) and the target language (MISRA AC AGC).

SUV-PR2	Perform Software Units Structural Metrics Check
Q-clause	Measurements of the structure of source code shall be obtained
Elaboration	Several software structural metrics are available in order to measure the software. The metrics to be calculated focus on the software quality characteristics of maintainability: ● Mc Cabe Cyclomatic Complexity (MCCC) – Measure of the algorithmic complexity [Compliance threshold is 12] ● Comment Density – Relationship of the number of comments to the number of statements [Compliance threshold is 20%] Deviations shall be documented and justified. In case of model based design, the state-of-the-art allow the collection of specific metric for model
Improvement Guidance	Several commercial and freeware tools are available.
Tailoring Guidance	Additional source code metrics can be calculated: - Number of Function Input Parameters (NFIP) - Function Fan-In/Fan-Out Agile Tailoring: Relevant artifacts/approaches are: - Definition of Done The identified artifacts address/**partially address**/do not address the requirement expectations.

Notes	-

SUV-PR3	Conduct Software Units Analysis
Q-clause	Human analysis of the source code shall be performed.
Elaboration	Human analysis of source code aims at verifying the compliance with its interface specifications and algorithmic correctness of software. Procedure, independence of analysts, purpose of analysis and results (i.e. errors or warning found) of software unit analysis shall be documented. . LINKS TO ISO 26262 Requirement(s): ISO 26262-6:2018, Clause 8.4.5. LINKS TO APQP Requirement(s):
Improvement Guidance	For hand-written code, there is availability of tools that feature the capability of associating the review output conveniently to the source code.
Tailoring Guidance	Source code inspections may be limited to critical software parts. Source code inspections may be limited according to the software reuse policy.
Notes	-

SUV-PR4	Conduct Software Unit Testing
Q-clause	Software unit testing shall be performed in accordance with the SW Unit Testing policy in order to demonstrate that the software units fulfill its design specifications and its functional requirements.
Elaboration	Test case description comprises testing conditions, input data, and the expected output. Software unit test cases address three main dimensions: - Functional (relevant software requirements) - Robustness (boundary tests, interface tests, negative tests) - Coverage (statement, branch, …) Result of each test cases execution is recorded. LINKS TO ISO 26262 Requirement(s): ISO 26262-6:2018, Clause 9.4. LINKS TO APQP Requirement(s):
Improvement Guidance	Test records may be provided by testing tools
Tailoring Guidance	For safety-critical software units ISO 26262. Agile Tailoring: Relevant artifacts/approaches are:

	- Definition of Done - Test Driven development - Sprint Review The identified artifacts **address**/partially address/do not address the requirement In the case of Model-based Software development, the unit test cases are developed to run the models first and, once the code has been generated, reused to test the generated software units.
Notes	-

Governance Requirements:

SUV-GR1	Define Software Unit Static Analysis Strategy
Q-clause	A policy for the Software Unit Static Analysis shall be defined and documented.
Elaboration	Strategy provides a (tailored) classification of MISRA C/C++ rules (*mandatory, required, advisory*). Strategy provides objectives in terms of MIRSA C/C++ compliance of each software increment. Strategy provides a description (inclusive of purpose, procedure, involved roles, and acceptable outcomes) of code walkthrough or inspections of software units.
Improvement Guidance	Tailoring of MISRA rules shall maintain the whole set of “mandatory” rules at least for the final release of software. Agile Tailoring: Relevant artifacts/approaches are: - Definition of Ready The identified artifacts address/**partially address**/do not address the requirement.
Tailoring Guidance	Tailoring criteria for MISRA C/C++ rules classification may be: re-used software units, special simple functions, avoiding runtime degradation. In the case of Agile software development approach the policy may be defined without a formal document.
Notes	-

SUV-GR2	Define Software Unit Testing Strategy
Q-clause	A policy for the performance of software unit testing shall be defined and documented
Elaboration	Software Unit testing policy provides: - unit testing objectives for each increment of software (unit testing objectives may be expressed in terms of passed tests, coverage level, functional requirements compliance) - guidelines for performing software unit non-regression testing - guidelines for domain partition testing and negative testing (if applied) - criteria for the independence of testers Software Unit Testing policy shall address the following techniques: - Software-in-the-loop (SIL): software units are tested in a software environment emulating the target systems. - Hardware-in-the-Loop (HIL): software units are test on benches that simulates the target hardware environment (with electrical emulation of sensors and actuators).
Improvement Guidance	The rigor of software unit testing may be growing with software increments
Tailoring Guidance	Agile Tailoring: Relevant artifacts/approaches are:

	- Definition of Ready The identified artifacts address/**partially address**/do not address the requirement. In the case of Model-based software developments the software Unit Testing Strategy shall address the use of Model-in-the-Loop (MIL) technique.
Notes	-

Technological Requirements:

SUV-TR1	Deploy Effective Static Analyzer
Q-clause	MISRA C/C++ check and structural metrics calculation shall be performed according to means aligned to the technological state-of-the-art.
Elaboration	Several automatic tools preforming structural metrics calculation and MISRA C/C++ check are available and widely applied. Tool support for this activity is prominent for the performance of this process.
Improvement Guidance	Set up the tool in order to calculate and store statistics and measurements [M4]
Tailoring Guidance	-
Notes	-

SUV-TR2	Deploy Effective Software Unit Testing Environment
Q-clause	Unit testing shall be supported by automatic tools
Elaboration	According to the Software Unit Testing Strategy, tools supporting the deployment of Software-in-the-Loop (SIL) and Hardware-in-the-Loop (HIL) techniques shall be made available.
Improvement Guidance	-
Tailoring Guidance	In the case of Model-based software development the Software Unit Testing Environment includes Model-in-the-Loop (MIL) tools
Notes	-

Output Work Products:

SUV-OWP1	Software Unit Verification Strategy
Expected Contents	The policy shall elaborate on: ● Applicable MISRA C/C++ rules ● Description of applicable Software Units Structural Metrics along with reference ranges ● Static analysis objectives and instruction for performance, including involved roles ● Unit testing objectives for each increment of software (unit testing objectives may be expressed in terms of passed tests, coverage level, functional requirements compliance) ● Criteria for performing domain partition testing and negative testing (if applied) ● Parameter for the independence of testers and analysts ● Policy for the performance of software unit non-regression testing
Notes	**SUV-GR1, SUV-GR2**

SUV-OWP2	Software Units Static Analysis Report
Expected Contents	Results of software unit analyses executed (MISRA, metrics, manual code analysis…). Summary of results of MISRA C/C++ check (e.g. number of deviations, software version tested). Detailed information on MISRA C/C++ rules compliances and deviations justifications.
Notes	This output can be conveniently split in two separate reports (MISRA and human software unit analysis). This report (MISRA C/C++ check) can be partially produced automatically by a tool. **SUV-PR1, SUV-PR2, SUV-PR3**

SUV-OWP3	Software Unit Test Report
Expected Contents	Results Summary (e.g. pass/fail statistics, software version tested) Results of each software unit test case executed, along with its description [SWE4-PR4]
Notes	This report can be produced by automatically tool. **SUV-PR4**

6.5 SIV – Software Integration and Validation

Context of process:

Software Integration and Validation deals with bringing together the software components into the complete software following an incremental approach, and verify them at different steps of integration. This process includes the final test of the software for acceptance.

Input Work Products

- Software requirements
- Software design
- Software units

Process Requirements

SIV-PR1	Verify integrated software components
Q-clause	Software units shall be integrated to compose consistent software entities. Integrated software components shall be verified shall at each software integration step.
Elaboration	Integration of software units shall proceed according to a defined integration planning. Integration planning includes the conditions and the criteria to carry out integration steps as well as the indication of reused software entities. Interfaces of software entities shall be identified. Software entities derived from the integration of software unit shall be verifiable. To make verification possible, test harnesses (as driver and stubs) may be necessary. Test environment (benches, test harnesses, …) shall be setup and described. Tests for verifying integrated software entities shall be specified, and results recorded. LINKS TO ISO 26262 Requirement(s): ISO 26262-6:2018, Clause 10.4. LINKS TO APQP Requirement(s):
Improvement Guidance	Software integration tests are principally aimed at assuring the compliance with software design. For this reason, test cases are to be conceived for the verification of the interfaces and the interactions between software entities.
Tailoring Guidance	**Agile Tailoring**: Relevant artifacts/approaches are: - Definition of Done - Sprint Review - Continuous Integration - Testing Automation - Test Driven Development The identified artifacts **address**/partially address/do not address the requirement.
Notes	Software integration test can be performed automatically. In the case of automated software integration testing performed by test scripts, the amount of data in test logs may be large.

