PIS4A

Process Improvement Scheme for Automotive

Version 2.0

National Research Council of Italy

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1. Introduction

1.1 Background

In the last two decades, automotive witnessed a continuous and unstoppable trend to innovation. Cars moved from being mechanical/electromechanical systems, to being very complex vehicles where electronics and software are playing a predominant role for the vehicle's functions. In this setting, the quality of on-board automotive electronic systems is strongly dependent on the quality of their development practices. Accordingly, car-makers and suppliers are proactively focusing on the improvement of technical and organizational processes.

To face and support such a tremendous trend towards innovation, several models and standards addressing both automotive system and software development are available for the automotive market. These models and standards have typically a strong focus on processes; among them the most relevant and influencing are Automotive SPICE and ISO 26262.

1.2 Purpose

The specifics and the complexities reached by today's automotive software-intensive systems have shown that current models and standards have some limitations in responding to the needs of the automotive industry. In particular, the automotive players are in need of the following aspects: more focus on projects rather than a pure process-centered approach, improved technical guidance, and explicit links to already established automotive quality frameworks.

The PISA (Process Improvement Scheme for Automotive) Model aims at responding to such precise needs. In fact, the purpose of the PISA Model is to provide the automotive community with a quality model with innovative features that targets the specific needs of the automotive industry in the context of the development of electronic systems.

Explicitly, the needs for an effective quality model in the context of automotive electronics developments are:

- Ability to evaluate the project performance in order to provide usable and timely feedbacks on the project risk level;
- Ability to evaluate and improve the process and organizational capability as a means to address risks associated to development processes.

Accordingly, the PISA model addresses both project evaluation and process improvement in a balanced fashion and targets a hand-on approach for the practitioners.

1.3 Scope

The PISA model, in the context of electronic automotive systems, addresses:

1. System-level development
2. Electronic and mechanical hardware-level developments
3. Software-level development.

1.4 Glossary

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

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]*

lifecycle: 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 breakdown structure: a hierarchical representation of the project organization that illustrates the relationship between project activities and the organizational units that will perform those activities. *[PMBOK® Guide]*

organizational maturity: extent to which an organization has explicitly and consistently deployed processes that are documented, managed, measured, controlled, and continually improved. *[ISO/IEC/IEEE 24765]*

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 process capability *[IEEE 730]*

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

process capability: characterization of the ability of a process to meet current or projected business goals. *[ISO/IEC 33020]*

process model: a model comprising definitions of processes in a life cycle described in terms of process purpose and outcomes, together with an architecture describing the relationships between the processes [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]*

requirement specification: a document that specifies the requirements for a system or item. Typically included are functional requirements, performance requirements, interface requirements, design requirements, and development standards. *[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 adequacy 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]*

testing: Activity in which an item (system, hardware, or software) is executed under specific conditions; and the results are recorded, summarized and communicated. *[Automotive SPICE]*

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 segment 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]*

1.5 Acronyms

AIAG: Automotive Industry Action Group

APQP: Advanced Product Quality Planning

AUTOSAR: Automotive Open System Architecture

BOM: Bill of Material

CASE: Computer-aided Software Engineering

CCB: Change (or Configuration) Control Board

CMMI: Capability Maturity Model Integration

DFMA: Design for Manufacturing and Assembly

DNN: Deep Neural Network

DV: Design Validation

E/E: Electric and Electronic

ECU: Electronic Control Unit

EITVOX: Entry Criteria – Input – Tasks – Verification – Output – Exit Criteria

FMEA: Failure Mode and Effect Analysis

HIL: Hardware-In-the-Loop

HIS: 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

SWEBOK: Software Engineering Body of Knowledge

VDA: Verband der Automobilindustrie

V&V: Verification and Validation

1.6 References

[1] APQP-2 Advanced Product Quality Planning and Control Plan, 2008, AIAG.

[2] Automotive SPICE Process Assessment / Reference Model, ver. 3.1, Verband der Automobilindustrie, 2017.

[3] AUTOSAR Std. (autosar.org)

[4] CMMI for Development, Version 1.3 Improving processes for developing better products and services. November 2010. TECHNICAL REPORT CMU/SEI-2010-TR-033.

[5] IATF 16949:2016 - Quality management system requirements for automotive production and relevant service parts organizations.

[6] ISO 26262:2011, Road Vehicles - Functional Safety.

[7] ISO/IEC 12207:2008, Systems and software engineering — Software life cycle processes

[8] ISO/IEC 25000:2014 Systems and software Engineering — Systems and software product Quality Requirements and Evaluation (SQuaRE) — Guide to SQuaRE, 4.1

[9] ISO/IEC 33000:2015 Information technology - Process assessment

[10] ISO/IEC/IEEE 24765:2017, Systems and Software engineering – Vocabulary

[11] Guidelines for the Use of the C Language in Critical Systems, ISBN 978-1-906400-10-1. March 2013

[12] Guidelines for the Use of the C++ Language in Critical Systems, ISBN 978-906400-03-3. June 2008

[13] MISRA AC GMG: Generic modelling design and style guidelines, ISBN 978-906400-06-4, May 2009

[14] MISRA AC SLSF: Modelling design and style guidelines for the application of Simulink and Stateflow, ISBN 978-906400-07-1, May 2009.

[15] Project Management Institute (PMI) and IEEE Computer Society. Software Extension to the PMBOK® Guide Fifth Edition

[16] Guide to the Software Engineering Body of Knowledge, Version 3.0, IEEE Computer Society, 2014

2. A Tour of the PISA Model

2.1 Overview

This part of the document provides an introductory description of the characteristics of the PISA Model in order to introduce its original concepts. These very concepts are described in more detail in the subsequent sections.

The PISA Model is a quality model that extends the typical process model framework approach. The PISA Model fits the characteristics of automotive developments by incorporating automotive technical and procedural requirements as well as a more project-centered perspective into an integrated standard process framework.

2.1.1 From Process Model to Process Improvement Scheme

Conceptually, the PISA Model can be defined as an automotive-specific "augmentation" of a system-level process model, conceived to serve better the needs of automotive electronics developments for process improvement. In order to highlight this transition, the explicit term "scheme" is introduced – in fact PISA stands for Process Improvement Scheme for Automotive.

Although it is generally accepted that the quality of a product depends on the quality of the underlying development process, more than a decade of field experience has strongly indicated the need of:

1. a more comprehensive and pragmatic scheme to evaluate automotive projects in automotive
2. focusing purposely on key process elements of development projects

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 a characteristic is called ADEQUACY that targets a project evaluation by integrating several process and project attributes, as shown by Figure 1.

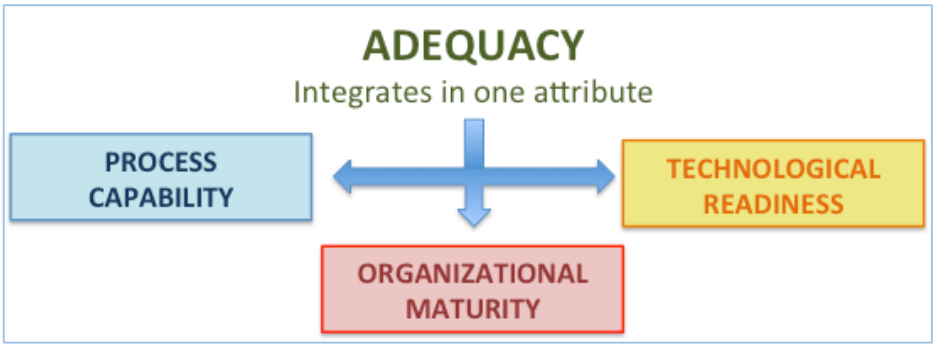


Figure 1: Adequacy vs. process / project attributes

ADEQUACY attribute integrates three dimensions: Process Capability, Organizational Maturity, and Technological Readiness.

Fulfilling the requirements associated to the ADEQUACY attribute framework means, in summary, that a project is satisfactorily conducted from the technical and managerial viewpoints.

2.2 Main Features of PISA Model

PISA Model emphasizes the following elements:

- Acknowledgement of the specifics of Automotive Lifecycle (context sensitivity)
- Leverage on core requirements (avoiding excessive complexities)
- Improved guidance on required outputs and contents (operative support)
- Integration of technological aspects (technology readiness)
- Integration of essential organizational aspects (organization appraisal)
- Explicit links with automotive functional safety (ISO 26262) and APQP (integrated view)
- Strengthened focus on actual project results (technical solution)
- Acknowledgement of the impact of skilled staff (human factor)

2.3 Architecture of PISA Model

The three pillars the PISA Model is based on are:

1. Process Scope and Augmented Framework
2. Process Structure and Requirements
3. Evaluation and Rating System

2.3.1 Processes Scope and Augmented Framework

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 PISA Model are twenty-two (22) in total.

They are divided into five (5) Process Segments:

- Three (3) Technical Segments: System Engineering, Hardware Engineering, and Software Engineering
- Two (2) Coordination Segments: Management, and Sustenance.

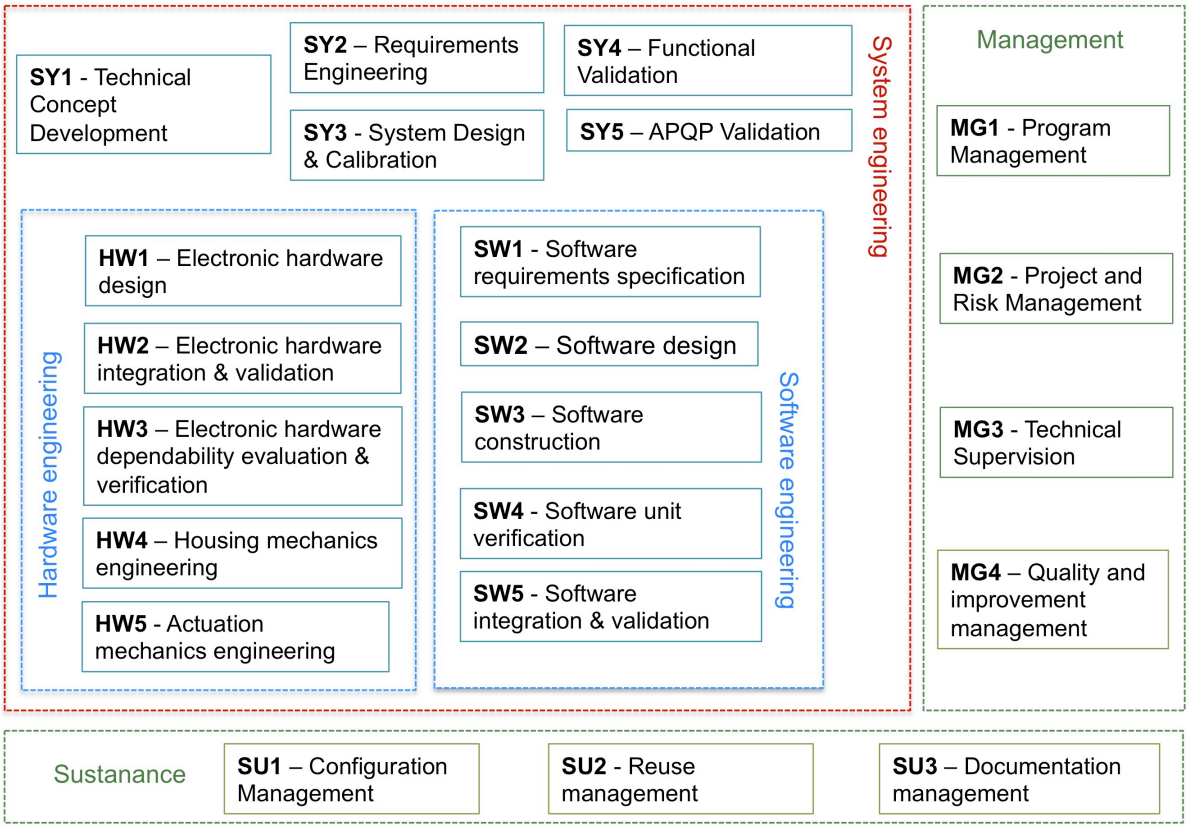


Figure 2: PISA Model process scope

As shown in Figure 2, the PISA Model is composed of the following processes:

System Engineering Segment processes address the product view – the processes belonging to this segment are:

SY1 - Technical Concept 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].

SY2 – Requirements Engineering: it pertains to the definition, documentation and maintenance of requirements for development at system level.

SY3 – System Design and Calibration: it pertains to the definition of a detailed system design with strong focus on hardware-software interfaces and system calibration aspects. Such a level of design takes into account automotive design drivers such as “design for manufacturing”.

SY4 – Functional Validation: it pertains to the verification of the conformance of the developed system to functional specifications.

SY5 – 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.

Hardware Engineering Segment processes address the electronics development according to the automotive industry best practices – the processes belonging to this segment are:

HW1 – Electronic Hardware Design: it pertains to the definition of electronics design, including the preparation of the physical layout.

HW2 – Electronic Hardware Integration and Validation: it pertains to the validation of electronic sub-system(s) from functional and electrical point of views.

HW3 – Electronic Hardware Verification and Dependability Evaluation: it pertains to the performance of E/E design verification as well as the performance of dependability analysis.

HW4 – Housing Mechanics Engineering: it pertains to the deployment of both the design and the verification of mechanical housing.

HW5 – Actuation Mechanics Engineering: it pertains to the deployment of both the design and the verification of actuation mechanical hardware.

Software Engineering Segment processes address the development of software as well as the integration of software components; the processes belonging to this segment are:

SW1 – Software Requirements Specification: it pertains to the definition, documentation and maintenance of requirements for software development.

SW2 – Software Design: it pertains to the definition of the software architectural design following a multi-level and multi-perspective approach.

SW3 – Software Construction or software production: it pertains to the deployment of best practices for the implementation of the software design.

SW4- 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.

SW5 – Software Integration and Validation: it pertains to the verification and validation of software sub-system(s) from a functional and performance point of views.

Management Segment processes provide lean requirements targeting management needs of the automotive electronics developments; the processes belonging to this segment are:

MG1 – Program Management: it pertains to high-level management of projects within the program framework and to the related customer interfacing.

MG2 – Project and risk management: it pertains to management of projects according to management best practices tailored for the automotive.