SIV-PR2	Software validation
Q-clause	Integrated software shall be tested against software requirements.
Elaboration	Test cases specification (inclusive of expected results, test environment description, test input data) for the integrated software shall be provided. Test cases shall be aimed at assuring compliance with software requirements and correctness of hardware/software interfaces. Tests are executed according to test cases specification. In the case of

	automated software test, the completeness and consistency of used test script with respect the test cases that it intends perform shall be guaranteed. Test results shall be recorded. A software validation report aimed at summarize the testing results shall be released. LINKS TO ISO 26262 Requirement(s): ISO 26262-6:2018, Q-clause11.4. LINKS TO APQP Requirement(s):
Improvement Guidance	Test cases can benefit from developer know-how to target complex situations that are not clear to testers.
Tailoring Guidance	Early software releases can be tested with limited formality (if acceptable for the final customer). Agile Tailoring: Relevant artifacts/approaches are: - Definition of Done - Sprint Review - Continuous Integration - Testing Automation - Test Driven Development The identified artifacts **address**/partially address/do not address the requirement.
Notes	Software tests can be performed automatically. In the case of automated software testing performed by test scripts, the amount of data in test logs may be large.

SIV-PR3	Test cases traceability
Q-clause	Traceability of validation test cases to software requirements and hardware/software interfaces definition shall be provided.
Elaboration	Back and forth traceability links are expected.
Improvement Guidance	Support of requirements management tool for traceability is recommended in the case of complex software requirements specification.
Tailoring Guidance	Agile Tailoring: Not Addressed.
Notes	-

Governance Requirements:

SIV-GR1	Software Validation Strategy
Q-clause	A policy for the performance of software validation shall be defined and documented.
Elaboration	Software Validation Testing policy provides: - testing objectives for integrated software and approach - guidelines for performing software validation non-regression testing - criteria for the independence of testers - scope of test automation Software Integration policy provides: - Software Integration objectives and approach
Improvement Guidance	Software validation policy shall take into account the following techniques, as appropriate: - Hardware-in-the-Loop (HIL): software is test on benches that simulates the target hardware environment (with electrical emulation of sensors and actuators). - Testing on target environment.
Tailoring Guidance	Agile Tailoring: Relevant artifacts/approaches are: - Definition of Ready The identified artifacts address/**partially address**/do not address the requirement.
Notes	Reference techniques for selecting input value for test cases: - Positive testing - Negative testing - Error guessing - Equivalence classes partitioning - Boundary value analysis - Pair-based testing - Fault injection

Technological Requirements

SIV-TR1	Software Testing Environment
Q-clause	Software testing shall be conducted with the support of an effective and productive technical environment.
Elaboration	Automatic tools supporting software integration testing according to the software integration policy shall be available. Test harnesses for software integration testing (for instance test drivers and test stubs) shall be integrated in the test environment when necessary. Automatic tools supporting software validation according to the software validation policy shall be available. Tool for automatic testing execution (both at integration and verification level) shall allow, script management, test execution, test log generation.
Improvement Guidance	Focus on: - automatic log retrieval from testing execution - modular approach in the setup of test-bench, with particular reference to the test software Agile Tailoring: Relevant artifacts/approaches are: - DevOps The identified artifacts **address**/do not address the requirement.
Tailoring Guidance	In the case of Model-based software development the Environment may include Model-in-the-Loop (MIL) and Software-in-the-loop SIL settings. Agile Tailoring: Relevant artifacts/approaches are: - DevOps The identified artifacts **address**/do not address the requirement.
Notes	-

Output Work Products

SIV-OWP1	Software Test Plan
Expected Contents	- scope of testing - levels of testing (software integration testing, software validation testing) - identification of software entities to be tested (software integration testing) - sequence of software integration testing phases - assumptions and constraints - stakeholders - identification of any constraints/risks and how these will be addressed - test completion criteria - test ending criteria - schedule for performing testing activities - metrics to be collected - test data requirements - non-regression testing policy - degree of independence of testers - test environment requirements - test deliverables - responsibility assignment - tool to be used for software testing (integration and validation)
Notes	**SIV-PR1, SIV-PR2, SIV-GR1, SIV-TR1, SIV-TR2**

SIV-OWP2	Software Test Cases
Expected Contents	- Test Case Specification - Test Procedure Specification including possible requested hardware elements, wiring elements, settings for parameters (such as application parameters or global variables), data bases, etc. - Identification of test cases for regression testing
Notes	**SIV-PR1, SIV-PR2**

SIV-OWP3	Software testing report
Expected Contents	- Anomaly Report - test cases not passed - test cases not executed - information about the test execution (date, tester name etc.) - Links to tested requirements
Notes	The possibility to merge testing report and test specification can be considered. **SIV-PR1, SIV-PR2**

SIV-OWP4	Software Test Logs
Expected Contents	Chronological record of all relevant details about execution of a test.

Notes	Software test logs are generated automatically by during automated test execution. **SIV-PR1, SIV-PR2, SIV-TR1, SIV-TR2**

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7. Management Family Processes

In the context of PISA model, Management family addresses the provision of planning, control, assessment, and support to project activities in order to straighten up the project deviations and minimize the chance of missing project objectives.

Reference automotive management goals are:

- Definition of project objectives and constraints
- Control the project progress, correct deviations, and reduce risks
- Provide the project with support for managerial and technical challenges
- Optimize project deployment to provide organizational benefits
- Continuous project evaluation for improvement

The processes belonging to the Management Family are:

- PRM – Project and Risk Management
- TSU – Technical Supervision
- QMG – Quality Management
- SPM – Supplier Management
- CMG – Configuration Management
- DIM – Documentation and Information Management

TRACEABILITY TO IATF 16949:

The project management family processes of the PISA model target the following IATF 16949 requirements:

- Section 4.3: Determining the scope of the QMS
- Section 5: Leadership
- Section 6: Planning

7.1 PRM – Project and Risk Management

Context of process:

Project and Risks Management process deals with the identification and provision of needed resources and skills to achieve the intermediate and final project objectives. The control of the status of the project and the deployment of possible necessary corrective actions are part of this process as well. The scope of this process includes also the identification, evaluation and treatment of possible project risks.

In addition, this process embraces an aspect often occurring in an automotive project, that is its inclusion in an organizational program. In fact, program management deals with managing several related projects with the aim of optimizing resources, coordinating practices, and take initiatives for improving organization's performance.

Input Work Products

- Customer requirements
- Contract agreement
- Corporate program objectives
- Corporate organizational chart
- Skill profiles

Process Requirements

PRM-PR1	Project Initiation
Q-clause	A project plan shall be provided including time schedule of activities, needed resources, necessary skills.
Elaboration	Define project objectives in terms of business benefits for the organization as for example: resource optimization, performance, costs reduction. Define critical success factors and related metrics able to provide evaluation of the level of achievement of project objectives. Perform a contract agreement analysis aimed at identifying: ● the technical characteristics of the product; ● the scope of the project activities; ● the project team members, with reference to the interface roles. Personnel responsible for Quality and Improvement management shall hold commitment, authority and sufficient skills. Perform the analysis of the needs in terms of: ● tools and infrastructures; ● staff and skills; ● suppliers to achieve the project targets and address the outcomes of such analysis. Identify project milestones and related schedule. Project milestones shall include as a minimum the major releases to the customer. Identify project roles and assign responsibilities to each role. Project tasks are defined. Each task shall be specified in terms of expected results, time and effort. Project tasks shall be assigned to project team members. Identify tools for project deployment to be used and make them available. Set up a tool procurement plan if necessary.
Improvement Guidance	Establishing a program office (with more than one program manager) to support the effective execution of project management. Defining the organizational interfaces among projects.
Tailoring Guidance	Project may be part of larger program initiative. Program assumes the existence of several related project to be included under the same program. If this assumption is not in place, program management doesn't apply. Agile Tailoring: Relevant artifacts/approaches are: - Release Planning/Backlog - Sprint Planning/Backlog - Agile Teams - DevOps - Definition of Ready - Metrics (SAFe) The identified artifacts **address**/partially address/do not address the requirement.

Notes	None of the elaborations of this process are affected by the application of Agile-based project approaches. The project tasks hardly can be defined at the beginning of the project. They are often effectively defined during the project deployment taking the week or the month as reference schedule timeframe. Refer to MG1-OWP1 for details on the expected contents of the project plan.