MG3 – Technical Supervision: it pertains to the management of technical operative aspects of project activities.

MG4 – Quality and Improvement Management: it pertains to the assurance of the deployment of an adequate quality management. It also pertains to improvement initiatives.

Sustenance Segment processes are key support processes providing a set of requirements aligned with automotive best practices; the processes belonging to this segment are:

SU1 – Configuration Management: it pertains to the deployment of configuration management at system, hardware and software levels.

SU2 – Reuse Management: it pertains to the management of the reuse of hardware and software elements.

SU3 – Documentation Management: it pertains to the deployment of a structured and lean documentation management.

2.3.2 Process Structure and Requirements

In order to increase readability and usability, each process belonging to the PISA Model is specified according to the EITVOX structure, as shown in Figure 3.

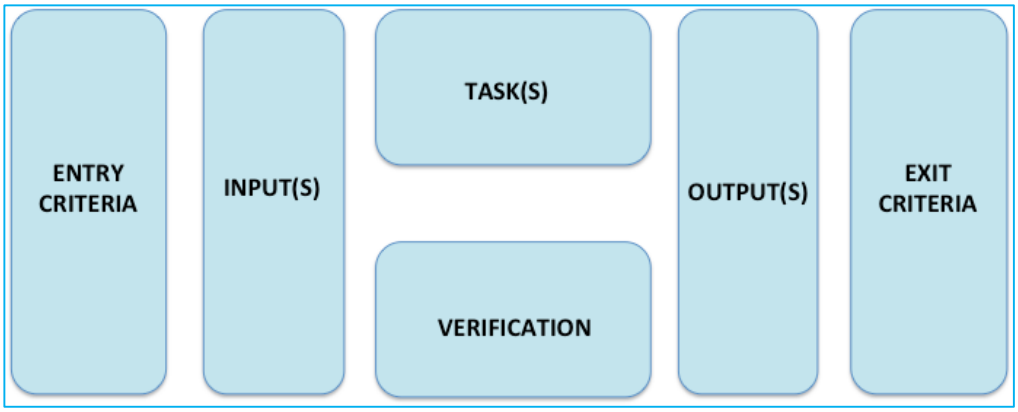


Figure 3: The EITVOX structure

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. Entry Criteria: pre-conditions that are expected to be satisfied when the process starts.
4. Input Work products
5. 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.
6. Output Work Products and related content outline
7. Exit Criteria: conditions that are expected to be satisfied when the process ends.

The PISA model requirements are divided into three (3) categories:

a. Process Requirements
b. Governance Requirements
c. Technological Requirements

PISA Model requirements are prioritized in terms of impact on ADEQUACY evaluation. High priority requirements are indicated by means of red-colored mark in the upper-left corner of the corresponding requirement description.

In order to exemplify the PISA Model process requirements, a sample of requirements for each category from the "Software Units Verification" process is provided in the following tables.

High priority process requirements define the purpose and outcomes of the related process.

Example of process requirement:

SW4-PR1	Perform MISRA (Motor Industry Software Reliability Association) C/C++ Check
Clause	Source code shall be verified in respect to MISRA C/C++ compliance.
Elaboration(s)	MISRA C/C++ guidelines comprises 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 or latest release applies • MISRA C++:2008 or latest release applies As these guidelines evolve, additional MISRA publications are to be taken into account, such as: • MISRA C:2012 - Technical Corrigendum 1: Technical clarification of MISRA C:2012, 2017 [8]. LINK TO ISO 26262 Requirement(s): Part 6, clause 5.4.7 LINK TO APQP Requirement(s): This requirement is need for PPAP Readiness of software part.
Tip(s)	Check of MISRA C/C++ at developing time is strongly recommended. MISRA C/C++ check is supported by several tools providing automatic check and advanced reporting features. Model-based technology allows to perform specific checks on the models to maximize MISRA C:2012 compliance of the generated code (refer to Notes).
Tailoring Criteria	The following tailoring criteria may apply as appropriate: • If requested by customer, MISRA C/C++ check can be performed using an older version (e.g. MISRA C:2004). • For C++ High Integrity C++ Coding Standard (HIC++) can be used instead of MISRA C++ • 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 (See note below).

Notes	MODEL BASED DEVELOPMENT: For model-based development, a set of specific guidelines is available. 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. The available relevant references 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. • MathWorks Automotive Advisory Board (MAAB) Rules • MathWorks High-Integrity System Modeling Guidelines

Example of governance requirement:

SW4-GR1	Ensure suitable skills
Clause	Personnel allocated to Software Unit Verification activities shall hold adequate technical skills and professional experience.
Elaboration(s)	Demands in terms of personnel's skills, training and expertise to deploy Software Unit Verification activities as well as to use and optimize related tools are identified. Personnel holding the needed skill, knowledge and expertise is allocated to software unit verification activities.
Tip(s)	Authority on the software unit verification team to be assigned to a senior V&V engineer.
Tailoring Criteria	The following tailoring criteria may apply as appropriate: • Resources limitations • Carry-over of a stable project • Support of a senior
Notes	A data-base of personnel technical skills (at detailed level) and training profiles is instrumental to the requirement implementation.

Example of technological requirement:

SW4-TR1	Deploy Effective Static Analyzer
Clause	MISRA C/C++ checking and static analysis (including structural metrics calculation capability) shall be performed according to means aligned to the technological state-of-the-art.
Elaboration(s)	Tool support for these activities is key for the implementation of this requirement.

	Several automatic tools preforming structural metrics calculation and MISRA C/C++ check are available and widely applied.
Tip(s)	Set up the tool in order to calculate and store statistics and measurements [M4]
Tailoring Criteria	The following tailoring criteria may apply as appropriate: • Adoption of a combination of tools to address sufficiently the verification • Visual inspection (this acceptable only for small start-up environments)
Notes	For model based development it is possible to check that the model complies with MathWorks® Automotive Advisory Board (MAAB) Guidelines by running the Model Advisor. As a reminder, the MAAB involves major automotive OEMs and suppliers in the process of evolving MathWorks technology.

2.3.3 Evaluation and Rating System

Evaluation and rating within the PISA Model is governed by the Adequacy Rating System (ARS) which is described in the dedicated section.

Again, the PISA Model allows the evaluation of a development project in terms of the project ADEQUACY attribute.

The PISA Model evaluation process works according to a bottom-up approach. The following picture shows the conceptual path towards the project evaluation in terms of project ADEQUACY attribute.

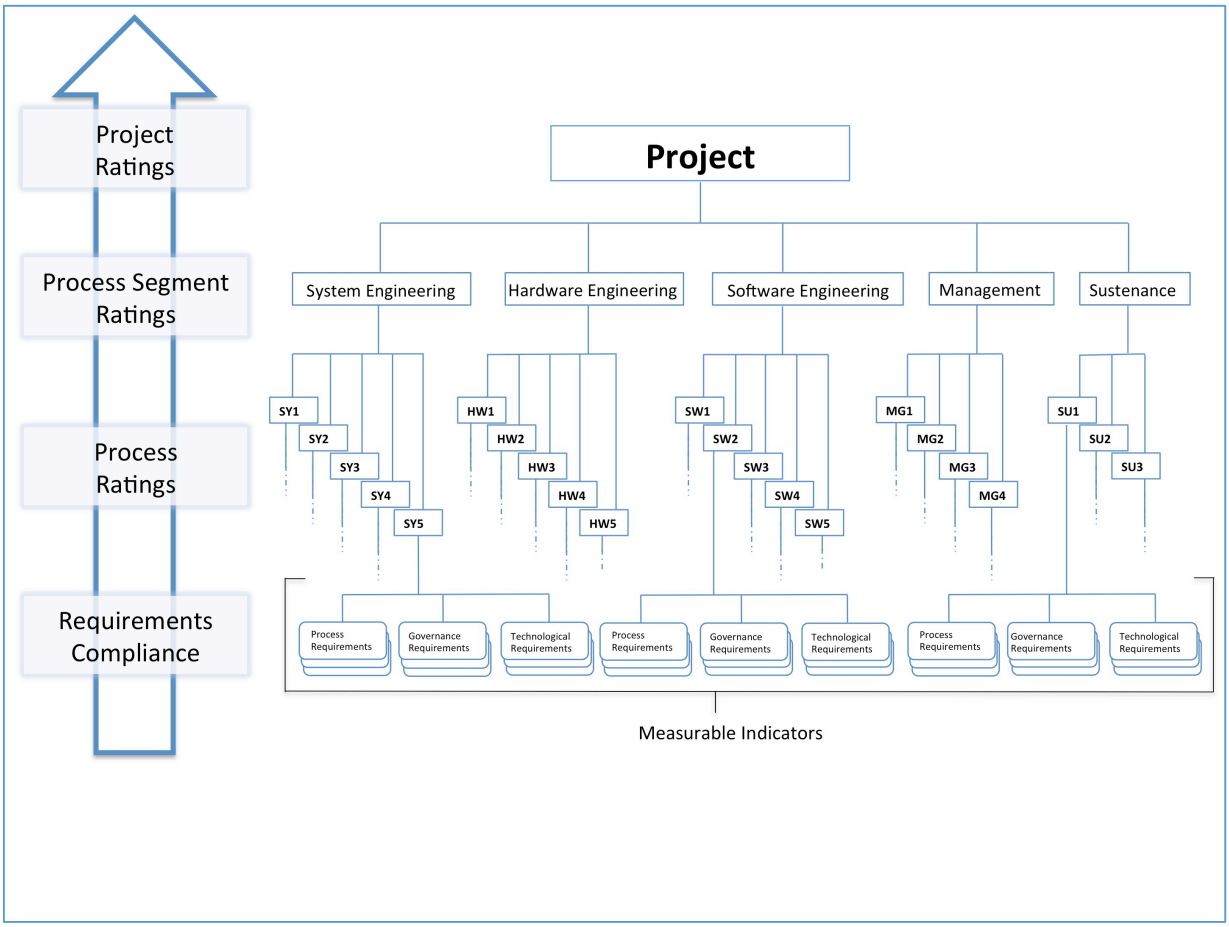


Figure 4: The Adequacy Rating System (ARS)

As the Figure 4. shows, the ARS provides a bottom-up project evaluation mechanism that is based on process-specific sets of requirements belonging to three categories (process, governance, and technological).

The first step of the rating process is the evaluation of the compliance to the three categories requirements (requirements compliance level) – the priority of the requirements is also taken into account for the rating. Based on the requirements compliance rating, the process rating in terms of ADEQUACY is established (process rating level).

The aggregation of process ratings determines the relevant process segment rating (segment rating level). Finally, the combination of the process segments ratings determines the project rating in terms of ADEQUACY attribute.

In addition, a set of argumentations are provided in a dedicated section (Annex B) on how to use the ADEQUACY attribute rating (that is a project level) in the context of organizations benchmarking. These argumentations support the exploitation of the PISA Model to give a risk-based evaluation that is specifically referred to the involved organization (e.g. an ECU supplier).

The following tables introduces the layered hierarchy of the PISA Evaluation System attributes:

PISA MODEL RATING LEVELS	PISA MODEL RATING ATTRIBUTES
PROJECT	ADEQUACY
PROCESS SEGMENT	
PROCESS	
REQUIREMENT	COMPLIANCE

The rating of process requirement category and the process requirement layers is based on the self-explanatory **4P scale:**

1.POOR -> 2.PARTIAL -> 3.PERFORMED -> 4.PROFICIENT

The following table describes the possible ratings of the ADEQUACY attribute and associated semantics.

ADEQUACY Attribute	
FULL OR ADEQUATE	Project is deployed adequately and project objectives are not at risk. Process improvement opportunities are limited in scope and criticality.
SUFFICIENT	Project is deployed satisfactorily and project objectives are largely not at risk. Process improvement opportunities are present.
INCOMPLETE	Project is deployed nearly satisfactorily and project objectives are exposed to some noteworthy risk. Significant Process improvement opportunities are present.
POOR	Project objectives are at risk. Process improvement opportunities are important and require immediate improvement action items.

3. PISA Model Processes

In this section, the processes belonging to PISA Model scope are provided.

The processes are divided into three Technical Segments and two Coordination Segments. The presentation of the processes is structured by Segments.

Technical Segments are:

- System Engineering
- Hardware Engineering
- Software Engineering

Coordination Segments are:

- Management
- Sustenance

3.1 System Engineering Segment 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.

A "system" can be seen as the combination of elements that function together to produce the capability required to meet a need. 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

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

- 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 segment 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 Segment are:

- SY1 – Technical Concept Development
- SY2 – Requirements Engineering
- SY3 – System Design and Calibration
- SY4 – Functional Validation
- SY5 – APQP Validation

3.1.1 SY.1 – Technical Concept Development

Context of the process:

Technical Concept Development process initiates the system development by defining the technical scope and directions for the technical solution to be adopted by the project.

Successfully understanding and defining the system objectives and 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 technical concept development 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.

Process Entry Criteria:

1. Market request(s)
2. Internal request(s)

Input Work Products:

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

Additional relevant inputs are:

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

Process Requirements:

SY1-PR1	Develop technical concept of the system.
Clause	As the project or pre-project activities start, a technical concept shall be developed to provide a documented technical, economic and strategic view of the system to be developed.
Elaboration(s)	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 supports also 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. LINKS TO APQP Requirement(s): Team Feasibility Commitment and Management Support, Design Goals, Preliminary Bill of Material LINKS TO ISO 26262 Requirement(s): ISO 26262-3:2011, clause 5.5; ISO 26262-4:2011, clause 7.4
Tip(s)	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.
Tailoring Criteria	Reuse of technical concept as appropriate in case of: - Carry over projects - Development within a consolidated product family
Notes	The results of this activity shall be refined by the system design process.

SY1-PR2	Develop high-level functional analysis.
Clause	In order to achieve a sufficient understanding on the system to be developed, a high-level functional analysis shall be conducted.
Elaboration(s)	The purpose of the functional analysis is to confirm the soundness of the technical concept. 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. LINKS TO APQP Requirement(s): Product Reliability Studies LINKS TO ISO 26262 Requirement(s): ISO 26262-4:2011, clause 7.4
Tip(s)	Function tree technique can be used as proved suitable.
Tailoring Criteria	In case of low functional complexity, informal analysis can be done.
Notes	This activity can also support elicitation of new requirements from customer or stakeholders.