PRM-PR2	Project control
Q-clause	Deviations from the project plan shall be identified and corrective actions shall be deployed.
Elaboration	Means to monitor and control the progress of the project activities shall be defined and applied. Deviations from the planning or emerging needs of the project shall be recorded. Project deviations or the emerging needs shall be evaluated and their impact quantified. The quantification of the impact of project deviations or emerging needs shall take into account: effort, time, technology demands, and side effects. Project issues which may affect the ability of the project to achieve its goals are identified and recorded and tracked to closure. Supplier(s) technical performance shall be monitored.
Improvement Guidance	Structured reports of regular project progress meetings are easy and effective means to record the progress of the project. Project progress meetings can be combined with quality assurance checkpoints (see MG3).
Tailoring Guidance	Agile Tailoring: Relevant artifacts/approaches are: - Scrum - Kamban - Release Planning/Backlog - Sprint Planning/Backlog - Impediment Backlog - Daily meeting - Sprint Review and Retrospective - Definition of Ready The identified artifacts **address**/partially address/do not address the requirement.
Notes	-

PRM-PR3	Project Issues and Risks Management
Q-clause	Project Issues and Risks shall be identified, assessed, controlled, and, if necessary, reduced.
Elaboration	Identify and assess project risks throughout the life of the project. Set up a risk rating procedure. Risk rating shall assign a discrete value to a risk as a combination of the severity and probability of occurrence of that risk. The acceptability threshold of risks shall be defined. In the case a risk is rated over the acceptability threshold, actions shall be undertaken to mitigate the risk and reduce its rating under the acceptability threshold. The status of the risks is continuously monitored in order to verify if their rating changed.
Improvement Guidance	The initial risk assessment and rating is an input for the project planning. Exemplar sources of risk are lack of resources, lack of skills, dependencies from project stakeholders (as suppliers) schedule, introduction of reuse items and, delays in task schedule.
Tailoring Guidance	Agile Tailoring: Risk is managed in Agile by constantly adjusting to new circumstances, rather than relying on a specific plan that was decided months ago — by valuing “Responding to Change over Following a Plan”. As a result, a pure agile approach requires additional focus to risk management in order to fully respond to this requirement.
Notes	Risk treatment is not to act to remove risks but to act to move risk rating under the acceptability threshold. Risk management at program management applies as appropriate.

Governance Requirements

PRM-GR1	Provide commitment for program team and involved parties.
Q-clause	Program management responsible shall receive explicit commitment
Elaboration	Responsibility for program management activities shall be assigned. Program management responsible shall receive commitment and authority.
Improvement Guidance	Setup of a program office (whose responsibility is to oversee the development of an organization's programs) is highly beneficial.
Tailoring Guidance	Agile Tailoring: Relevant artifacts/approaches are: - Agile Teams - Product Owner - Business Owner The identified artifacts **address**/partially address/do not address the requirement.
Notes	-

PRM-GR2	Project measurement
Q-clause	Metrics shall be defined, and measurements shall be performed to evaluate project status. Measurements shall be used to take decisions.
Elaboration	A set of Key Performance Indicators (KPI) to evaluate the project progress shall be defined. For each KPI the purpose, measurement scale, formula, and thresholds shall be specified. A measurement plan shall be available. The measurement plan shall identify the applicable KPI, the KPI target values, the schedule of KPI measurements, the KPI measurement responsible persons, the means to report and store KPI measurement results. KPI measurement shall be made according to the measurement plan. An analysis of KPI measurement results shall be performed and possible corrective actions shall be undertaken in the case of measures out of target values. KPI measurements shall be recorded and stored.
Improvement Guidance	Define appropriate chart(s) to allow the project manager an easy control of KPI measurements status and trends. Basic set of project KPI measurements addresses: number of open issues, delays in task schedule, resource availability, technical shortcomings, technology lacks, risks status.

Tailoring Guidance	Qualitative approach can be applied as appropriate. Agile Tailoring: Relevant artifacts/approaches are: - Burndown chart - Velocity chart - Iteration Metrics The identified artifacts **address**/partially address/do not address the requirement.
Notes	KPI can be classified according to the following: - general KPI (addressing the status of the project work) - cost KPI (addressing the effort, time and resources consumption of the project activities)

Technological Requirements

PRM-TR1	Project Management support tool
Q-clause	Automatic tool supporting project management activities shall be used.
Elaboration	The project management support tool shall be able to make: - the information on the status of the project, - the assigned responsibilities on project activities, - the schedule of the project tasks, - the project milestones, and - the release schedule available to project stakeholders. The project management support tool shall facilitate the exchange of information between project team members and project managers. The project management support tool shall allow the definition, update and exchange of information on the status of tasks. The project management support tool shall be able to make: - the applicable KPI, - the results of KPI measurement, - KPI measurement trends, available to project stakeholders. Used KPI can be related technical and quality project aspects.
Improvement Guidance	Using a unique tool for requirements management, issue and task management, change management and technical issues management can be considered.
Tailoring Guidance	The Project Management support tool shall be fitting with the development approach adopted in the project. In the case of agile-based software development approach, an agile-specific project management support tool is recommended.
Notes	-

PRM-TR2	Issue and Risk management tool
Q-clause	Automatic tool supporting risk management activities shall be used.
Elaboration	The risk management support tool shall be able to make: - the risk assessment procedure, - the information on the status of the project risks, - the assigned responsibilities on risk treatment activities, available to project stakeholders. The tool shall facilitate the exchange of information on risks between project team members and project managers. The tool shall allow the definition, update and exchange of information on status of project risks.

Improvement Guidance	Consider a Project Management supporting tool that includes support for risk management too.
Tailoring Guidance	-
Notes	Risks are different than problems/issues. Take risk treatment and problem/issue treatment separate.

Output Work Products

PRM-OWP1	Program plan
Expected Contents	- Program scope - Program objectives and policy - Organizational structure including external interfaces - Program budget - Communication plan
Notes	**MG1-PR1**

PRM-OWP2	Program Schedule
Expected Contents	Gantt chart or equivalent
Notes	**MG1-PR1**

PRM-OWP3	Project Plan
Expected Contents	- Work products to be developed - Life cycle model - Development methodology - Customer requirements related to project management - Project resources and tools - Milestones and target dates - Project control methods and procedures - Project skill needs - Project team members and related responsibilities - Applicable KPI and measurement schedule - Estimates - Processes and techniques - Contingency actions - Risk assessment procedure - Risk monitoring procedure - Project interfaces and contact persons
Notes	As for recent advances in automotive software industry, artificial intelligence may be included in the scope of the project. **MG1-PR2**

PRM-OWP4	Project Schedule
Expected Contents	- Task time schedule and effort consumption record - Work products delivery schedule

Notes	Gantt chart can, in some cases, be a suitable way to make scheduling Schedule can be embedded into the Project Plan. **MG1-PR2**

PRM-OWP5	Project Status report

Expected Contents	Report of the current status of the project in terms of:
	- Schedule:
	  ○ planned progress (established objectives/goals) or completion (dates/deadlines) of tasks against actual progress of tasks
	  ○ reasons for deviations from planned progress
	  ○ threats to continued progress
	  ○ deviations and actions to recover variance from planned progress
	- Resources (human resources, infrastructure, hardware/materials, budget):
	  ○ Planned against actual expenditure
	  ○ Reasons for deviations between planned and actual expenditure
	  ○ Expected future expenditure
	  ○ Actions to achieve budget goals
	- Project issues:
	  ○ Issues which may affect the ability of the project to achieve its goals
	  ○ Actions to overcome threats to project goals
	- Project KPIs:
	  ○ Technical
	  ○ Quality

Notes	**MG1-PR3**

PRM-OWP6	Project Issue and Risk List
Expected Contents	Document the current status of the project issues and risks.
Notes	Quality issues can be addressed as well. **MG1-PR3, MG1-PR4**

7.2 TSU – Technical Supervision

Context of process:

Technical Supervision deals with the provision of managerial and technical guidance for the specific tasks within the project.

Agile development paradigms (for instance SAFe) fully respond to the requirements of this process.

Input Work Products

- Technical concept
- Program Plan

Process Requirements

TSU-PR1	Operative supervision for project technical developments
Q-clause	Technical supervision on key technical areas issues shall be provided to project team.
Elaboration	Technical supervisors of each key technical area shall provide technical support to project teams to assess technical issues arising from the project team and take decisions if necessary. A communication channel shall be established in order to allow project team issues be provided to technical supervisors. Technical solution for project technical open issues shall be communicated to project team reference persons.
Improvement Guidance	Involve relevant technical supervisors in project progress meeting in order to assess technical issues and take decisions.
Tailoring Guidance	Technical developments may supersede project boundaries.
Notes	-

TSU-PR2	Technical guidance for project key technical issues
Q-clause	Technical supervisors shall regularly assess and approve technical solutions settings for relevant key technical areas.
Elaboration	The technical solutions related to key technical areas are evaluated and approved by technical supervisors. Possible changes are indicated and communicated to project team reference persons. Technical supervisors monitor the progress of the development project to identify possible changes to technical solutions. For complex issues involving different technical areas, a technical supervision board shall be constituted.
Improvement Guidance	-
Tailoring Guidance	-
Notes	-

TSU-PR3	Ensure deployment of suitable skills
Q-clause	Personnel allocated to specific activities shall hold adequate skills to deploy the necessary value.
Elaboration	The focus of this requirement is on removing the gap between the current skills of each individual and the skills required to perform their assignments. Demands in terms of personnel's skills, training, and expertise to activities as well as to use and optimize related tools are identified.

	Personnel holding the needed skill, knowledge and expertise is allocated to the relevant activities.
Improvement Guidance	A database of personnel skills and training profiles is beneficial.
Tailoring Guidance	
Notes	The purpose of Training and Development is to ensure that all individuals have the skills required to perform their assignments and are provided relevant development opportunities.

Governance Requirements

TSU-GR1	Assign technical supervision responsibilities
Q-clause	Responsibility for key areas technical supervision shall be assigned following criteria based on expertise and skills.
Elaboration	Demands in terms of skills and expertise to play the role of technical supervisor are identified. Personnel holding the needed skill, knowledge and expertise is appointed as key technical area supervisor.
Improvement Guidance	-
Tailoring Guidance	-
Notes	-

Technological Requirements

TSU-TR1	Collaboration support
Q-clause	A tool supporting the information exchange between technical supervisors and project team members shall be used.

Elaboration	The technical supervision support tool shall be able to provide the following information on technical issues:
	- record of technical issues arising on project
	- for each technical issue:
	  ○ unique identifier
	  ○ reference technical area,
	  ○ description of technical issues,
	  ○ technical solution from reference technical supervisor or board.
	
	The tool shall facilitate the exchange of information between project team members, project managers, and technical supervisors or technical supervision boards.
	
	The tool shall allow the definition, update, and exchange of information on status of technical issues.

Improvement Guidance	Using a unique tool for issue management, change management, quality and technical issues management, and task management can be profitable.
Tailoring Guidance	-
Notes	-

Output Work Products

TSU-OWP1	Task(s) description
Expected Contents	Unique identifier of the task Description of the task to perform including assignee, due date and technical details.
Notes	Typically, technical activities belong to hardware, software or mechanical developments. **TSU-PR1, TSU-PR2**

TSU-OWP2	Technical issue
Expected Contents	Unique identifier of the technical issue Description of the technical issue Reference key technical area(s) Technical solution from reference technical supervisor or board.
Notes	Typically, technical issues belong to hardware, software or mechanical developments. **TSU-PR1, TSU-PR2**

TSU-OWP3	Project Training Management Plan
Expected Contents	It addresses: - Identification of gaps - Action Items - Management of training material
Notes	**TSU-PR3**

7.3 QMG – Quality Management

Context of process:

Quality Management process is based on following pillars:

- Deployment of a Quality Management System (QMS)
- Issue and defect Management
- Quality Assurance on development project.

Input Work Products

- Project Plan

Process Requirements

QMG-PR1	Compliance with IATF 16949 or equivalent
Q-clause	The project shall work according to an organizational Quality Management System (QMS) aligned with IATF 16949 or equivalent.
Elaboration	IATF 16949 [5], a technical specification for automotive sector quality management systems, has become the most widely used international standards in the automotive industry, harmonizing the different assessment and certification systems in the global automotive supply chain. The QMS required by the IATF 16949 addresses continuous improvement, defect prevention, reduction of variation and waste in supply chain, performance evaluation. The scope of the IATF 16949 is: - Design and development - Production - Assembly - Installation - Services of automotive-related products including products with embedded software.
Improvement Guidance	QMS based on APQP is widely adopted in automotive industry.
Tailoring Guidance	Application of a QMS reference equivalent to IATF 16949 is acceptable depending on the context. Example is ISO 9001
Notes	Current version is IATF 16949:2016 Equivalent standards compliant with IATF may be applied.

QMG-PR2	Peer Review Implementation
Q-clause	Quality assurance activities shall be performed according to the plan.
Elaboration	Quality issues shall be identified and recorded. Quality issues shall be analyzed, and corrective actions shall be defined. Responsibilities for corrective actions shall be allocated. Quality issues (coming from technical and quality reviews) solution shall be recorded.
Improvement Guidance	Clear distinction between quality issues and product defects is necessary. The effort to be spent in quality assurance activities shall be estimated, controlled and reported.
Tailoring Guidance	-
Notes	-
Notes	Also, issues coming from QA reviews are included in this requirement.

QMG-PR3	Issue and Defect tracking quality
Q-clause	The project shall track identified issue and/or defects on final or intermediate work-products work to closure.
Elaboration	This requirement points to the activities required to address identified defects throughout the lifecycle (typically during the testing activities), and to determine the resolution to those problems. It also demands for ensuring that the resolution is implemented through the appropriate control procedures. Typical work-flow steps are: - Recording - Analysis (may lead to issue/defect rejection) - Diagnosis (including root cause) - Resolution planning - Resolution implementation - Defect removal verification - Defect Closure
Improvement Guidance	-
Tailoring Guidance	Simplified workflow may apply as appropriate. Agile Tailoring: Relevant artifacts/approaches are: - Sprint Planning/Backlog - Daily meeting - Kamban - Definition of Done The identified artifacts **address**/partially address/do not address the requirement.
Notes	Also issues coming from QA reviews are included in this requirement.

QMG-PR4	Identify and Deploy Improvement Actions
Q-clause	Improvement opportunities at organizational and project level, resulting from Quality Management deployment, shall be identified, prioritized and deployed according to an improvement planning.
Elaboration	To reduce lack of quality or invert or arrest negative trends in terms of quality, improvement actions in terms of: - process definition and deployment (arising from the QMS) - project performance - work products management and control are identified and deployed. Changes in processes and work products are prioritized according to cost-effectiveness criteria. Quality improvement actions are defined and deployed in order to implement higher priority changes. Definition of improvement actions shall include involved roles, responsibilities assignment, needed resources and skills, and expected benefits. The goals and the expected benefits of each improvement action shall be identified and reported.

	The effects of improvement actions shall be monitored and assessed.
Improvement Guidance	-
Tailoring Guidance	-
Notes	Effective improvement actions shall be evaluated for wider applications in order to extend benefits to different organizational departments.

Governance Requirements

QMG-GR1	Peer Review Planning
Q-clause	Activities aimed at verifying the compliance of work products with respect quality prescriptions, and the alignment of project tasks with respect plans shall be scheduled and the necessary resources allocated.
Elaboration	Work product quality prescriptions shall be available to personnel performing quality assurance activities. Plans for quality assurance deployment (i.e. the sequence, the priority, the responsibilities, the expected output of project activities to be deployed) shall be available to quality assurance activities stakeholders. The Plans shall include the schedule and the scope of the quality checkpoints (both addressing work products and tasks compliance). Roles and responsibilities for quality assurance activities are defined. Resources and tools to be used for quality assurance are identified and made available. Quality Assurance checkpoints shall be scheduled at main customer releases (as a minimum).
Improvement Guidance	In the case of work product is a document, the use of document template is a way to define quality prescriptions. Quality activities can conveniently leverage existing tools already in place for project management or defect management.
Tailoring Guidance	-
Notes	Work product quality assurance is different than work product review. Work product quality assurance deals with the compliance of structural, and formal aspects of a work product (for instance no section of a document shall be left empty or incomplete, the versioning and history of a work products shall be updated, the time of performance and the version of the product under test shall be indicated in a test log …), work product review deals with the verification of the correctness of the contents of that work product. See also SU3-PR1

Technological Requirements

QMG-TR1	Quality issue and defect tracking tool
Q-clause	Automatic tool supporting issue management shall be used.
Elaboration	The tool shall effectively support the defined defect workflow. In addition, the tool shall facilitate the exchange of information between project team members and project managers.
Improvement Guidance	Consider adopting unique tool for issue/defect/risk/supplier management.
Tailoring Guidance	Integrated tool-chain is preferable.
Notes	Valid open source solutions are available.

QMG-TR2	Quality Assurance support tool
Q-clause	Tool supporting quality assurance activities shall be used.
Elaboration	The quality assurance support tool shall be able to make: - the record of non-compliances found on project work products and processes, - the assigned responsibilities on quality assurance activities and improvement actions, - the schedule of the quality assurance activities, - the release schedule available to project stakeholders. The tool shall facilitate the exchange of information between project team members, project managers, and quality assurance personnel. The tool shall allow the definition, update and exchange of information on status of enacted improvement actions.
Improvement Guidance	Using a unique tool for issue management, change management, quality issues management, and task management can be profitable. Check lists may be effective and easy tools to support the compliance verification of work products with respect quality prescriptions and project activities with respect plans.
Tailoring Guidance	Adoption of a combined tool for issue and QA management.
Notes	-

Output Work Products

QMG-OWP1	Quality Plan
Expected Contents	- Objectives/goal for quality of work products and project activities - Definition of the quality assurance activities to deploy - References to any regulatory requirements, standards, customer requirements - Specification of the schedule of quality checkpoints for work products and project activities - Definition of the methods of assuring quality of work products and project activities - Identification of the quality criteria for work products and project tasks - Identification of personnel involved in quality assurance activities and definition of the approach to guarantee independence - Identification of escalations opportunities and channels
Notes	Contents of Quality Plan can be merged with those of Project Plan. **QMG-PR2, QMG-GR1**

QMG-OWP2	Improvement Plan
Expected Contents	- Improvement objectives - Strategy - Means - Main action items
Notes	**QMG-PR4, QMG-GR1**

QMG-OWP3	Release Check Report
Expected Contents	- Functional Content - Test Results - Release Package Integrity
Notes	**QMG-PR5, QMG-GR1**

7.4 SPM – Supply Management

Context of process:

Supply Management process deals with the establishment of technical characteristics and warranties of the supply (including safety, cybersecurity, and quality aspects).