SY1-PR3	Determine quality and reliability goals of the system.
Clause	As the project or pre-project activities start, a documented view of the quality and reliability goals for the project shall be provided.
Elaboration(s)	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 26262-4:2011, clause 7.4
Tip(s)	1. Collaborate with customer to identify quality and reliability goals. 2. Use benchmarks as appropriate.
Tailoring Criteria	This requirement can be fulfilled by the SY2-PR2.
Notes	A specific APQP requirement exists.

Governance Requirements:

SY1-GR1	Involve organization stakeholders.
Clause	The involvement of a cross functional team is key to conduct effective preliminary analysis of the project.
Elaboration(s)	Cross-functional team may include several organization elements, such as: • Engineering • Validation • Management • Quality • Production • Marketing • Logistics. Cross-functional team meeting minutes shall be recorded and traced.
Tip(s)	Involve suppliers as appropriate. Involve customer as appropriate. Project boards may provide effective support.
Tailoring Criteria	None specific.
Notes	Management support is key in this context (APQP: Plan for management support)

SY1-GR2	Reuse of organization data
Clause	The reuse of organization data is key to conduct effective preliminary analysis of the project.
Elaboration(s)	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
Tip(s)	Qualitative data such as lessons learned gathered in the corporate QMS (Quality Management System) can be exploited.
Tailoring Criteria	None specific.
Notes	-

Technological Requirements:

None specific 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:

SY1-OWP1	Technical Concept
Expected Contents	Content includes: - Preliminary architecture - Main technical solutions and evaluations of alternatives - Preliminary release plan - Functional safety considerations, if applicable - Quality goals - Reliability goals
Notes	Related requirements: **SY1-PR1, SY1-PR3**

SY1-OWP2	Preliminary BOM
Expected Contents	Content includes: - Data on main parts of the system (to support technical, logistic and costs evaluations)
Notes	Related requirements: **SY1-PR1** Availability of preliminary BoM can be deferred, depending on project needs.

SY1-OWP3	Functional analysis report
Expected Contents	Content includes: - system functions and their relationships - operational scenarios - analysis of system functions vs. external interfaces
Notes	**SY1-PR2**

SY1-OWP4	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	**SY1-PR2** This work-product shall be kept in use during the whole development.

Process Exit Criteria:

1. Organization is ready to initiate the technical development

3.1.2 SY.2 – 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.

Requirements engineering is a step-wise 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

Process Entry Criteria:

1. Availability of Technical Concept
2. Project Kick-off

Input Work Products:

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

Additional relevant inputs are:

- Project documentation of similar developments

Process Requirements:

SY2-PR1	Determine functional requirements of the system.
Clause	The functional requirements of the system shall be developed in a documented format in accordance to the timing project needs.
Elaboration(s)	System requirements analysis process aims at identifying, analyzing and tracking system requirements to allow a full control of the development in terms of content and validation. System Requirements analysis often starts during the commercial offer. The default system requirements analysis process typically follows the pattern shown in this table below:

Project Phase	A (Proto)	B (Product Engineering)	C (Process Engineering)
Requirements Engineering	YES (Analysis)	YES	YES (Change management)

YES (Analysis)	Focus on analysis of customer requirements in terms of feasibility
YES	Full analysis and documental specification
YES (Change management)	Focus on change request management on requirements

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 – for example Mechanics, PCB, SW, Application SW... (the actual options for the project shall be consistent with the preliminary design considerations)

Functional safety requirements, if any, shall expressed according to this process requirement.

The language used must be clear, exact, and in sufficient 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.

LINKS TO APQP Requirement(s): Engineering Specification

	LINKS TO ISO 26262 Requirement(s): ISO 26262-4:2011, clause 6.4
Tip(s)	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 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 Criteria	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 has to be done by identifying the necessary tasks, actions or activities that must be accomplished.

SY2-PR2	Determine non-functional requirements of the system.
Clause	The non-functional requirements of the system shall be developed in a documented format to the project team in accordance to the timing project needs.
Elaboration(s)	Typical categories of non-functional requirements include: • performance requirements • technical requirements • interface requirements • environmental requirements • physical requirements • operational requirements, • production requirements, • quality requirements, • configuration and calibration requirements • design-constraint requirements. For general elaboration on requirements specification, see SY2-PR1
	LINKS TO APQP Requirement(s): Engineering Specification LINKS TO ISO 26262 Requirement(s): ISO 26262-4:2011, clause 6.4
Tip(s)	Minimize the number of non-functional requirements

	Due to the often large number of Customer documents to be analysed, it is important to map each Customer document on a reference person (that supposedly has the necessary skills).
Tailoring Criteria	See SY2-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.

SY2-PR3	Control requirements evolution
Clause	As project requirements changes at system level affect the project, it is required that formal change management is applied to project system requirements.
Elaboration(s)	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 a defined work-flow. It is responsibility of the project management and of the QA functions to monitor that the Change Requests implementation proceed as planned and to make timely adjustments when necessary. The requirements traceability infrastructure shall allow to determine and control the impact of the changes. --- LINKS TO APQP Requirement(s): Drawing and Specification Changes LINKS TO ISO 26262 Requirement(s): ISO 26262-4:2011, clause 6.4, ISO 26262-8:2011 Clause 8.4
Tip(s)	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 other functionality, validation and production aspects.
Tailoring Criteria	As, by definition, change request management process tracks change requests having impact on baselined work-products, apply change management also to drafts.
Notes	Change management is typically supported by dedicated tool(s) and it can be defined as cross-functional activity.

Governance Requirements:

SY2-GR1	Ensure suitable skills for requirements engineering activities.
Clause	Personnel allocated to requirements engineering activities shall hold suitable technical skills.
Elaboration(s)	Requirements engineering skills are related to: 1. Domain knowledge shills 2. Analysis skills 3. Elicitation skills 4. Documentation and review skills.
Tip(s)	Skill management can be addressed at project level and organization level to better address specific needs.
Tailoring Criteria	None specific.
Notes	Related Work Product is MG2-OWP1

SY2-GR2	Involve project teams and relevant parties as appropriate
Clause	Requirements engineering activities, with particular reference to the review phase, shall be conducted by a cross functional team in order to achieve a comprehensive analysis.
Elaboration(s)	This requirement is instrumental at conducting an in-depth, holistic review of project requirements. The cross functional team is under the supervision of the project manager.
Tip(s)	Rely only on decision by consensus as decision making process for technical aspects.
Tailoring Criteria	None specific.
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.

SY2-GR3	Change Control Board (CCB)
Clause	The project is supported by dedicated board for change management related to system requirements.
Elaboration(s)	Composition, roles, and workflow shall be defined in the project plan.
Tip(s)	-
Tailoring Criteria	In case of small project, the project leader can be main component of the board.
Notes	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.

Technological Requirements:

SY2-TR1	System requirements management tool
Clause	Deploy Effective Requirements Development and Management tool(s) as appropriate.
Elaboration(s)	The market offers a variety of tools and solutions, from open-source to commercial full-fledged suites, able to address all needs.
Tip(s)	Do no tailor process on tool, but do vice-versa.
Tailoring Criteria	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:

SY2-OWP1	Project system requirements
Expected Contents	It may include specification of requirements 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 database.
Related Requirements	**SY2-PR1, SY2-PR2, SY2-PR3**

SY2-OWP2	Traceability data
Expected Contents	Forward and Backward traceability to Customer requirements.
Related Requirements	**SY2-PR1, SY2-PR2, SY2-PR3**

SY2-OWP3	Review report of project requirements at system level
Expected Contents	Its content includes: - Reviewers - Review summary results - Requirements review criteria - Review findings
Notes	**SY2-GR2**

Process Exit Criteria:

1. Consolidated project system requirements are available to project stakeholders.

3.1.3 SY.3 – System Design and Calibration

Context of the process:

System Design and Calibration 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).

Process Entry Criteria:

- Availability of system requirements analysis outcomes

Input Work Products:

- Project Requirements
- Technical 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:

SY3-PR1	Development of design of the system.
Clause	Develop design at system level that fits the project requirements with the target operational environment.
Elaboration(s)	System design provides an 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. A 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. Other key elements are: - Partitioning of system elements - Allocation of system requirements to the system elements - Definition of the system elements to be developed - Operating modes 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. LINKS TO ISO 26262 Requirement(s): ISO 26262-4:2011, clause 7.4 LINKS TO APQP Requirement(s): Engineering specification
Tip(s)	Balance the design abstraction level among different sub-systems. Semi-formal specification language (e.g. SysML) can be used.
Tailoring Criteria	In case of a safety-critical development, the system design activity shall address also the technical safety concept development.
Notes	As the system architecture is composed by architectural elements it represents the level of decomposition required at this level of design.

SY3-PR2	Determine and maintain calibration and configuration needs of the system.
Clause	Calibration and configuration parameters shall be identified in accordance to the system functions and the operating environment.

	Refine calibration design during the project life as more detailed design of the project is developed
Elaboration(s)	ECUs in all domains (e.g. 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). LINKS TO ISO 26262 Requirement(s): ISO 26262-4:2011, clause 6.4 LINKS TO APQP Requirement(s): Engineering specification
Tip(s)	Calibration tasks are often conducted in a work-split between OEM, ECU-suppliers and engineering companies.
Tailoring Criteria	Consider reuse of calibration data for carry-over projects.
Notes	Typical calibration systems are currently based on ASAM standard architecture.

SY3-PR3	Conduct FMEA
Clause	Develop FMEA at functional level or design level as appropriate.
Elaboration(s)	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 26262-4:2011, clause 7.4.3 LINKS TO APQP Requirement(s): DFMEA
Tip(s)	The use of the FMECA technique is recommended.
Tailoring Criteria	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 is provided by SAE and VDA.

SY3-PR4	Conduct DFMA
Clause	DFMA (Design for Manufacturing and Assembly) principles shall be applied during the development of the system design.

Elaboration(s)	The DFMA objectives are to develop a product that meets all the functional needs and it is convenient for manufacturing and assembly. Applying DFMA principles and methods allows to optimize both the manufacturing and the assembly phase at production time. LINKS TO ISO 26262 Requirement(s): ISO 26262-4:2011, clause 7.4 LINKS TO APQP Requirement(s): DFMA
Tip(s)	Typical criteria to adopt DFMA are to reduce part count and types.
Tailoring Criteria	None specific.
Notes	DFMA is a set of methods of design for ease of manufacturing and the assembly of the collection of parts that will form the product.

SY3-PR5	Design review
Clause	A set of design reviews shall be conducted along the project to make sure that the design is correct.
Elaboration(s)	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 26262-4:2011, clause 7.4.8 LINKS TO APQP Requirement(s): Design verification, design review, Team Feasibility Commitment and Management Support
Tip(s)	Exploitation of simulation, testing of prototypes is recommended.
Tailoring Criteria	None specific
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.

Governance Requirements:

SY3-GR1	Ensure suitable skills for system design
Clause	Personnel allocated to system design activities shall hold adequate technical skills.
Elaboration(s)	Demands in terms of personnel's skills, training and expertise to deploy system design activities as well as to use and optimize related tools are identified. Personnel holding the needed skill, knowledge and expertise is allocated to system design activities.
Tip(s)	A database of personnel skills and training profiles is beneficial.
Tailoring Criteria	None specific.
Notes	-

SY3-GR2	Evaluate reuse opportunities for system design
Clause	Reuse of consolidated design patterns and experiences (including for calibration) shall be taken into account during the system design, at all levels of design.
Elaboration(s)	Design patterns are key in designing robust solutions, especially in safety.
Tip(s)	E-gas design pattern is a reference safety solution for safety critical developments
Tailoring Criteria	None specific.
Notes	-

Technological Requirements:

SY3-TR1	Prototyping support
Clause	Deploy prototyping development environment, as appropriate, to facilitate a robust design.
Elaboration(s)	The development of prototypes is strongly beneficial to explore technical solutions and minimize the risks of project failures.
Tip(s)	Dedicated team and facility can be allocated to this activity.
Tailoring Criteria	Prototyping support can be performed by third-parties.
Notes	

SY3-TR2	Simulation tool support
Clause	Deploy simulation tools, as appropriate, to facilitate a robust design.
Elaboration(s)	The exploitation of simulation approaches to better design the system is strongly beneficial to design improvement.
Tip(s)	
Tailoring Criteria	
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.

SY3-TR3	Calibration tool support.
Clause	Deploy calibration tools, as appropriate, to facilitate effective calibration.
Elaboration(s)	To manage complex calibration tasks, calibrators require solutions that combine human expertise with best practice optimization methods and easy data handling.
Tip(s)	“In field calibration testing” has to be supported.
Tailoring Criteria	Project may not require this support according to project characteristics.
Notes	

Output Work Products:

SY3-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	**SY3-PR1, SY3-PR4, SY3-GR2**

SY3-OWP2	System Interfaces Specification
Expected Contents	Its content includes: - External interfaces - Internal interfaces ○ Focus on Hardware Software Interfaces specifications
Notes	It can be combined with system design specification. **SY3-PR1, SY3-GR2**

SY3-OWP3	Configuration and Calibration Data Specification
Expected Contents	Its content includes: - Configuration data (purpose, range, default, actuals, variants, measure unit) - Calibration data spec (purpose, range, default, actuals, variants, measure unit) This output shall be developed and baselined during the all project as appropriate.
Notes	**SY3-PR1, SY3-PR2, SY3-TR3**

SY3-OWP4	Functional FMEA
Expected Contents	Its content includes: - Failure mode analysis of system functions - Impact analysis on external environment
Notes	To be linked with Functional Analysis **SY3-PR3**

SY3-OWP5	Traceability data
Expected Contents	Forward and Backward traceability between system requirements and system design elements. Semantic: requirement allocation
Notes	It can be combined with system design specification. **SY3-PR1**

SY3-OWP6	Review report
Expected Contents	Its content includes: - Reviewers - Review summary results - Design review criteria - Review findings
Notes	**SY3-PR5, SY3-TR1, SY3-TR2**

Process Exit Criteria:

1. Consolidated project system design is available to project stakeholders.

3.1.4 SY.4 – Functional Validation

Context of the process:

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

Process Entry Criteria:

- Availability of project requirements at system level
- Validation resources (e.g. test benches, dedicated test tools)

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:

SY4-PR1	System Integration verification
Clause	Verify integration of the system under test (SUT).
Elaboration(s)	System Integration Testing 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 26262-4:2011, clause 8.4 LINKS TO APQP Requirement(s): Product & Process Validation
Tip(s)	- The starting point for system integration and verification is the release of elements from the suppliers. - Special focus on testing critical hardware-software interfaces.
Tailoring Criteria	System Integration testing can focus on selected interfaces by providing technical rationale.
Notes	The system integration strategy at system level depends on the system under development. 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.