Whether the supply is developed by an independent organization on the basis of customer requirements, the process deals with the agreement on the scheduling of the supply development phases, releases, joint activities (as design reviews, and quality audits). The identification of communication channels and interfaces (both for technical and managerial issues) as well as the regular usage of these channels for sharing information on the advancements of the development, for providing the requested incoming quality verification records, and for sharing the status of risks is also part of the process activities.

Whether the supply consists of a COTS (Commercial of the shelf) or Open-Source software, this process deals with the management of the risk related to the supply, the definition through an explicit agreement on the responsibility of third-party software, the acceptance criteria, the identification of functional and non-functional requirements

Input Work Products

- Supply Contract (or open-source software licence agreement)
- Project Plan (RACI matrix)
- Risk Management Plan
- Quality Management System

Process Requirements

SPM-PR1	Technical Agreement
Q-clause	The technical characteristics and the warranties of the supply shall be defined and agreed between the parties
Elaboration	A baseline of technical requirements is defined and explicitly agreed. Typical technical requirements categories are: - Safety - Cyber-security - Environmental - Material - Functional - Quality (e.g. reliability, availability, …) - Performance - Interfaces Mutual responsibilities and liabilities are clearly and unambiguously defined. The compliance with respect to applicable standards shall be assured. Changes in technical requirements and provision of additional technical requirements are explicitly agreed
Improvement Guidance	-
Tailoring Guidance	COTS: non-functional characteristics of COTS that are of interest for the project (as, for instance, coding rules compliance, or performance requirements) shall be available and verifiable. Warranties shall cover the characteristics of the COTS of interest for the project. Open-source software: non-functional requirements of the Open-source software, that ae of interest for the project, shall be defined
Notes	-

SPM-PR2	Supply Monitoring and Control
Q-clause	The evaluation of the degree of advancement of the development of the supply shall be performed through technical checks and managerial audits.
Elaboration	Type of information to be exchanged between the parties and related frequency shall be established. Regular joint review meetings, focused on key artefacts (as for instance software architectural design, verification and validation plan), are performed to get a common understanding, identify open issues on those artefacts, and to get customer approval to proceed. The actual status of the development against the planning is regularly provided to the customer. An Open Issue list is jointly maintained updated in order to control and monitor the resolution of defects or implementation of improvement.

	Existing risks due to the supply development and release are updated, controlled, and monitored. New risks are added when necessary.
Improvement Guidance	Take and treat open issues and risk separately
Tailoring Guidance	In the case of COTS or Open-Source software SPM-PR3 is not applicable.
Notes	-

SPM-PR3	Supply acceptance
Q-clause	Supply acceptance mechanisms and principles shall be defined and applied to accept/reject the supply
Elaboration	Release description shall be included in the supply. Release information shall contain as a minimum: - Software version - Hardware version (if applicable) - Build information - External interface description - Release note (description of functional content, fixed defect, latent defects, …) The acceptance principles shall be explicitly defined. They may include: - evidence of full functional development (full functional test passed) - evidence of compliance with relevant standards - evidence of passing qualification test suites (smoke test passed) - compliance with defined coding rules (for instance MISRA C 2012) - compliance with AUTOSAR - performance of qualification test by customer
Improvement Guidance	-
Tailoring Guidance	COTS: the acceptance may consist of the acquisition of the licence of use after a trial period Open-Source software: the acceptance may be subject to coding rules compliance or achievement of target software code metrics
Notes	-

Governance Requirements:

SPM-GR1	Trusted suppliers' selection
Q-clause	A list of trusted suppliers shall be identified and maintained.
Elaboration	Criteria for identification of trusted suppliers are defined as well as organizational responsibilities to manage the suppliers.
Improvement Guidance	Effective link with corporate procurement is highly beneficial.
Tailoring Guidance	-
Notes	Supplier must maintain a documented quality system to ensure control and conformance to the requirements of drawings and specifications.

SPM-GR2	Supply Release Planning
Q-clause	The supply release in terms of contents and scheduling shall be planned in accordance with the customer needs and developments milestones
Elaboration	Several supply releases are usually performed according to an incremental supply releases can be planned. Increments of the supply may deal with functionalities implemented, maturity/quality of the code, verification degree. The release planning shall be agreed by both parties and shall be integrated and consistent with the customer development milestones.
Improvement Guidance	-
Tailoring Guidance	COTS (and COTS software updates) release dates and conditions are defined and agreed.
Notes	In the case of Agile approach, the releases of the software may correspond to sprints.

SPM-GR3	Identify interfaces and establish commitment
Q-clause	Reference persons for interactions between supplier and customer shall be identified, and related responsibilities and commitment shall be defined.
Elaboration	A person shall be appointed for every information to be exchanged and for every joint activity to be carried on. Responsibilities for change negotiation and acceptance shall be established. An escalation mechanism shall be in place in the case an occurring issue cannot be solved by the reference persons.
Improvement Guidance	-
Tailoring Guidance	COTS: in the case of COTS supply, a commercial referent and a technical referent shall be appointed.
Notes	-

Technological Requirements

SPM-TR1	Issue and Risk management tool for supply management
Q-clause	Automatic tool supporting supply-related issue and risk management activities shall be used.
Elaboration	The risk management support tool shall be able to make: - the risk assessment procedure, - the information on the status of the project risks, - the assigned responsibilities on risk treatment activities, available to project stakeholders. The tool shall facilitate the exchange of information on issues and risks between project team members and supplier reference persons. The tool shall allow the definition, update and exchange of information on status of supply-related issues and risks.
Improvement Guidance	Consider a Project Management supporting tool that includes support for risk management too.
Tailoring Guidance	-
Notes	Risks are different than problems/issues. Take risk treatment and problem/issue treatment separate. The tool shall be separated from the Issue and Risk management tool used in QMG-TR1 and PRM-TR3 because the supply-related issues and risks are not to be mixed with internal ones.

Output Work Products

SPM-OWP1	Project Interface Agreement
Expected Contents	Identification of reference persons by customer and supplier part. For each reference person the following information are provided: - role - contacts - technical/managerial competence area
Notes	**SPM-GR3**

SPM-OWP2	Project Issue and Risk List
Expected Contents	Content includes: - Open issues and related analysis - Proposed solutions - Agreement on solution and due date Document the current status of the project issues and risks.
Notes	Quality issues can be addressed as well. **SPM-PR2**

SPM-OWP3	Supply technical requirements
Expected Contents	It may include specification of requirements for the supply at the following levels: – Functional – Functional Safety (if relevant) – Performance – Interface – Validation – Design constraints – Quality – Production and operational – EoL (End of Line) – Cyber-security – …. Its format can be documental or a shared database.
Notes	**SPM-TR1**

SPM-OWP4	Trusted Suppliers List
Expected Contents	
Notes	**SPM-GR1**

7.5 CMG – Configuration Management

Context of process:

Configuration Management deals with the identification, versioning, storage, retrieval and access control of project work products. This process also deals with the releasing activities.

Input Work Products

- Project work-products
- Incoming work-products

Process Requirements

CMG-PR1	Configuration control
Q-clause	Project Configuration Items (project work-products) shall be uniquely identified and made available in a controlled manner at any time to project participants, and the relations and differences between earlier and current versions shall be traced.
Elaboration	Project configuration item list shall be created and maintained. A unique identifier shall be assigned to each configuration item (possibly according to a scheme). Different versions of a configuration item shall be uniquely identified and maintained under control; changelog shall summarize configuration item evolution. All the versions of configuration items can be available at any time. Versioning of configuration items shall allow the identification of the temporal sequence of versions. The access and the modification of configuration items shall be controlled to avoid conflicts among different versions. The control of the access to configuration items shall be based on the assignment of rights and limitations to stakeholders.
Improvement Guidance	The use of naming conventions for configuration items and software/hardware/mechanical identifiers and related versioning is beneficial.
Tailoring Guidance	Some configuration items may be not subject to versioning.
Notes	The elaborations of this requirement can be effectively supported by the use of a configuration management automatic tool. Configuration items are work products at system, hardware and software level.

CMG-PR2	Project repositories
Q-clause	Project work-products shall be accessed, used, and modified in dedicated repositories that ensure the integrity and the controlled access for the project work-products. Such project repositories shall be maintained operative for the appropriate timeframe.
Elaboration	The repositories provide secure and reliable storage for all relevant configuration management items. The repositories shall guarantee secure and reliable back-up storage of key project work products after the end of the project itself.
Improvement Guidance	1. Harmonized organization in federated repositories 2. Support balance between confidentiality and information exchange
Tailoring Guidance	-
Notes	The elaborations of this requirement can be effectively deployed with the use of a configuration management automatic tool.

CMG-PR3	Project baselines
Q-clause	Project baselines shall be identified and consolidated as appropriate during the project lifetime.
Elaboration	Project product baselines (including software baselines) shall be available at any time. Baselines can be provided for internal or external release at certain project milestones or for any other reason (e.g. for implementing a change). Baseline shall be formally approved by the responsible persons.
Improvement Guidance	Baselines should be established before a release to identify consistent and complete delivery.
Tailoring Guidance	Baselines serve as basis for further development, and can be changed only through formal change control procedures.
Notes	A baseline identifies a state of one or a set of work products and artefacts which are consistent and complete. Software baseline is a composition of software components that, at a point in time, constitutes a functionally consistent logical basis for a release. Work products baseline is a selection of relevant project work product versions that guarantees mutual consistency in term of contents.

CMG-PR4	Project releases
Q-clause	Project releases (internal and external) shall be identified and verified in terms of configuration items versions and content before the release event.
Elaboration	The functional content of releases shall be defined Configuration items and work products associated with the release shall be identified Classification and naming conventions to be applied to the releases shall be defined and applied In the case of software release the build steps, conditions and environment shall be specified
Improvement Guidance	Coordination with the QA function is beneficial.
Tailoring Guidance	-
Notes	-

Governance Requirements

CMG-GR1	Project Configuration Management Planning
Q-clause	Planning of Configuration Management shall be defined including scope, roles definition and responsibilities allocation, schedule, branching policy, and tools.
Elaboration	The list of work products to be put under configuration management (that is configuration items) shall be defined and made available. The configuration management tool(s) shall be identified and made available to stakeholders according to a precise rights and restrictions policy. The responsible person(s) for Configuration Management shall be identified. Configuration Management responsible shall guarantee the availability of configuration management tool, the consistency of the work product under configuration management, and the set-up of the configuration management tool (including the rights and restrictions of use). Baseline and internal/external releases shall be planned in terms of elements to be included, implemented functionalities and project-time schedule. The effort for configuration management activities shall be estimated, controlled and reported.
Improvement Guidance	In the case of small team/project the configuration manager and project manager can be the same person.
Tailoring Guidance	-
Notes	-

Technological Requirements

CMG-TR1	Automatic support for configuration and information management
Q-clause	Configuration management tools that are aligned with the state of the art and project needs shall be used.
Elaboration	The configuration management tool(s) shall provide at least the following functionalities: ● authorship, versioning, and control of changes of work products and software, ● building of baselines, ● comparison among versions and highlighting of changes, ● provision of status and history of controlled items ● set up of rights and restrictions of use ● branching support ● back up and storing ● recreation of any release or test configuration ● ability to report configuration status ● work-flow management Documental configuration items shall benefit from the deployment of specific tools for documentation management, accessibility and collaboration.
Improvement Guidance	The selection of the suitable configuration management tool is crucial for a project. Make a careful selection or customization of tools available on the market (many of them are open source).
Tailoring Guidance	Open source and freeware technology is acceptable upon specific and documented rationale.
Notes	Aspects as multisite operation, size of the project, multi-project or multi-variant application shall be taken into account in the identification of the configuration management tool to use.

Output Work Products

CMG-OWP1	Configuration Management Plan
Expected Contents	• Defines or references the procedures to control changes to configuration items and software components • Identifies work products under configuration management • Defines branching policy and rules • Baseline compositions and schedule • Identifies the project configuration management tool and eventual setup/customizations • Defines responsibilities, rights and limitations of use of the configuration management tool • Specifies the location and access mechanisms for the configuration management library • Specifies storage, handling and delivery (including archival and retrieval) mechanisms
Notes	**CMG-GR1, CMG-PR3**

CMG-OWP2	Configuration Item List
Expected Contents	• List of configuration items including the reference to the baselines they have to be included in.
Notes	**CMG-GR1, CMG-PR1, CMG-PR2**

CMG-OWP3	Project repository(ies)
Expected Contents	Collection of project work products (or references to them)
Notes	**CMG-TR1**

SU1-OWP4	Release Package(s)
Expected Contents	• Elements of the release (hardware / software / product elements / associated documentation list) • application parameter definitions defined • command language defined • installation instructions • release letter
Notes	**CMG-PR4**

7.6 DIM – Documentation and Information Management

Context of process:

Documentation and Information management deals with the definition of which documents are to be released throughout the project life, what are their expected contents and structure, what are

the mechanisms applied to assure the expected contents, what are the mechanism to control evolution and the correct distribution.

Input Work Products

- Configuration Management Plan
- Configuration Item List
- Communication Plan (part of the Project Plan)

Process Requirements

DIM-PR1	Information and documentation models
Q-clause	Project documents and information shall be identified, and related expected formats, contents and structure defined.
Elaboration	Each project document shall be identified by a unique id, title and version. For each project document the expected contents and the way information is structured in the document itself shall be defined. Each document shall contain name of the author(s), the approver(s), the date of release, the change log, the description of the purpose, and the document status. The existence and consistency of requested information of a document shall be verified.
Improvement Guidance	The use of customer templates may facilitate the compliance to this requirement.
Tailoring Guidance	-
Notes	Verification of the existence and consistency of expected information is performed by Quality Assurance too.

DIM-PR2	Information and documentation workflow
Q-clause	Documents shall be reviewed before release
Elaboration	A review policy shall be defined containing the rules for identifying document reviewer(s) and rules to determine when a review is mandatory for document release. Document review shall be executed by appointed persons. The review of a document aims at verifying whether the contents of the document are technically sound, complete, and compliant with the document purpose.
Improvement Guidance	Plan and execute reviews before document major releases.
Tailoring Guidance	According to the dynamic of automotive project, the document can be used as input for other project activities as soon as its content is consolidated – in this setting the workflow shall make clear the status of the document.
Notes	Document review is different from document quality assurance. The first is about the technical soundness and completeness, the latter is about the control if the document complies with structural requirements (e.g. the template is respected, the history is consistent, the versioning is correct, …).

DIM-PR3	Documents distribution and information sharing
Q-clause	Access to document shall be under control.
Elaboration	The document stakeholders shall be able to get the current version of documents at any time. Document access rights and limitations shall be defined.
Improvement Guidance	It is important to make sure that addressees are informed timely of documents availability.

Tailoring Guidance	-
Notes	This requirement can be satisfied by the use of a configuration management tool (see CMG.TR1) Security and confidentiality issues shall be addressed at organizational or project level as appropriate – application of relevant standards such ISO 27000 series may apply

Governance Requirements

DIM-GR1	Documentation and information management
Q-clause	Resources and responsibilities for naming, setup and review of project documents shall be identified and made available.
Elaboration	The documents to produce in the project shall be identified and their release associated to project phases. Standards and templates applicable to project documents are identified. Rules for determine the version code of a project document shall be defined. The authorship of the documents shall be assigned. The persons responsible of the review of a document are identified and committed. Required expertise of reviewers is defined. Criteria and schedule of document reviews are provided. The document approval mechanism shall be defined. Document change mechanism shall be defined.
Improvement Guidance	Checklists are effective and easy means to provide review criteria and guidelines
Tailoring Guidance	-
Notes	This requirement may be integrated with the MG2-PR1

For technological requirements refer to configuration management process (CMG) **CMG-TR1**.

Output Work Products

DIM-OWP1	Document and Information Management Plan
Expected Contents	Content includes: - Documentation and Information Models and supporting resources - Work-flow definition - Information security and confidentiality management
Notes	**DIM-PR1, DIM-PR2, DIM-PR3, DIM-GR1, DIM-GR2**

ANNEX A
PISA Model Rating System – Application Guideline

This Annex describes how to determine the rating of a development project in terms of Q-CLASS.

The procedure to determine the Q-CLASS rating is named PISA model Rating System (PISA model-RS).

The PISA model-RS is a stepwise bottom-up mechanism based on the process-specific sets of requirements belonging to the three categories (process, governance, and technological).

The PISA model Rating System is compliant with the ISO/IEC 33003 “Information Technology – Process Assessment – Requirements for Process Measurement Framework” standard.

The rating process is composed of the following steps:

Step 1: using the work products of the project (as well as and other available valid evidence), the requirements (process, governance, and technological requirements) associated to each process are evaluated to determine if they are satisfied or not. (rating at Requirements level).

Step 2: based on the rating of the requirements associated to each process, the process rating in terms of Q-CLASS is established (rating at Process level).