SY4-PR2	Validation specification.
Clause	Validation specification shall be developed to target project system requirements.
Elaboration(s)	Design of the tests cases, according the defined strategy, 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 26262-4:2011, clause 9 LINKS TO APQP Requirement(s): Product & Process Validation
Tip(s)	1. Avoid duplication with the other levels of testing 2. Consider the application of fault injection testing techniques
Tailoring Criteria	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.

SY4-PR3	Validation execution.
Clause	Validation testing shall be performed as planned.
Elaboration(s)	Validation testing execution is to be performed according to the defined strategy. Execution logs shall be generated and maintained. LINKS TO ISO 26262 Requirement(s): ISO 26262-4:2011, clause 9 LINKS TO APQP Requirement(s): Product & Process Validation
Tip(s)	The order of the test execution can be defined according to project needs or technical constraints.
Tailoring Criteria	Witnessing technique is acceptable in case of technical difficulties in registering test logs.
Notes	-

Governance Requirements:

SY4-GR1	Ensure suitable skills for System Validation
Clause	Personnel allocated to System Validation activities shall hold adequate technical skills.
Elaboration(s)	Demands in terms of personnel's skills, training and expertise to deploy System Validation 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.
Tip(s)	A database of personnel skills and training profiles is beneficial.
Tailoring Criteria	In case of validation sub-contracting, evidences of qualification and skills has to be provided by the involved third-parties.
Notes	-

SY4-GR2	Determine validation strategy
Clause	A strategy for the Validation shall be defined and documented.
Elaboration(s)	Taking into account the typical phases of system development in automotive projects, the default system process is to be applied according this table below:

Project Phase	A (Proto)	B (Product Engineering)	C (Process Engineering)
System Testing	YES (Functional)	YES	YES (Change Management)

Legenda:

YES (Functional)	Focus on main functional aspects
YES	Focus on full requirements
YES (Change Management)	Focus on avoiding regression

Definition of the system testing strategy 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 3. Error guessing 4. Fault injection In addition, (but very important) definition of the regression strategy for the several project phases in accordance with project and quality objectives to be provided. Default regression strategy is full regression.
Tip(s)	1. Involve designers in the strategy definition in order to reach better validation effectiveness.
Tailoring Criteria	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 strategy shall also address the approach adopted for the verification of system integration.

SY4-GR3	Ensure suitable and sufficient validation resources
Clause	The project shall make sure that sufficient validation resources are available on time.
Elaboration(s)	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.
Tip(s)	A dedicated role for validation activities management is often useful.
Tailoring Criteria	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:

SY4-TR1	Automation support for Integration and Validation
Clause	Deploy automation validation means as appropriate in the context of integration testing and validation.
Elaboration(s)	Automated testing facilitates and improves regression testing with increased coverage and reduced costs as a result.
Tip(s)	-
Tailoring Criteria	-
Notes	-

SY4-TR2	HIL Support
Clause	Deploy Hardware-In-the-Loop (HIL) technology as appropriate
Elaboration(s)	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.
Tip(s)	-
Tailoring Criteria	-
Notes	-

Output Work Products:

SY4-OWP1	Integration Report
Expected Contents	Its content includes: - Summary results - List of test performed - Identification of the integrated system
Notes	**SY4-PR1, SY4-GR1**

SY4-OWP2	Validation Strategy
Expected Contents	Its content includes: - Test environment - Test tools - Test techniques - Test risks - Regression strategy - Test resources - Set of tests to perform
Notes	**SY4-GR2, SY4-GR3, SY4-TR1, SY4-TR2**

SY4-OWP3	Validation Specification
Expected Contents	Its content includes: - Test settings - Test procedures - Pass/fail criteria - Test chains
Notes	**SY4-PR2, SY4-TR1, SY4-TR2**

SY4-OWP4	Validation Report
Expected Contents	Its content includes: - Summary results - Test results - Link to logs
Notes	**SY4-PR3, SY4-TR1**

SY4-OWP5	Review report of validation specification
Expected Contents	Its content includes: - Reviewers - Review summary results - Design review criteria - Review findings

Notes	**SY4-PR2, SY4-GR1**

SY4-OWP6	Traceability data
Expected Contents	Its content includes: - Link to system requirements (forward and backward) - Link to system interfaces
Notes	**SY4-PR2**

Process Exit Criteria:

1. Validation results match the quality criteria defined for the correlated development step

3.1.5 SY.5 – 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.

Process Entry Criteria:

- Design freeze
- Availability of integrated systems in the needed number

Input Work Products:

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

Additional relevant inputs are:

- System Design
- Configuration and Calibration Data
- User Manual

Process Requirements:

SY5-PR1	Develop DV (Design Validation) plan
Clause	Design Validation plan shall be developed in accordance with customer and regulatory requirements.
Elaboration(s)	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 26262-4:2011, clause 9 LINKS TO APQP Requirement(s): Production Validation Testing
Tip(s)	DV plan is linked to DFMEA.
Tailoring Criteria	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.

SY5-PR2	Perform and report DV tests
Clause	DV activities shall conducted as planned and reporting shall be produced.
Elaboration(s)	Key elements of reporting are: - Summary of results - Tester identification - Traceability to test - Logs availability including test settings - Samples identification LINKS TO ISO 26262 Requirement(s): ISO 26262-4:2011, clause 9 LINKS TO APQP Requirement(s): Production Validation Testing
Tip(s)	DV plan is linked to DFMEA.
Tailoring Criteria	Design changes during DV execution are acceptable only if impact is minimal and analysis is documented.
Notes	-

SY5-PR3	Develop PV (Process Validation) plan
Clause	Production Validation plan shall be developed in accordance with customer and

	regulatory requirements.
Elaboration(s)	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 26262-4:2011, clause 9 LINKS TO APQP Requirement(s): Production Validation Testing
Tip(s)	PV plan is linked to PFMEA.
Tailoring Criteria	None specific
Notes	.

SY5-PR4	Perform and report PV tests
Clause	PV activities shall be conducted as planned and accurate reporting shall be produced.
Elaboration(s)	Key elements of reporting are: - Summary of results - Tester identification - Traceability to test - Logs availability including test settings - Samples identification LINKS TO ISO 26262 Requirement(s): ISO 26262-4:2011, clause 9 LINKS TO APQP Requirement(s): Production Validation Testing
Tip(s)	-
Tailoring Criteria	-
Notes	-

Governance Requirements:

SY5-GR1	Ensure suitable skills for Product Validation Testing
Clause	Personnel allocated to Production Validation Testing activities shall hold adequate technical skills.
Elaboration(s)	Demands in terms of personnel's skills, training and expertise to Production Validation Testing 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.
Tip(s)	A database of personnel skills and training profiles is beneficial.
Tailoring Criteria	-
Notes	-

SY5-GR2	Approved laboratories
Clause	Make sure that DV/PV activities are conducted in accredited facilities as appropriate.
Elaboration(s)	-
Tip(s)	-
Tailoring Criteria	-
Notes	Accreditation of facilities follows National Accreditation schemes

Technological Requirements:

SY5-TR1	Automation support for DV and PV
Clause	Deploy automation validation means in the context of DV and PV testing as appropriate
Elaboration(s)	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.
Tip(s)	-
Tailoring Criteria	-
Notes	-

Output Work Products:

SY5-OWP1	DV Plan
Expected Contents	According to customer or regulatory requests (e.g. VDA, SAE).
Notes	**SY5-PR1**

SY5-OWP2	PV Plan
Expected Contents	According to customer or regulatory requests (e.g. VDA, SAE).
Notes	**SY5-PR3, SY5-TR1**

SY5-OWP3	Test Report(s)
Expected Contents	Its content includes: - Summary results - Test results - Link to logs
Notes	DV Report PV Report **SY5-PR2, SY5-PR4, SY5-TR1, SY5-GR2**

Process Exit Criteria:

- DV/PV are concluded and emerged issues are under control.

3.2 Hardware Engineering Segment Processes

In the context of PISA Model, Automotive hardware engineering (electronics and mechanical) addresses the related development throughout the electronics and mechanics lifecycles, including requirement, specification, design, verification and validation of these sub-systems.

Implementation, that is sample productions for the electronics and the mechanics, is out of scope of the version of the PISA Model.

TRACEABILITY TO IATF 16949:

The system-engineering segment 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 Segment are:

- HW1 – Electronic Hardware Design
- HW2 – Electronic Hardware Integration & Validation
- HW3 – Electronic Hardware Dependability Evaluation and Verification
- HW4 – Housing Mechanics Engineering
- HW5 – Actuation Mechanics Engineering

3.2.1 HW.1 – Electronic Hardware Design

Context of the process:

Electronic Hardware Design process is a key in the context of automotive electronic developments because it addresses how the Electric/Electronic (EE) functions shall be addressed.

Process Entry Criteria:

- Availability of system design

Input Work Products:

- System Requirements
- System Design (including interface specification)

Additional relevant inputs are:

- Software requirements specification
- Software design
- Mechanical requirements
- Mechanical design

Process Requirements:

HW1-PR1	Electronic hardware requirements
Clause	Electronic hardware requirements shall be developed in accordance to system requirements and system design.
Elaboration(s)	Electronic hardware requirements specification activity converts the relevant system requirements (taking into account also 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 requirements types: - functional - safety - performance - technical - interface - quality (reliability, environmental...) . It is key to associate requirements to a specific HW release 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 26262-5:2011, clause 6.4 LINKS TO APQP Requirement(s): Engineering specification
Tip(s)	-
Tailoring Criteria	It is acceptable that some hardware requirements are expressed at system level
Notes	-

HW1-PR2	Determine electronic hardware architecture
Clause	Develop electronic hardware architectural design in order to provide a design able to support the implementation of the electronic hardware requirements.
Elaboration(s)	Develop electronic HW architecture taking into account standard 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 26262-5:2011, clause 7.4 LINKS TO APQP Requirement(s): Engineering specification
Tip(s)	Reuse of past design that proved functional and robust is a best practice. Adoption of complex architectural elements such as SoC and/or ASIC can offer substantial advantages.
Tailoring Criteria	-
Notes	In case of introduction of new electronic hardware blocks, electrical characterization shall be performed and documented.

HW1-PR3	Design hardware detailed design
Clause	Detail design in order to define electrical drawings of circuits and components specifications aligned with the architectural design.
Elaboration(s)	The hardware design is an articulated process that include: - BoM Definition - Layout and netlist definition - Components and circuit dimensioning - Connectors design LINKS TO ISO 26262 Requirement(s): ISO 26262-5:2011, clause 7.4 LINKS TO APQP Requirement(s): Engineering specification
Tip(s)	AEC-Q100/101/200 is the reference qualification standards for automotive components.
Tailoring Criteria	-
Notes	-

Governance Requirements:

HW1-GR1	Ensure suitable skills for hardware design
Clause	Personnel allocated to hardware design activities shall hold adequate technical skills.
Elaboration(s)	Demands in terms of personnel's skills, training and expertise to deploy to hardware design activities as well as to use and optimize related tools are identified. Personnel holding the needed skill, knowledge and expertise is allocated to relevant activities.
Tip(s)	A data base of personnel skills and training profiles is beneficial.
Tailoring Criteria	-
Notes	-

HW1-GR2	Co-design
Clause	Project shall exploit co-design or simultaneous engineering to improve the quality of the design process.
Elaboration(s)	This approach complements or replaces the sequential series of phases where results are transmitted to the next area for execution. The purpose is to expedite the development of quality products. 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.
Tip(s)	-
Tailoring Criteria	-
Notes	Co-design is typically adopted in conjunction with concurrent engineering.

Technological Requirements:

HW1-TR1	Design tools support
Clause	Suitable tools for electronic hardware design shall be deployed.
Elaboration(s)	The market offers a variety of tools for digital, analog, ASIC design.
Tip(s)	-
Tailoring Criteria	-
Notes	VHDL is most diffused formalism to design hardware together with Verilog.

Output Work Products:

HW1-OWP1	HW requirements
Expected Contents	Its content includes: - functional requirements - safety requirements - performance requirements - technical requirements - interface requirements - quality requirements
Notes	**HW1-PR1**

HW1-OWP2	HW design
Expected Contents	Its content includes: - architecture description - block descriptions - connector(s) design
Notes	**HW1-PR2**

HW1-OWP3	HW schematics
Expected Contents	Its content includes: - netlist - board structure
Notes	**HW1-PR3, HW1-TR1**

HW1-OWP4	HW BoM
Expected Contents	Its content includes: - primary source components - secondary source components Should be accessible to buyers
Notes	**HW1-PR3, HW1-TR1**

HW1-OWP5	HW design book
Expected Contents	Its content includes: - calculations to dimension circuits and components
Notes	**HW1-PR3, HW1-TR1**

Process Exit Criteria:

1. The HW design is completed according to the planned maturity level.

3.2.2 HW.2 – Electronic Hardware Integration and Validation

Context of the process:

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

Process Entry Criteria:

1. Availability of hardware

Input Work Products:

- Hardware requirements
- Hardware design

Additional relevant inputs are:

- Software requirements
- Software design
- Mechanical requirements
- Mechanical design

Process Requirements:

HW2-PR1	Perform electric HW block characterization
Clause	Perform electric HW tests at block level to ensure the correctness of the design.
Elaboration(s)	The project shall conduct testing at block level to make sure that actual behaviors of components and circuits are what expected. Back to back testing with simulations apply. LINKS TO ISO 26262 Requirement(s): ISO 26262-5:2011, clause 10 LINKS TO APQP Requirement(s): -
Tip(s)	-
Tailoring Criteria	-
Notes	-

HW2-PR2	Hardware integration verification
Clause	Project shall integrate electronic hardware blocks into the electronics hardware sub-system(s) and shall verify the related integrity.
Elaboration(s)	The electronic Integration activity addresses the integration and the related integration verification of the electronic hardware blocks. It typically includes the following steps: - Perform visual inspection - Automatic check - Perform electrical sanity test on PCBA - Smoke testing LINKS TO ISO 26262 Requirement(s): ISO 26262-5:2011, clause 10 LINKS TO APQP Requirement(s): -
Tip(s)	-
Tailoring Criteria	Not applicable for semiconductor development.
Notes	-

HW2-PR3	Perform HW Validation
Clause	Perform electronic HW tests at electronic sub-system level.
Elaboration(s)	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 26262-5:2011, clause 10 LINKS TO APQP Requirement(s): -
Tip(s)	-
Tailoring Criteria	This activity can be performed at system level.
Notes	Refer to SY2-PR1 for general notes on requirement specification.

Governance Requirements:

HW2-GR1	Ensure suitable skills for Hardware Testing
Clause	Personnel allocated to hardware testing activities shall hold adequate technical skills.
Elaboration(s)	Demands in terms of personnel's skills, training and expertise to deploy to hardware testing activities as well as to use and optimize related tools are identified. Personnel holding the needed skill, knowledge and expertise is allocated to relevant activities.
Tip(s)	A data base of personnel skills and training profiles is beneficial.
Tailoring Criteria	-
Notes	-

HW2-GR2	Determine HW testing strategy
Clause	A strategy for the analysis (see HW3 process), integration, verification and validation of the hardware sub-systems shall be defined and documented.
Elaboration(s)	Definition of the strategy 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 - Functional safety Testing - Interface Testing - Performance Testing - 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 strategy for the several project phases in accordance with project and quality objectives. Default regression strategy is full regression.
Tip(s)	Involve designers in the strategy definition in order to reach better validation effectiveness.
Tailoring Criteria	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:

HW2-TR1	Automation support for HW testing
Clause	Deploy automation validation means as appropriate
Elaboration(s)	Automated testing facilitates 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.
Tip(s)	-
Tailoring Criteria	-
Notes	-

Output Work Products:

HW2-OWP1	Characterization Report(s)
Expected Contents	Its content includes: - Summary results - List of test performed - Identification of the HW block and main features - Detailed test results
Notes	**HW2-PR1**

HW2-OWP2	Electronic HW Integration Report
Expected Contents	Its content includes: - Summary results - List of test performed - Identification of the integrated HW sub-system
Notes	Not applicable for semiconductor development. **HW2-PR2**

HW2-OWP3	Electronic HW Validation Strategy
Expected Contents	Its content includes: - Test environment - Test tools - Test techniques - Test risks - Regression strategy - Test resources - Set of tests to perform
Notes	**HW4-GR2**

HW2-OWP4	Electronic HW Validation Specification
Expected Contents	Its content includes: - Test settings - Test procedures - Pass/fail criteria - Test chains
Notes	**HW2-PR3**

HW2-OWP5	Electronic HW Validation Report
Expected Contents	Its content includes: - Summary results

	- Test results - Link to logs
Notes	**HW2-PR3**

HW2-OWP6	Review report of electronic HW validation specification
Expected Contents	Its content includes: - Reviewers - Review summary results - Design review criteria - Review findings
Notes	**HW2-PR3**

HW2-OWP7	Traceability data
Expected Contents	Its content includes: - Link to HW requirements (forward and backward)
Notes	**HW2-PR3**

Process Exit Criteria:

1. The electronic hardware sub-system is integrated and functionally validated.

3.2.3 HW.3 – Electronic Hardware Dependability Evaluation and Verification

Context of the process:

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

Process Entry Criteria:

- Availability of consolidated electronic hardware design

Input Work Products:

- Hardware Requirements
- Hardware Design
- Hardware BoM

Additional relevant inputs are:

- System Requirements
- System Design

Process Requirements:

HW3-PR1	Review electronic hardware design
Clause	A set of design reviews shall be conducted along the project to make sure that the design is correct.
Elaboration(s)	An electronic design Review is a formal 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 26262-5:2011, clause 7.4.4 LINKS TO APQP Requirement(s): Design verification, design review
Tip(s)	1. Plan at least for: - Preliminary design review - Critical design review
Tailoring Criteria	The review techniques that can be considered are: - Walkthrough - Inspection - simulation
Notes	-

HW3-PR2	Perform DFMEA on electronic hardware sub-system
Clause	Develop FMEA analysis at component level or design level as appropriate
Elaboration(s)	The objective of this requirement is 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 electronic hardware. LINKS TO ISO 26262 Requirement(s): ISO 26262-5:2011, clause 7.4 LINKS TO APQP Requirement(s): DFMEA
Tip(s)	1. FMEA instead of FMECA technique is not recommended.
Tailoring Criteria	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 applied in accordance with ISO 26262

HW3-PR3	Perform HW simulation
Clause	The project shall make use of functional and electrical simulations to corroborate the electronic design.
Elaboration(s)	The exploitation of simulation approaches to better design the system is strongly beneficial to design improvement.

	LINKS TO ISO 26262 Requirement(s): ISO 26262-5:2011, clause 7.4 LINKS TO APQP Requirement(s): Design verification
Tip(s)	-
Tailoring Criteria	-
Notes	-

Governance Requirements:

HW3-GR1	Ensure suitable skills for dependability evaluation
Clause	Personnel allocated to hardware dependability evaluation activities shall hold adequate technical skills.
Elaboration(s)	Demands in terms of personnel's skills, training and expertise to deploy hardware dependability evaluation activities as well as to use and optimize related tools are identified. Personnel holding the needed skill, knowledge and expertise is allocated to relevant activities.
Tip(s)	A data base of personnel skills and training profiles is beneficial.
Tailoring Criteria	-
Notes	-

Technological Requirements:

HW3-TR1	Use simulation and/or dependability analysis tools as appropriate
Clause	The project shall make use of state of the art simulations tools to perform in depth analysis for electric/electronic aspects.
Elaboration(s)	The exploitation of simulation tools is key to achieve high-quality.
Tip(s)	-
Tailoring Criteria	-
Notes	PSPICE suite is an example.

Output Work Products:

HW3-OWP1	Electronic HW design review report
Expected Contents	Its content includes: - Reviewers - Review summary results - Design review criteria - Review findings
Notes	**HW3-PR1**

HW3-OWP2	Electronic HW DFMEA
Expected Contents	Its content includes: - Failure mode analysis of HW components - Impact analysis on external environment
Notes	**HW3-PR2**

HW3-OWP3	Electronic HW Simulation Report(s)
Expected Contents	Its content includes: - Summary results - List of the performed simulations - Link Log data.
Notes	**HW3-PR3, HW3-TR1**

Process Exit Criteria:

1. The verification of the hardware design is proved robust according to the performed analysis.

3.2.4 HW.4 – ECU Housing Mechanics Engineering

Context of the process:

The ECU itself typically consists of a Printed Circuit Board (PCB) and Input/output (I/O) connectors inside a mechanical enclosure or housing.

Housing mechanics engineering process addresses the main process requirements that development of the ECU housing needs to satisfy.

Process Entry Criteria:

- Availability of consolidated system design

Input Work Products:

- System Requirements
- System Design

Additional relevant inputs are:

- Mechanical design of similar projects
- Start of the art for the specific mechanical development

Process Requirements:

HW4-PR1	Determine mechanical requirements for ECU housing
Clause	Document and analyze functional and non-functional requirements allocated to the mechanical sub-system(s).
Elaboration(s)	Non-functional requirements may include material, production, maintenance, logistic, packaging, costs, testing
Tip(s)	-
Tailoring Criteria	Mechanical requirements can be expressed at system level.
Notes	-

HW4-PR2	Determine mechanical design of the ECU housing sub-system.
Clause	Document the design of mechanical sub-system(s). The design shall be submitted to a formal review.
Elaboration(s)	The design of mechanical sub-system(s) shall address in detail the structural design as well as the interfaces (internal and external). DFMA shall be used in the design process. Mechanical design shall allocate the related requirements.
Tip(s)	Co-design with electronic HW development is needed. Make sure appropriate versioning is applied.
Tailoring Criteria	-
Notes	-

HW4-PR3	Analyze and verify the mechanical design.
Clause	The project shall conduct a set of analysis on the mechanical sub-system(s) as appropriate to ensure the soundness of the mechanical design.
Elaboration(s)	Examples of technical analysis include, but are not limited to: - FEA (Finite Element Analysis) - CFD (Computational Fluid Dynamics) analysis - MBD (Multi-body Dynamic) analysis Mechanical design shall undergo a DFMEA.
Tip(s)	-
Tailoring Criteria	-
Notes	-

HW4-PR4	Validation of the mechanical components.
Clause	The project shall conduct mechanical inspection and/or test on components to verify

	the respect of the design.
Elaboration(s)	External designed components shall be qualified according to a documented and approved procedure performed by the supplier.
Tip(s)	Testing can be performed also by virtual means.
Tailoring Criteria	-
Notes	-

HW4-PR5	Validation of the mechanical sub-system(s).
Clause	The project shall validate the mechanical sub-system(s) against the specified mechanical design and/or requirements.
Elaboration(s)	Validation at mechanical level may include: - Dimensional validation - Assembly procedures - Material checks
Tip(s)	-
Tailoring Criteria	Validation of the ECU housing function is complemented by tests performed at system validation level (e.g. heat dissipation, IP protection).
Notes	-

Governance Requirements:

HW4-GR1	Ensure suitable skills for mechanical development activities
Clause	Personnel allocated to mechanical development activities shall hold adequate technical skills.
Elaboration(s)	Demands in terms of personnel's skills, training and expertise to deploy mechanical development activities as well as to use and optimize related tools are identified. Personnel holding the needed skill, knowledge and expertise is allocated to software unit verification activities.
Tip(s)	A database of personnel skills and training profiles is beneficial.
Tailoring Criteria	-
Notes	-

HW4-GR2	Trusted suppliers' selection
Clause	Identify, maintain a list of trusted suppliers of mechanical components and material for ECU housing sub-system.
Elaboration(s)	Criteria for identification of trusted suppliers are defined as well as organizational responsibilities to manage the suppliers.
Tip(s)	Effective link with corporate procurement is highly beneficial.
Tailoring Criteria	-
Notes	Supplier must maintain a documented quality system to ensure control and conformance to the requirements of drawings and specifications.

Technological Requirements:

HW4-TR1	CAD (Computer Aided Design) support
Clause	Deploy CAD tools as appropriate.
Elaboration(s)	Effective mechanical design shall be supported by tools aligned with the state of the art
Tip(s)	Integration with electronic hardware design tools is highly beneficial.
Tailoring Criteria	-
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.

HW4-TR2	CAE (Computer Aided Engineering) support.
Clause	Deploy CAE as appropriate in order to converge towards a correct and robust design.
Elaboration(s)	CAE tools shall support: - Calculation - Simulation - FEA - CFD analysis - MBD analysis - And other analysis as appropriate
Tip(s)	-
Tailoring Criteria	-
Notes	-

Output Work Products:

HW4-OWP1	Mechanical Requirements
Expected Contents	Its content includes the following type of requirements: - Functional - Safety - Technical - Performance - Quality
Notes	**HW4-PR1**

HW4-OWP2	2D Drawings
Expected Contents	Its content includes: - Geometrics characteristics - Tolerances specs - Special characteristics
Notes	**HW4-PR2**

HW4-OWP3	3D Drawings
Expected Contents	Its content includes: - Geometrics characteristics - Cinematic capability - Show/hide mode
Notes	**HW4-PR2**

HW4-OWP4	Mechanical Analysis Report(s)
Expected Contents	Its content includes: - Summary results (including applied checks according to the) - Analysis results
Notes	**HW4-PR3**

HW4-OWP5	Mechanical BoM
Expected Contents	Its content includes: - All involved mechanical part numbers organized in hierarchical mode
Notes	**HW4-PR2, HW4-GR2**

HW4-OWP6	Inspection Report(s)

Expected Contents	Its content includes: - Summary results (including applied checklist) - Inspection results Also called FAI (First Article Inspection) report
Notes	**HW4-PR4, HW4-PR5**

HW4-OWP7	Component Mechanical Test Report(s)
Expected Contents	Its content includes: - Summary results (including DUT identification) - Test case results - Link to log - Tester
Notes	Required formally for main mechanical components. **HW4-PR4**

HW4-OWP8	Sub-system Mechanical Test Report
Expected Contents	Its content includes: - Summary results (including DUT identification) - Test case results - Link to log - Tester
Notes	**HW4-PR5**

HW4-OWP9	DFMEA
Expected Contents	Its content includes: - Failure mode analysis of mechanical components - Impact analysis on external environment
Notes	**HW4-PR3**

HW4-OWP10	Design Review report
Expected Contents	Its content includes: - Reviewers - Review summary results - Design review criteria - Review findings
Notes	**HW4-PR2**

Process Exit Criteria:

1. Mechanics sub-system for ECU housing is ready for integration and testing at system level

3.2.5 HW.5 – Actuation Mechanics Engineering

Context of the process:

Sensoring and actuation mechanics engineering is a composite process that encompasses the related activities for designing the actuation sub-system(s) of a system with actuation needs.

Sensors and actuators are two critical classes of components of automotive mechatronics system that are based on several and distinct physics branches:

- Mechanics
- Optics
- Acoustics
- Thermal
- Fluid-dynamics.

Leveraging the specific needs of these disciplines, the PISA Model intends to provide a set of requirements (process, governance and technical) for the projects organization.

Process Entry Criteria:

- Availability of consolidated system design

Input Work Products:

- System Requirements
- System Design

Additional relevant inputs are:

- Mechanical design of similar projects
- Start of the art for the specific mechanical development

Process Requirements:

HW5-PR1	Determine actuation mechanical requirements.
Clause	Document and analyze functional and non-functional requirements allocated to the actuation mechanical sub-system(s).
Elaboration(s)	Non-functional requirements may include material, production, maintenance, logistic, packaging, costs, testing
Tip(s)	
Tailoring Criteria	Mechanical requirements can be expressed at system level.
Notes	-

HW5-PR2	Determine actuation mechanical design.
Clause	Document the design of actuation mechanical sub-system(s). The design shall be submitted to a formal review.
Elaboration(s)	The design of mechanical sub-system(s) shall address in detail the structural design as well as the interfaces (internal and external). DFMA shall be used in the design process. Mechanical design shall allocate the related requirements.
Tip(s)	-
Tailoring Criteria	-
Notes	-

HW5-PR3	Analyze and verify the actuation mechanical design.
Clause	The project shall conduct a set of analysis on the actuation mechanical sub-system(s) as appropriate to ensure the soundness of the actuation mechanical design.
Elaboration(s)	Examples of technical analysis include, but are not limited to: - Thermal analysis - CFD (Computational Fluid Dynamics) analysis - MBD (Multi Body Dynamics) analysis Mechanical design shall undergo a DFMEA.
Tip(s)	-
Tailoring Criteria	-
Notes	-

HW5-PR4	Validation of the mechanical components.
Clause	The project shall conduct inspections and/or mechanical test on components to verify the respect of the design.