Step 3: the aggregation according to specific rules of process ratings determines the related process family rating in terms of Q-CLASS (rating at Family level).

Step 4: the aggregation according to specific rules of the process families ratings determines the project rating in terms of Q-CLASS attribute (rating at Project level).

A.1 Q-CLASS attribute

The purpose of the PISA model is to evaluate the responsiveness of process deployed in development projects to automotive demands from technical and organizational perspectives.

Such an indicator is called Q-CLASS.

A.2 Rules to make project Q-CLASS rating

In this section, the rules to apply for rating a project in terms of Q-CLASS are provided. The following sub-sections show how to proceed to assess a project in terms of Q-CLASS according to the PISA model Rating System.

The project rating is a stepwise procedure composed of four phases:

1. Rating at Requirements level
2. Rating at Process level
3. Rating at Family level
4. Rating at Project level

Accordingly, The PISA model Rating System applies to 4 items: Requirements, Processes, Process Families, and Project.

The reference rating scale of the PISA model Rating System is defined in Table A.1.

Table A.1 PISA model reference rating scale

Q-CLASS Index Scale	
Ratings	**Semantics**
FULL	The item is deployed adequately, and related objectives are not at risk. Improvement opportunities are limited in scope and criticality.
SUFFICIENT	The item is deployed satisfactorily, and related objectives are largely not at risk. Improvement opportunities are present.
INCOMPLETE	The item is deployed nearly satisfactorily and related objectives are exposed to noteworthy risk. Significant improvement opportunities are present.
POOR	Item's objectives are at high risk. Improvement opportunities are important and require immediate improvement action items.

A.2.1 Rating at Requirement level

A set of requirements is associated to each process in the PISA model process scope. These requirements belong to three categories:

- Process requirements
- Governance requirements
- Technological requirements

The requirement rating shall be based on the availability of work products or any other valid evidence demonstrating the extent to which the requirement is fulfilled. Ratings based on assessor's personal beliefs or feelings, not based on objective evidence, are not acceptable in the PISA model Rating System.

With reference to the requirement ratings scale above, a requirement is:

- **Satisfied** if it is rated Sufficient or Full
- **Not satisfied** if it is rated Poor or Incomplete

The definition of work product is provided in section 1.4 "Glossary". A "valid evidence" is intended as a proof of the performance of an activity or the proof of the existence of a property of an artifact, or the proof of use of a technique or tool.

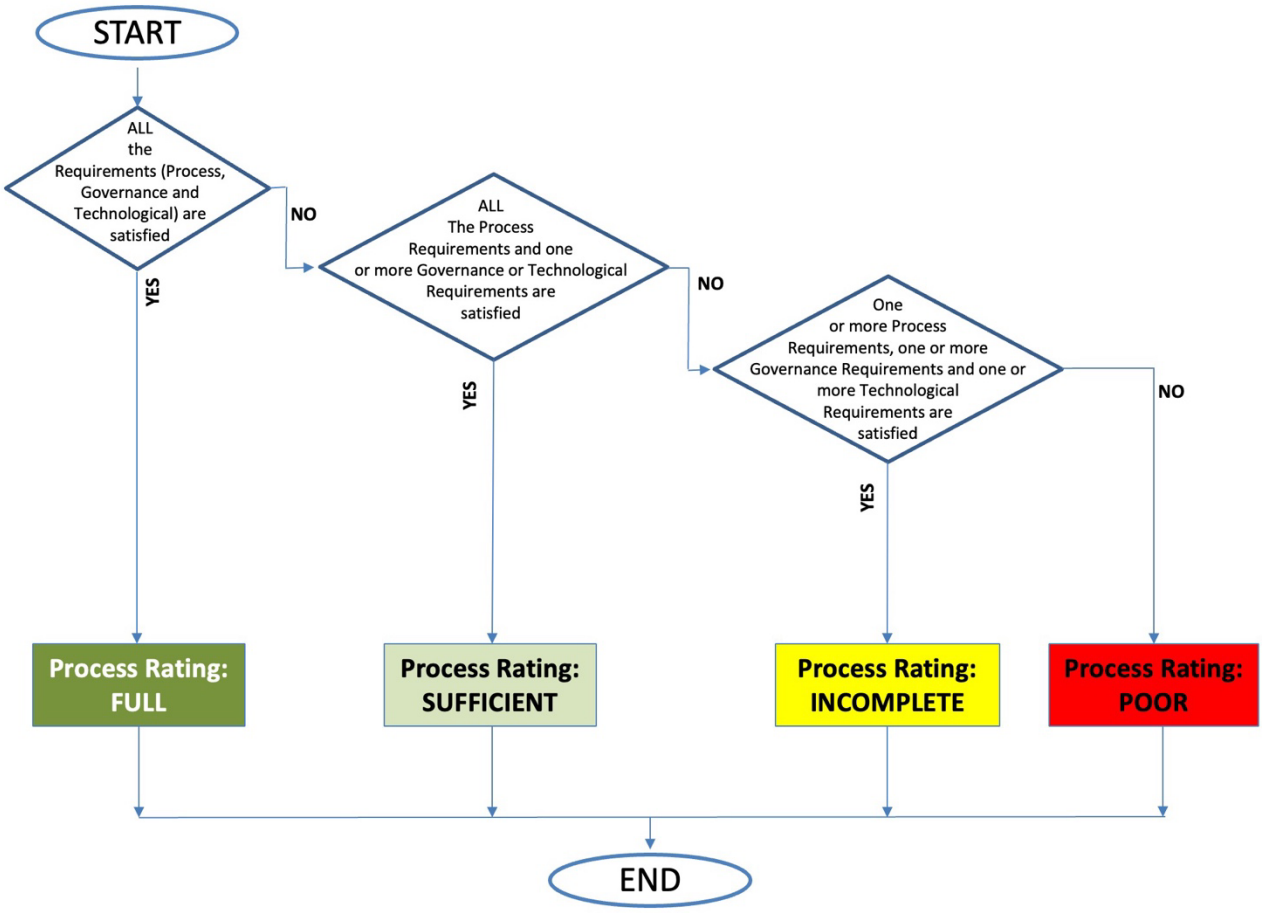
A.2.2 Rating at Process level

The rating rules at Process Level are:

- A Process is rated as "Full" if **all** the Requirements (Process, Governance, and Technological) are satisfied.
- A Process is rated as "Sufficient" if it is not rated as "Full" and all the Process Requirements are **satisfied** and one or more requirements belonging to Governance and Technological category are **satisfied**.
- A Process is rated as "Incomplete" if it is not rated as "Sufficient" and one or more requirement per each requirement category (Process, Governance, and Technological) are **satisfied**.
- A Process is rated as "Poor" otherwise.

The diagram in Figure A.1 summarizes the rating rules at Process Level.

Figure A.1: PISA model rating rules at Process Level



A.2.3 Rating at Process Family level

The rating of a Process Family is based on the ratings achieved by the processes it contains.

It is possible that, due to the characteristics of the project under evaluation, some activities are not executed and, consequently, evidences cannot be available for determining the rating at process level. A process that cannot be ratable because out of the scope of the project is classified as **not applicable**.

Argumentation and justification in support of the non-applicability of a Process shall be provided.

Thus, it is possible that not all the processes belonging to a Process Family are applicable in the rating of a specific project. According to that, given N the number of the processes belonging to a Process Family, let be $\boldsymbol{N_p}$ *(with* $N_p \leq N$*)* the number of applicable processes in a Process Family for a specific project.

The rules to rate the Process Families are:

- A Process Family is rated as **Full** if:
  - N_p processes belonging to that Process Family are rated as Full or

- N_p *-1* processes belonging to that Process Family are rated as Full and one (1) is rated as Sufficient.