Elaboration(s)	External designed components shall be qualified according to a documented and approved procedure performed by the supplier.
Tip(s)	Testing can be performed also by virtual means.
Tailoring Criteria	-
Notes	-

HW5-PR5	Validation of the actuation mechanical sub-system(s).
Clause	The project shall validate the mechanical sub-system(s) against the specified mechanical requirements.
Elaboration(s)	Validation at mechanical level may include: - Dimensional validation - Assembly procedures Material checks
Tip(s)	-
Tailoring Criteria	Validation of the ECU housing function is complemented by tests performed at system validation level (e.g. heat dissipation, IP protection).
Notes	-

Governance Requirements:

	HW5-GR1	Ensure suitable skills for mechanical development activities related to sensoring and actuation
Clause		Personnel allocated to mechanical development activities shall hold adequate technical skills.
Elaboration(s)		Demands in terms of personnel's skills, training and expertise to deploy mechanical development activities as well as to use and optimize related tools are identified. Personnel holding the needed skill, knowledge and expertise is allocated to software unit verification activities.
Tip(s)		A database of personnel skills and training profiles is beneficial.
Tailoring Criteria		-
Notes		-

Technological Requirements:

HW5-TR1	CAD support
Clause	Deploy CAD tools as appropriate.
Elaboration(s)	Effective mechanical design shall be supported by tools aligned with the state of the art
Tip(s)	Integration with electronic hardware design tools is highly beneficial.
Tailoring Criteria	-
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.

HW5-TR2	CAE support.
Clause	Deploy CAE as appropriate in order to converge towards a correct and robust design.
Elaboration(s)	CAE tools shall support: - Calculation - Simulation - FEA - CFD analysis - MBD analysis - And other analysis as appropriate
Tip(s)	-
Tailoring Criteria	-
Notes	-

Output Work Products:

HW5-OWP1	Mechanical Requirements
Expected Contents	Its content includes the following type of requirements: - Functional - Safety - Technical - Performance - Quality
Notes	**HW5-PR1**

HW5-OWP2	2D Drawings
Expected Contents	Its content includes: - Geometrics characteristics - Tolerances specs - Special characteristics
Notes	**HW5-PR2**

HW5-OWP3	3D Drawings
Expected Contents	Its content includes: - Geometrics characteristics - Cinematic capability - Show/hide mode
Notes	**HW5-PR2**

HW5-OWP4	Traceability data
Expected Contents	Forward and Backward traceability from design to Mechanical requirements
Notes	**HW5-PR2**

HW5-OWP5	Review report of actuation mechanical requirements.
Expected Contents	Its content includes: - Reviewers - Review summary results - Design review criteria - Review findings
Notes	**HW5-PR1**

HW5-OWP6	Mechanical Analysis Report(s)
Expected Contents	Its content includes: - Summary results (including applied checks according to the) - Analysis results
Notes	**HW5-PR3**

HW5-OWP7	Mechanical BoM
Expected Contents	Its content includes: - All involved mechanical part numbers organized in hierarchical mode
Notes	**HW5-PR2**

HW5-OWP8	Inspection Report(s)
Expected Contents	Its content includes: - Summary results (including applied checklist) - Inspection results Also called FAI (First Article Inspection) report
Notes	**HW5-PR4, HW5-PR5**

HW5-OWP9	Component Mechanical Test Report(s)
Expected Contents	Its content includes: - Summary results (including DUT identification) - Test case results - Link to log - Tester
Notes	Required formally for main mechanical components. **HW5-PR4**

HW5-OWP10	Sub-system Mechanical Test Report
Expected Contents	Its content includes: - Summary results (including DUT identification) - Test case results - Link to log - Tester
Notes	**HW5-PR5**

HW5-OWP11	DFMEA
Expected Contents	Its content includes: - Failure mode analysis of mechanical components - Impact analysis on external environment
Notes	**HW5-PR3**

HW5-OWP12	Design Review report
Expected Contents	Its content includes: - Reviewers - Review summary results - Design review criteria - Review findings
Notes	**HW5-PR2**

Process Exit Criteria:

1. Mechanics sub-system is ready for integration and testing at system level

3.3 Software Engineering Segment 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 Segment are:

- SW1 – Software Requirements Specification
- SW2 – Software Design
- SW3 – Software Production
- SW4 – Software Unit Verification
- SW5 – Software Integration & Validation

TRACEABILITY TO IATF 16949:

The software-engineering segment 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

3.3.1 SW1 – Software Requirements Specification process

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.

Process Entry Criteria:

1. Project requirements at system level available and under configuration management.
2. System design including target hardware environment characteristics

Input Work Products

- Project requirements at system level
- System design

Process Requirements

SW1–PR1	Document software requirements
Clause	Requirements at software level shall be documented and made available to stakeholders.
Elaboration(s)	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. Requirements specification shall be under configuration management. LINKS TO ISO 26262 Requirement(s): ISO 26262-6:2011, clause 6.4.1. ISO 26262-8:2011, clause 6.4. LINKS TO APQP Requirement(s): Engineering specification
Tip(s)	Define rules for software requirements Id. so that some relevant information is derivable by the Id. itself.
Tailoring Criteria	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.
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 (e.g. DNN) software shall be documented.

SW1-PR2	Review software requirements specification
Clause	Software requirements specification shall be reviewed to find out possible defects.
Elaboration(s)	Software requirement specification review shall address both any single requirements and requirement specification. Review of single software requirements shall aim at finding lacks in terms of non-ambiguity, feasibility, testability, atomicity. Review of software requirement specification shall aim at finding lacks in terms of traceability, completeness, and consistency. Compatibility of software requirements with the target hardware environment shall be verified. 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. LINKS TO ISO 26262 Requirement(s): ISO 26262-6:2011, clause 6.4.1, 11.2; ISO 26262-6:2011, clause 9.4. LINKS TO APQP Requirement(s): Design Reviews
Tip(s)	Check-lists are cost-effective, easy, flexible, maintainable means to support software requirements reviews (see SW1-TR2).
Tailoring Criteria	Review technique (e.g. walkthrough, inspection…) shall be tailored according to project needs.
Notes	A software requirements defects is considered a major software requirements 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.

SW1-PR3	Traceability between software requirements and system requirements.
Clause	A complete traceability between software requirements and system requirements shall be demonstrated.

Elaboration(s)	Mechanisms that, given a software requirement, identify the related system requirement(s) shall be available. Mechanisms that, given a system requirement, identify the derived software requirement(s) shall be available. LINKS TO ISO 26262 Requirement(s): ISO 26262-8:2011, clause 6.4.3. LINKS TO APQP Requirement(s):
Tip(s)	Support of requirements management tool for traceability is recommended in the case of complex software requirements specification.
Tailoring Criteria	In the case of platform-based development approach, some software requirements can be derived from platform requirements instead of system requirements. Consequently, the traceability shall be established between platform requirements and related software requirements.
Notes	Traceability mechanism is a key means for conducting impact analysis as well as requirement specification review. See SW4-TR1 for tool support for traceability demonstration.

Governance Requirements:

SW1-GR1	Software requirements change management
Clause	Software requirements changes shall be documented, analysed and approved as appropriate.
Elaboration(s)	Change management workflow for software requirements shall be defined and applied. 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. LINKS TO ISO 26262 Requirement(s): ISO 26262-8:2011, clause 8.4. LINKS TO APQP Requirement(s): Drawing and specification changes
Tip(s)	Software requirement management tool may support the change management procedure.
Tailoring Criteria	In the case of minor software requirement changes, the estimation of the impact of their implementation may be implicit.
Notes	Major software requirement corrective changes are those impacting either on software architectural design, or software detailed design, or interface specifications it is a major corrective change. Otherwise it is a minor corrective change.

SW1-GR2	Ensure suitable skills for software requirements analysis
Clause	Personnel allocated to software requirement analysis and specification activities shall hold adequate technical skills.
Elaboration(s)	Demands in terms of personnel's skills, training and expertise to deploy software requirement analysis and specification activities as well as to use and optimize related tools are identified. Personnel holding the needed skill, knowledge and expertise is allocated to software requirement analysis and specification activities.
Tip(s)	Authority on the software requirement analysis and specification team to be assigned to a senior software engineer. A data base of personnel skills and training profiles is beneficial.

Tailoring Criteria	-
Notes	-

SW1-GR3	Software Change Control Board (CCB)
Clause	The project is supported by dedicated board for change management related to software requirements,
Elaboration(s)	Composition, roles, and workflow shall be defined in the project plan.
Tip(s)	Typically there is only one CCB covering all the aspects of change management across the project.
Tailoring Criteria	In case of small project, the project leader can be main component of the board.
Notes	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.

Technological Requirements:

SW1-TR1	Software requirement management tool
Clause	Use an automatic tool supporting requirements management, documentation, storing, traceability, and classification.
Elaboration(s)	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 (e.g. safety-related requirements, non-functional requirements, …). Guidance on the use of the tool shall be available to stakeholders.
Tip(s)	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 requirements management, issue and tasks management, change management, and task management is suggested. Consider the use of a unique tool for system requirements and software requirements management.
Tailoring Criteria	Spread-sheets (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

SW1-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
	• Identification of software units related to any functional software requirements
	• Reference to applicable standards

Notes	**SW1-PR1**

SW1-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. **SW1-PR2**

SW1-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 **SW1-PR3**

Process Exit Criteria:

- Software requirements are specified and under configuration management
- Software requirements issues are identified and addressed

3.3.2 SW2 – Software Design process

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.

Process Entry Criteria:

1. Availability of specification of external software interfaces
2. Availability of software requirements specification

Input Work Products:

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

Additional relevant inputs are:

- Hardware technical environment characteristics

Process Requirements:

SW2-PR1	Develop high-level software design
Clause	Software design shall be provided in order to represent the software part of the system and its interfaces.
Elaboration(s)	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, SysML) - informal notations 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 strategy can be equated to high-level design. LINKS TO ISO 26262 Requirement(s): ISO 26262-6:2011, clause 6.4.1, 11.2; ISO 26262-6:2011, clause 9.4. LINKS TO APQP Requirement(s): Engineering Drawings
Tip(s)	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. To address software design dynamic aspects, the use of graphical notation is

	profitable.
Tailoring Criteria	High-level design can be expressed as collection of separate work-product, documental and electronic.
Notes	AUTOSAR provides a set of specifications that builds a common design methodology based on standardized exchange format.

SW2-PR2	Develop low-level software design
Clause	Each software unit shall be associated with a low-level design specification that is instrumental to develop or generate the software.
Elaboration(s)	Detailed design is the process of defining the lower level components, units and interfaces of the software. 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 26262-6:2011, clause 6.4.1, 11.2; ISO 26262-6:2011, clause 9.4. LINKS TO APQP Requirement(s): Engineering Drawings
Tip(s)	Avoid over design specification and focus on project complexities.
Tailoring Criteria	Reverse engineering from source code is acceptable in presence of adequate coding guidelines.
Notes	-

SW2-PR3	Software requirements allocation
Clause	Software requirements shall be allocated to software units/components
Elaboration(s)	Mechanisms that, given a software requirement, identify the related software unit shall be available. Mechanisms that, given a software unit, identify the related software requirement(s) shall be available. In the case of a layered software design a mechanism to allocate software requirements to software components shall be available. Verification of complete allocation of software requirements to software units/components shall be made. LINKS TO ISO 26262 Requirement(s): ISO 26262-8:2011, clause 6.4.3

	LINKS TO APQP Requirement(s): Engineering Drawings
Tip(s)	Support of requirements management tool for traceability is recommended in the case of complex software requirements specification. In the case of model-based software development: the process of deriving source code from models can be considered as a software design process. In that case the elaborations of this requirement apply to models.
Tailoring Criteria	The abstraction level at which the traceability shall be established can be tuned in accordance to project needs and characteristics. Default is software requirement(s) to and back from software unit(s).
Notes	The requirements allocation involves both functional and non-functional software requirements.

SW2-PR4	Design review
Clause	A set of design reviews shall be conducted along the project to make sure that the design is correct.
Elaboration(s)	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 - Critical design review The review techniques that can be considered are: - Walkthrough - Inspection LINKS TO ISO 26262 Requirement(s): ISO 26262-4:2011, clause 7.4.8 LINKS TO APQP Requirement(s): Design verification, design review
Tip(s)	Exploitation of simulation, testing of prototypes is recommended.
Tailoring Criteria	None specific
Notes	Software design simulation techniques are valid means for design review.

Governance Requirements:

SW2-GR1	Ensure suitable skills for software design activities
Clause	Personnel allocated to software design activities shall hold adequate technical skills.
Elaboration(s)	Demands in terms of personnel's skills, training and expertise to deploy software design activities as well as to use and optimize related tools are identified. Personnel holding the needed skill, knowledge and expertise is allocated to software design activities.
Tip(s)	Authority on the software design team to be assigned to a senior software engineer. A data base of personnel skills and training profiles is beneficial.
Tailoring Criteria	-
Notes	Special care is to be devoted to technical skills necessary to effectively use software modeling and automatic code generation tool chain, in the case of model-based software development.

SW2-GR2	Define software design objectives
Clause	Software design related objectives shall be defined
Elaboration(s)	Design for re-use is a basic objective to be addressed. Design for reuse objective can be addressed by emphasizing functional modularity in a software design. 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.
Tip(s)	-
Tailoring Criteria	Metrics target values may vary according to project-specific characteristics and constraints.
Notes	The elaborations of this Governance Requirement are valid both software units developed manually and for software units derived automatically from models. Compliance with AUTOSAR software reference architecture is not mandatory. Compliance with AUTOSAR could be necessary in the case of customer request or project constraints.

Technological Requirements:

SW2-TR1	Automatic support for software design
Clause	Apply software design graphical specification tool(s).
Elaboration(s)	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.
Tip(s)	Software design graphical specification is usually a feature of software modeling and automatic code generation environment. Therefore, consider the SWE2-TR1 and SWE2-TR2 jointly in the case of model-based software development approach.
Tailoring Criteria	In the case of model-based software development, this technological requirement is to be considered covered by the SW2-TR2 requirement.
Notes	-

SW2-TR2	Automatic support for software modeling and simulation
Clause	Suitable software modeling and automatic code generation tool chain is applied.
Elaboration(s)	In the case of model-based software development, a tool chain allowing model construction and automatic code generation is selected, setup and used.
Tip(s)	Consider that some environments for modeling, prototyping, verification and automatic code generation are able to support AUTOSAR compliance.
Tailoring Criteria	-
Notes	This requirement is applicable only in the case of model-based software development approach.

Output Work Products:

SW2-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
Notes	In the case of model-based software development, the expected contents are the same. **SW2-PR1, SW2-GR2, SW2-TR1**

SW2-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	**SW2-PR2, SW2-TR1**

SW1-OWP3	Software design review report
Expected Contents	Review record includes: • Review objectives • Reviewers identification • Review results
Notes	**SW2-PR3**

SW2-OWP4	Traceability data
Expected	The traceability between software requirements and software components/units.

Contents	Demonstration of complete traceability.
Notes	Software requirements support tools implement traceability and help demonstration of completeness. **SW2-PR4**

Process Exit Criteria:

1. The identification of software components, their relationships and interfaces is completed.
2. The identification of software units, their relationships and internals is completed.
3. Dynamic behavior of the software is defined.
4. The traceability of software requirements with software units/components is completed.

3.3.3 SW3 – Software Production process

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.

Process Entry Criteria:

1. Availability of stable development environment
2. Availability of representative hardware target environment
3. Availability of software requirements specification
4. Availability of a complete specification of software unit interfaces.

Input Work Products

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

Process Requirements

SW3-PR1	Software unit development
Clause	Develop source code of software unit according to the low-level software design constraints and software requirements.
Elaboration(s)	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. SW2). Source code shall be compliant with code style guidelines in order to assure its readability and maintainability (ref. SW3-GR2). Source code style guidelines shall be applied both to source code developed manually and generated automatically. LINKS TO ISO 26262 Requirement(s): ISO 26262-6:2011, clause 8.4.4. LINKS TO APQP Requirement(s): -
Tip(s)	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 Criteria	-
Notes	The software unit source code can be developed manually or generated automatically.

SW3-PR2	Build software from software units
Clause	The software shall be built from software units according to a defined process.
Elaboration(s)	- LINKS TO ISO 26262 Requirement(s): ISO 26262-6:2011, clause 8.4.5. LINKS TO APQP Requirement(s):
Tip(s)	-
Tailoring Criteria	-
Notes	-

SW3-PR3	Configuration and Calibration development
Clause	Calibration parameters and calibration data shall be identified, defined and implemented as per design.
Elaboration(s)	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 calibration parameters and calibration data shall be identified and maintained. Default value shall be assigned as per design. LINKS TO ISO 26262 Requirement(s): ISO 26262-6:2011, clause C.4. LINKS TO APQP Requirement(s):
Tip(s)	Consider the use of a calibration tool in the case of relevant number of calibration parameters.
Tailoring Criteria	SW3-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

SW3-GR1	Source directives and data objectives defined
Clause	Software unit related objectives shall be defined
Elaboration(s)	Structural objectives for software units shall be established. Possible structural objectives for software units are: cyclomatic complexity metrics, length in terms of lines of code, comment density. MISRA C/C++/Modeling rules to apply shall be identified when appropriate.
Tip(s)	Other source code objectives may be: no unreachable branches, limited number of global variables.
Tailoring Criteria	Metrics target values may vary according to project-specific choices.
Notes	The elaborations of this Governance Requirement are valid both software units developed manually and for software units derived automatically from models.

SW3-GR2	Assure suitable skills for software development
Clause	Personnel allocated to Software Construction shall hold adequate technical skills
Elaboration(s)	Demands in terms of personnel's skills, training and expertise to deploy Software Construction activities as well as to use and optimize related tools and software development environment are identified. Personnel holding the needed skill, knowledge and expertise is allocated to software development activities.
Tip(s)	Authority on the software development team to be assigned to a senior testing engineer. A database of personnel skills and training profiles is beneficial.
Tailoring Criteria	-
Notes	Specific different skills are requested for manual software development and for model-based software development

Technology Requirements

SW3-TR1	Software development environment
Clause	Software development environment and related supporting tools are identified, setup, and used.
Elaboration(s)	In the case of software units developed manually, software development environment is identified. In particular configuration parameters, set up and version of the used compiler are identified and recorded. 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 and recorded.
Tip(s)	Use state-of-the-art tools and development environment.
Tailoring Criteria	-
Notes	-

SW3-TR2	Software version management
Clause	Software elements and software units are maintained under configuration management
Elaboration(s)	See process SU1 – Configuration Management
Tip(s)	-
Tailoring Criteria	-
Notes	-

Output Work Products

SW3-OWP1	Software unit(s)
Expected Contents	• source code, models and data • building instructions • executable code
Notes	It may include readme.txt file to track implementation changes and notes as appropriate

Process Exit Criteria:

1. software units are developed and available
2. software unit are under configuration control

3.3.4 SW4 – Software Unit Verification process

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.

Process Entry Criteria:

- Availability of stable Software Units development increments – this means that the SW Units to be verified shall not be necessary complete from functional point of view.
- Software Units under configuration management.

Input Work Products:

- Software Units Design Specification
- Software Units

Additional relevant inputs are:

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

Process Requirements:

SW4-PR1	Perform MISRA C/C++ Check
Clause	Source code shall be verified in respect to MISRA C/C++ compliance.
Elaboration(s)	MISRA C/C++ guidelines [6][7] 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 [9]. Reference versions are: • MISRA C:2012, • MISRA C++:2008 LINKS TO ISO 26262 Requirement(s): ISO 26262-6:2011, clause 8.4.4. LINKS TO APQP Requirement(s):
Tip(s)	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 Criteria	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
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).

SW4-PR2	Perform Software Units Structural Metrics Check
Clause	Measurements of the structure of source code shall be obtained
Elaboration(s)	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
Tip(s)	Several commercial and freeware tools are available.
Tailoring Criteria	Additional source code metrics can be calculated: - Number of Function Input Parameters (NFIP) - Function Fan-In/Fan-Out
Notes	-

SW4-PR3	Conduct Software Units Analysis
Clause	Perform human analysis of the source code
Elaboration(s)	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. Software units analysis can be performed by either walkthrough or by code inspection. LINKS TO ISO 26262 Requirement(s): ISO 26262-6:2011, clause 8.4.5. LINKS TO APQP Requirement(s):

Tip(s)	For hand-written code, there is availability of tools that feature the capability of associating the review output conveniently to the source code.
Tailoring Criteria	Source code inspections may be limited to critical software parts. Source code inspections may be limited according to the software reuse strategy.
Notes	-

SW4-PR4	Conduct Software Unit Testing
Clause	Software unit testing shall be performed in accordance to the SW Unit Testing strategy in order to demonstrate that the software units fulfill its design specifications and its functional requirements.
Elaboration(s)	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 26262-6:2011, clause 9.4. LINKS TO APQP Requirement(s):
Tip(s)	Test records may be provided by testing tools
Tailoring Criteria	For safety-critical software units ISO 26262 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:

SW4-GR1	Ensure suitable skills for SW Unit Verification
Clause	Personnel allocated to Software Unit Verification activities shall hold adequate technical skills.
Elaboration(s)	Demands in terms of personnel's skills, training and expertise to deploy Software Unit Verification activities as well as to use and optimize related tools are identified. Personnel holding the needed skill, knowledge and expertise is allocated to software unit verification activities.
Tip(s)	Authority on the software unit verification team to be assigned to a senior testing engineer. A data base of personnel skills and training profiles is beneficial.
Tailoring Criteria	-
Notes	-

SW4-GR2	Define Software Unit Static Analysis Strategy
Clause	A strategy for the Software Unit Static Analysis shall be defined and documented.
Elaboration(s)	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 unit.
Tip(s)	Tailoring of MISRA rules shall maintain the whole set of "mandatory" rules at least for the final release of software.
Tailoring Criteria	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 strategy may be defined without a formal document.
Notes	-

SW4-GR3	Define Software Unit Testing Strategy
Clause	A strategy for the performance of software unit testing shall be defined and documented
Elaboration(s)	Software Unit testing strategy 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 strategy 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).
Tip(s)	The rigor of software unit testing may be growing with software increments
Tailoring Criteria	In the case of Model-based software developments the software Unit Testing Strategy shall address the use of Model-in-the-Loop (MIL) technique. In the case of Agile software development approach the strategy may be defined without a formal document.
Notes	-

Technological Requirements:

SW4-TR1	Deploy Effective Static Analyzer
Clause	MISRA C/C++ checking and structural metrics calculation shall be performed according to means aligned to the technological state-of-the-art.
Elaboration(s)	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.
Tip(s)	Set up the tool in order to calculate and store statistics and measurements [M4]
Tailoring Criteria	-
Notes	-

SW4-TR2	Deploy Effective Software Unit Testing Environment
Clause	Unit testing shall be supported by automatic tools
Elaboration(s)	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.
Tip(s)	-
Tailoring Criteria	In the case of Model-based software development the Software Unit Testing Environment includes Model-in-the-Loop (MIL) tools
Notes	-

Output Work Products:

SW4-OWP1	Software Unit Verification Strategy
Expected Contents	The strategy 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	**SW4-GR2, SW4-GR3**

SW4-OWP2	Software Units Static Analysis Report
Expected Contents	Results of software unit analyses executed (MISRA, metrics, 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. **SW4-PR1, SW4-PR2, SW4-PR3**

SW4-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. **SW4-PR4**

Process Exit Criteria:

1. The verification of the Software Units is completed according to the defined strategies.
2. Identified issues are documented and injected to the next software development iterations.

3.3.5 SW5 – Software Integration and Validation process

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.

Process Entry Criteria:

- Software units developed and verified.
- Software interfaces specified

Input Work Products

- Software requirements
- Software design
- Software units

Process Requirements

SW5-PR1	Verify integrated software components
Clause	Software units shall be integrated in order to compose consistent software entities, verification shall be performed at each software integration step.
Elaboration(s)	Integration of software units shall proceed according to the 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 26262-6:2011, clause 10.4. LINKS TO APQP Requirement(s):
Tip(s)	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 Criteria	-
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.

SW5-PR2	Software behaviour validation
Clause	Integrated software shall be tested against software requirements.
Elaboration(s)	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 assure compliance with software requirements. 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 26262-6:2011, clause11.4. LINKS TO APQP Requirement(s):

Tip(s)	Test cases can benefit from developers know-how to target complex situations that are not clear to testers.
Tailoring Criteria	Early software releases can be tested with limited formality (if acceptable for the final customer).
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.

SW5-PR3	Test cases traceability
Clause	Traceability of validation test cases to software requirements shall be provided.
Elaboration(s)	Back and forth traceability links are expected.
Tip(s)	Support of requirements management tool for traceability is recommended in the case of complex software requirements specification.
Tailoring Criteria	-
Notes	-

Governance Requirements:

SW5-GR1	Software Validation Strategy
Clause	A strategy for the performance of software validation shall be defined and documented
Elaboration(s)	Software Validation Testing strategy 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 strategy provides: - Software Integration objectives and approach
Tip(s)	Software validation strategy 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 Criteria	-
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

SW5-GR2	Ensure suitable skills for software validation activities
Clause	Personnel allocated to software validation activities shall hold adequate technical skills.
Elaboration(s)	Demands in terms of personnel's skills, training and expertise to deploy software validation activities as well as to use and optimize related tools are identified. Personnel holding the needed skill, knowledge and expertise is allocated to software validation activities.
Tip(s)	Authority on the software validation team to be assigned to a senior testing engineer. A data base of personnel skills and training profiles is beneficial.
Tailoring Criteria	-
Notes	-

Technological Requirements

SW5-TR1	Software Testing Environment
Clause	Software testing shall be conducted in an effective and productive environment.
Elaboration(s)	Automatic tools supporting software integration testing according to the software integration strategy shall be available. Test harnesses for software integration testing (e.g. driver and stubs) shall be integrated in the test environment when necessary. Automatic tools supporting software validation according to the software validation strategy shall be available.
Tip(s)	-
Tailoring Criteria	In the case of Model-based software development the Environment may include Model-in-the-Loop (MIL) and Software-in-the-loop SIL settings.
Notes	-

SW5-TR2	Automated software testing support
Clause	Tools and test environments shall be made available and setup in order to perform automatic tests execution by means of test scripts
Elaboration(s)	Tool for automatic testing execution (both at integration and verification level) shall allow, script management, test execution, test log generation.
Tip(s)	Focus on: - automatic log retrieval from testing execution - modular approach in the setup of test-bench, with particular reference to the test software
Tailoring Criteria	-
Notes	-

Output Work Products

SW5-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 strategy - degree of independence of testers - test environment requirements - test deliverables - responsibility assignment - tool to be used for software testing (integration and validation)
Notes	**SW5-GR1, SW5-TR1**

SW5-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	**SW5-PR1, SW5-PR2**

SW5-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.)
Notes	The possibility to merge testing report and test specification can be considered. **SW5-PR1, SW5-PR2**

SW5-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. **SW5-PR1, SW5-PR2, SW5-TR1**

SW5-OWP5	Traceability data
Expected Contents	The traceability between software requirements and software tests. The traceability between software integration test cases and software design components. Demonstration of complete traceability.
Notes	Software requirements support tools implementing traceability and help demonstration of completeness. **SW5-PR3**

Process Exit Criteria:

- Software requirements are verified by executed tests
- Traceability between software requirements and software test cases is complete

3.4 Management Segment Processes

In the context of PISA Model, Management segment 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 System Engineering Technical Segment are:

- MG1 – Program Management
- MG2 – Project and Risk Management
- MG3 – Technical Supervision
- MG4 – Quality and Improvement Management

TRACEABILITY TO IATF 16949:

The project management segment 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

3.4.1 MG1 – Program Management process

Context of process:

Program management deals with managing several related projects with the aim of optimizing resources, coordinating practices, and take initiatives for improving organization's performance.