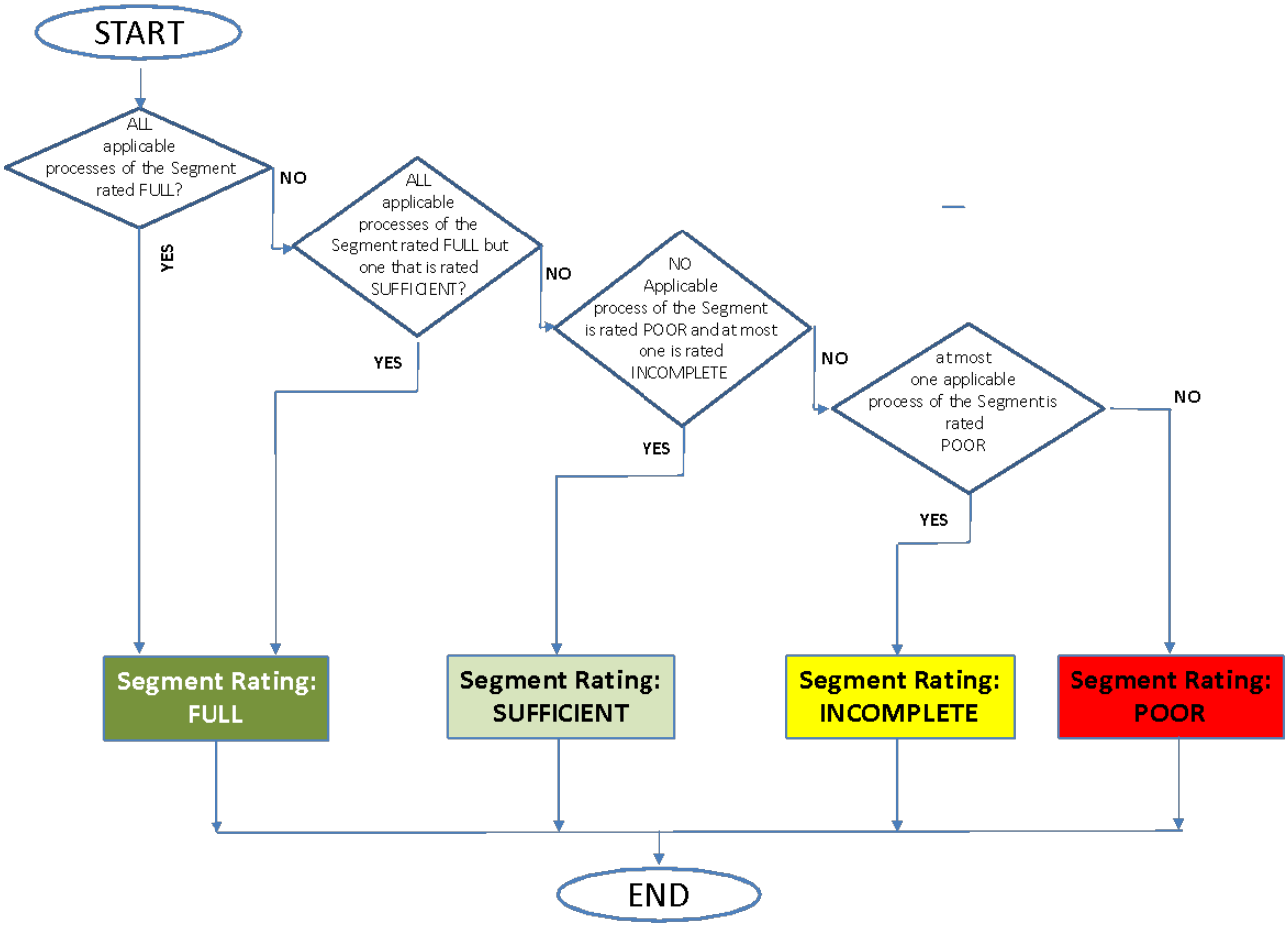
- A Process Family is rated as “Sufficient (S)” if it is not rated as Full and:
  - At most one (1) process belonging to that Process Family is rated as “Incomplete” and no process is rated as Poor,
- A Process Family is rated as “Incomplete (I)” if it is not rated Sufficient and:
  - At most one (1) process belonging to that Process Family is rated as Poor.
- A Process Family is rated as “Poor (N)” otherwise.

For System Engineering, Software Engineering, and Management Families if N_p <4 the whole Process Family is not applicable and, consequently, it cannot be rated.

For Hardware Engineering Family if N_p <3 the whole Process Family is not applicable and, consequently, it cannot be rated.

The diagram in Figure A.2 reports the rating rules at Family Level.

Figure A.2: PISA model rating rules al Family Level



In Table A.2 the rating rules at Family Level are summarized.

Table A.2 PISA model rating rules at Family Level summary

number of occurrences of process ratings				Process Family Rating
F	S	I	P	
*	0	0	0	F
*	1	0	0	
*	*	0	0	S
*	*	1	0	
*	*	*	0	I
*	*	*	1	
*	*	*	>1	P

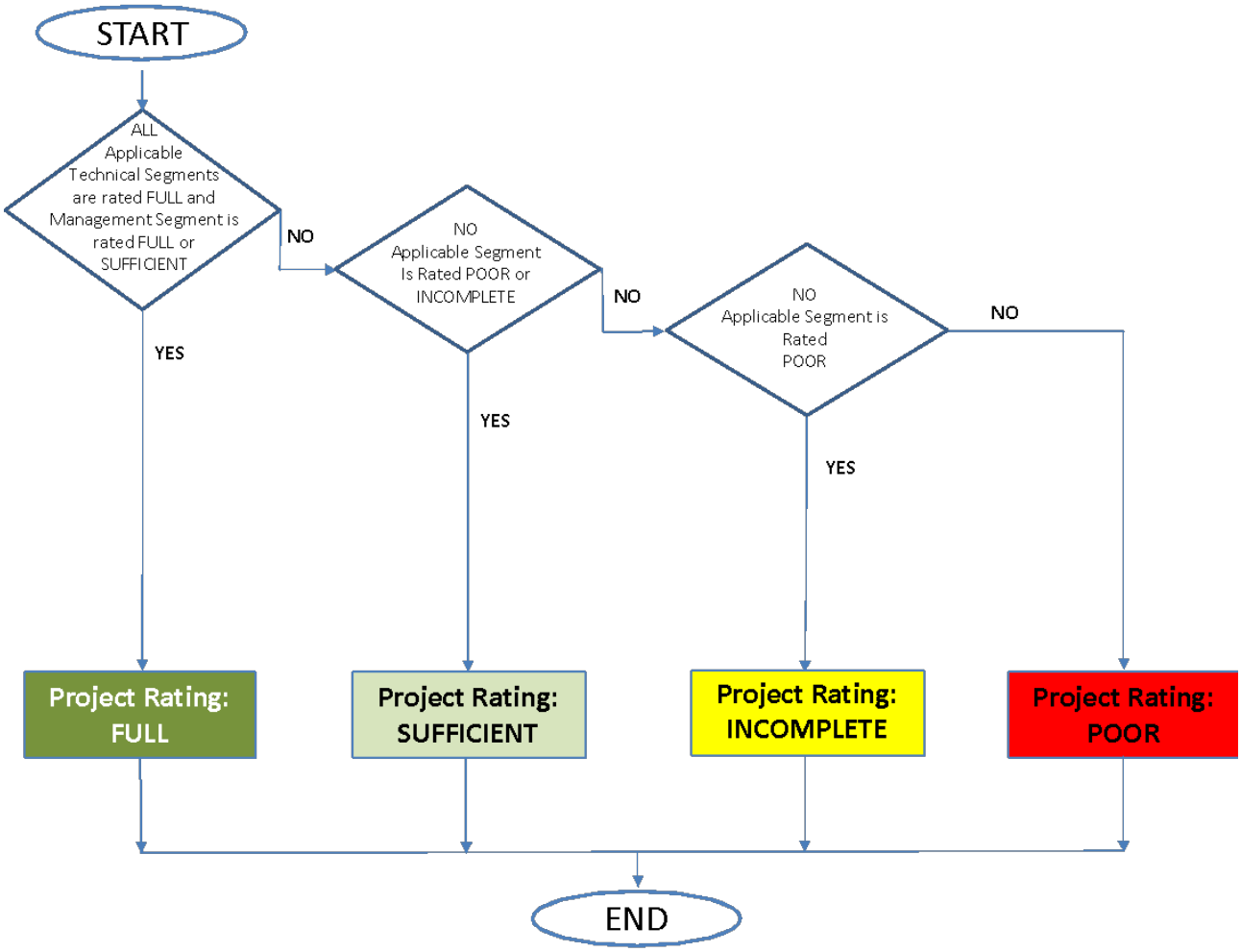
A.2.4 Rating at Project level

The Rating of a Project in terms Q-CLASS is based on the ratings of the three (3) Technical Families (System Engineering, Hardware Engineering, Software Engineering) and on the ratings of the Process Management Family. Nevertheless, it is possible that one or more Technical Process Families are **Not Applicable** (it is possible since some activities are not executed and, consequently, some processes are not performed).

The PISA model Rating System allows to evaluate a project in terms of Q-CLASS also in the case of one or two Technical Process Families are not applicable. Argumentation and justification in support of the non-applicability of a Process Family shall be provided.

The diagram in Figure A.3 reports the rules for rating at Project Level.

Figure A.3 - PISA model rating rules at Project Level



In Table A.3 the rating rules at Project Level are summarized.

Project Q-CLASS Index	Rating Rule
Fully	(All Applicable Process Families rated Fully) || ((All Applicable Process Technical Families rated Fully) && (the Management Process Family rated Fully or Sufficient))
Sufficient	(Project Not Rated Fully) && (No Applicable Process Families rated Incomplete or Poor)
Incomplete	(Project Not Rated Sufficient) && ((No Applicable Process Families rated Poor)
Poor	Otherwise

Table A.3 PISA model rating rules at Project Level summary

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