Process Entry Criteria:

- Program development in place

Input Work Products

- Corporate program objectives
- Corporate organizational chart

Process Requirements

MG1-PR1	Program planning
Clause	Program scope and objectives shall be defined.
Elaboration(s)	Define program scope by identifying all the projects and activities belonging to the program. The criteria to include a project into the scope of a program shall be defined as well. Define program 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 program objectives.
Tip(s)	Establishing a program office (with more than one program manager) to support the programs development. Defining the organizational interfaces among projects.
Tailoring Criteria	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.
Notes	Criteria to define the scope of a program are a combination of technical (e.g. project aimed at producing technically similar product), organizational (i.e. projects using common resources and involving same people), and business (i.e. benefits can be achieved because synergies or dependencies among projects) elements.

MG1-PR2	Program control
Clause	Continuous program progress monitoring and control shall be deployed
Elaboration(s)	Control and monitoring activities shall be performed regularly in order to verify the status of the program and to identify improvement opportunities and risks. Proper data from projects belonging to the program shall be collected, elaborated and maintained. Data elaboration shall allow to exploit economies of scale and to reduce coordination costs and risks. Data and trends shall be effectively made available to stakeholders.
Tip(s)	Program management might need to deal with interdependencies, conflicts and resource or knowledge sharing among the projects it manages. Take care of establish effective communication channels between program manager and project managers. Define a cockpit chart to allow the project manager an easy control of program status and trends based on collected data.

	Possible improvement opportunities due to interdependencies, conflicts, and resource or knowledge sharing among project shall be identified on the basis of the collected data.
Tailoring Criteria	-
Notes	-

MG1-PR3	Interaction with external and internal customers
Clause	Program manager shall interact on a regular basis and on demand with defined stakeholders to streamline program and project activities.
Elaboration(s)	Typical involved parties include, but are not limited to customer, production and validation managers, quality manager, suppliers. Interactions happen in shape of: - Meetings - Conference calls - E-mails Outcomes of such interactions shall be documented or shall lead to the update of existing work-products.
Tip(s)	Interfacing with customer(s) is typically supported by project staff as appropriate.
Tailoring Criteria	-
Notes	-

Governance Requirements

MG1-GR1	Provide commitment for program management
Clause	Program management responsible shall receive commitment
Elaboration(s)	Responsibility for program management activities shall be assigned. Program management responsible shall receive commitment and authority.
Tip(s)	Setup of a program office (whose responsibility is to oversee the development of an organization's programs) is highly beneficial
Tailoring Criteria	-
Notes	-

Technological Requirements

MG1-TR1	Project data collection, sync and analysis tool
Clause	Use an automatic tool supporting data collection on resources usage and synchronization.
Elaboration(s)	The program measurement support tool shall be able to make available to stakeholders the data collected and data aggregates.
Tip(s)	Dashboard capabilities provided by an integrated platform may be very useful to program management.
Tailoring Criteria	-
Notes	-

Output Work Products

MG1-OWP1	Program plan
Expected Contents	- Program scope - Program objectives and strategy - Organizational structure including external interfaces - Program budget - Communication plan
Notes	**MG1-PR1, MG1-PR2**

MG1-OWP2	Program Schedule
Expected Contents	Gantt chart or equivalent
Notes	MG1-PR1, MG1-PR2

MG1-OWP2	Program monitoring report
Expected Contents	- Data collected, graphics and trends on program progress - Action items
Notes	-

Process Exit Criteria:

Not applicable.

3.4.2 MG2 – Project and Risk Management process

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.

Process Entry Criteria:

- Availability of time and cost constraints
- Availability of technical description of the product

Input Work Products

- Customer requirements
- Contract agreement

Process Requirements

MG2-PR1	Project Planning
Clause	A project plan shall be provided including time schedule of activities, needed resources, necessary skills.
Elaboration(s)	Perform a contract agreement analysis aimed at identifying: • the technical characteristics of the product; • the scope of the project activities; • the project stakeholders, with particular reference to the interface entities (as suppliers). Perform the analysis of the needs in terms of: • tools and infrastructures; • staff and skills; • suppliers to achieve the project targets. 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.
Tip(s)	-
Tailoring Criteria	-
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 MG2-OWP1 for details on the expected contents of the project plan.

MG2-PR2	Project monitoring
Clause	Deviations from the project plan shall be identified and corrective actions shall be deployed.
Elaboration(s)	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.
Tip(s)	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 MG4).
Tailoring Criteria	-
Notes	-

MG2-PR3	Project Risks Management
Clause	Project Risks shall be identified, assessed, controlled, and, if necessary, reduced.
Elaboration(s)	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.
Tip(s)	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, delays in task schedule.
Tailoring Criteria	-
Notes	Risk treatment is not to act to remove risks but to act to move risk rating under the acceptability threshold.

MG2-PR4	Project Estimations
Clause	Make estimations on project demands in terms of resources, duration, effort, and personnel skills.
Elaboration(s)	Perform a technical feasibility analysis to identify resource, infrastructures, and personnel skills needs of the project.

	Apply an estimation procedure to determine the cost in terms of effort, time duration, and technology needs of the project activities. Record and store project estimation and possible deviations.
Tip(s)	The initial risk assessment and rating is an input for the project planning. Set up a method to maintain and make available project data for future estimations.
Tailoring Criteria	-
Notes	-

Governance Requirements

MG2-GR1	Project control
Clause	Define metrics and perform measurements for evaluating project status and use measurements to take decisions.
Elaboration(s)	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.
Tip(s)	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 Criteria	-
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)

MG2-GR2	Ensure suitable skills
Clause	Personnel responsible for Project and Risk Management activities shall hold adequate technical skills.
Elaboration(s)	Demands in terms of personnel's skills, training and expertise to deploy Project and Risk Management activities as well as to use and optimize related tools are identified. Personnel holding the needed skill, knowledge and expertise is appointed to Project and Risk Management activities. Commitment and authority shall be assigned to project management responsible.
Tip(s)	Certified training programs for management can be beneficial.

Tailoring Criteria	-
Notes	-

Technological Requirements

MG2-TR2	Project Management support tool
Clause	Use an automatic tool supporting project management activities.
Elaboration(s)	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.
Tip(s)	Using a unique tool for requirements management, issue and task management, change management and technical issues management can be profitable.
Tailoring Criteria	The Project Management support tool shall be fitting with the development approach adopted in the project. In particular, in the case of agile-based software development approach, an agile-specific project management support tool is recommended.
Notes	-

MG2-TR2	Project dashboard tool
Clause	Use an automatic tool supporting project measurement management.
Elaboration(s)	The project measurement 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.
Tip(s)	Consider a Project Management supporting tool that includes support for measurements too.
Tailoring Criteria	-
Notes	-

MG2-TR2	Issue and Risk management tool
Clause	Use an automatic tool supporting risk management activities.

Elaboration(s)	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.
Tip(s)	Consider a Project Management supporting tool that includes support for risk management too.
Tailoring Criteria	-
Notes	Risks are different than problems/issues. Take risk treatment and problem/issue treatment separate.

Output Work Products

MG2-OWP1	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. **MG2-PR1**

MG2-OWP2	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. **MG2-PR1**

MG2-OWP3	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	**MG2-PR2**

MG2-OWP4	Project Issue and Risk Status Report
Expected Contents	Report of the current status of the project issues/risks in terms of: - issue/risk statement - conditions - changes in priority - duration of issue resolution and risk mitigation activities, when started - issues resolution/risk mitigation activities in progress - responsibility - constraints
Notes	Contents of Risk Status Report can be merged with those of the Project Status Report. **MG2-PR2, MG2-PR3**

Process Exit Criteria:

- Project is under control in terms of schedule, costs, technical/technological issues
- Risks are under treatment: all risks are either under the acceptability threshold or under treatment

3.4.3 MG3 – Technical Supervision process

Context of process:

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

Process Entry Criteria:

- Technical concept available
- Product development plan available

Input Work Products

- Technical concept
- Program Plan

Process Requirements

MG3-PR1	Operative supervision for project technical developments
Clause	Technical supervision on key technical areas issues shall be provided to project team.
Elaboration(s)	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.
Tip(s)	Involve relevant technical supervisors in project progress meeting in order to assess technical issues and take decisions.
Tailoring Criteria	-
Notes	-

MG3-PR2	Technical guidance for project key technical issues
Clause	Technical supervisors shall regularly assess and approve technical solutions settings for relevant key technical areas.
Elaboration(s)	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 in order to identify possible changes to technical solutions. For complex issues involving different technical areas, a technical supervision board shall be constituted.
Tip(s)	-
Tailoring Criteria	-
Notes	-

Governance Requirements

MG3-GR1	Identify key technical areas
Clause	Project-relevant key technical areas shall be identified
Elaboration(s)	The key technical areas relevant for the project are identified on the basis of the analysis of technical characteristics and constraints of system to develop.
Tip(s)	Possible key technical areas are: System design, system integration and validation, hardware design, hardware compliance, software design, software development (possible by models), software testing, functional safety, cyber-security.
Tailoring Criteria	-
Notes	-

MG3-GR2	Assign technical supervision responsibilities
Clause	Responsibility for key areas technical supervision shall be assigned following criteria based on expertise and skills.
Elaboration(s)	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.
Tip(s)	-
Tailoring Criteria	-
Notes	-

Technological Requirements

MG3-TR1	Collaboration support
Clause	A tool supporting the information exchange between technical supervisors and project team members shall be used.

Elaboration(s)	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.

Tip(s)	Using a unique tool for issue management, change management, quality and technical issues management, and task management can be profitable.
Tailoring Criteria	-
Notes	-

Output Work Products

MG3-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. **MG3-PR1, MG1-PR2**

MG3-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	Typ**ically, technical issues belong to hardware, software or mechanical developments.** **MG3-PR1, MG3-PR2**

Process Exit Criteria:

- technical issues for project team are managed
- technical supervision is active for each project-relevant key technical area

3.4.4 MG4 – Quality and Improvement Management process

Context of process:

Quality and Improvement Management process is based on two pillars:

- Deployment of a Quality Management System (QMS)
- Quality assurance on development project.

Process Entry Criteria:

- Project Initiation

Input Work Products

- Project Plan
- Quality Assurance Report

Process Requirements

MG4-PR1	IATF 16949 Conformity
Clause	The project shall work according to a Quality Management System (QMS) aligned with IATF 16949.
Elaboration(s)	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.
Tip(s)	-
Tailoring Criteria	Eventual application of a QMS reference equivalent to IATF 16949 needs be justified.
Notes	Current version is IATF 16949:2016 Equivalent standards compliant with IATF may be applied.

MG4-PR2	Quality Assurance Planning
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(s)	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).
Tip(s)	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 Criteria	-
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 (e.g. 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

	MG4-PR3	Quality Assurance Plan Implementation
Clause		Quality assurance activities shall be performed according to the plan.
Elaboration(s)		Quality issues shall be identified and recorded. Quality issues shall be analysed and corrective actions shall be defined. Responsibilities for corrective actions shall be allocated. Quality issues solution shall be verified.
Tip(s)		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 Criteria		-
Notes		-

	MG4-PR4	Analysis of Quality Data and Trends
Clause		Results of quality assurance deployment are reported. Available data shall be analysed in order to identify quality issue trends and indications for improvement

Elaboration(s)	Collect, report and compare quality assurance results to identify recurrent issues in work products and process quality. Perform result analysis to point out either actual lacks of quality or negative trends to be reversed or arrested.
Tip(s)	Define and use a chart containing key indicators to allow managers an easy control the status and trends of quality issues.
Tailoring Criteria	-
Notes	-

MG4-PR5	Identify and Deploy Improvement Actions
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(s)	In order to reduce the effects of lacks 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 prioritised 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.
Tip(s)	-
Tailoring Criteria	-
Notes	Effective improvement actions shall be evaluated for wider applications in order to extend benefits to different organizational departments.

Governance Requirements

MG4-GR1	Quality Strategy
Clause	Project quality objectives along with related strategies shall be defined, established and maintained, and the way quality objectives are achieved shall be defined.
Elaboration(s)	The way the compliance with the IATF 16949 standard is achieved and maintained shall be defined. The scope (i.e. which work products and which processes have to be addressed), the reference schedule and timing of quality assurance activities as well as the required degree of independence of involved quality assurance personnel shall be defined and planned.
Tip(s)	Independence, with respect the project team members, of quality assurance personnel involved in the project is an added value that can enforce the efficacy of quality assurance. Therefore, quality assurance personnel involved in the project should not be hierarchically dependent from any project team member and project manager.
Tailoring Criteria	In the case of small organization or in the case of an independent quality department is missing in the organization, it can be acceptable the mere functional independence of quality assurance personnel involved in the project (i.e. quality assurance personnel shouldn't be directly involved in the project activities with different roles).
Notes	-

MG4-GR2	Ensure commitment, authority and organizational infrastructure
Clause	Personnel responsible for Quality and Improvement Management activities shall hold adequate commitment and authority.
Elaboration(s)	Personnel holding the needed skill, knowledge and expertise is appointed to Quality and Improvement Management activities. Personnel responsible for Quality and Improvement management shall hold commitment and authority
Tip(s)	-
Tailoring Criteria	-
Notes	-

Technological Requirements

MG4-TR1	Quality Assurance support tool
Clause	Use a tool supporting quality assurance activities.
Elaboration(s)	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.
Tip(s)	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 Criteria	-
Notes	-

Output Work Products

MG4-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. **MG4-PR2, MG4-GR1**

MG4-OWP2	Quality Checkpoints Report(s)
Expected Contents	- Date and scope of the deployed quality checkpoint for work products and project activities. - Involved persons - List and current status of quality issues - Identification and prioritization of requested improvement actions - Results of the evaluation of effectiveness of on-going improvement actions
Notes	**MG4-PR3, MG4-GR1**

MG4-OWP3	Improvement Plan
Expected Contents	- Improvement objectives - Strategy - Means - Main action items
Notes	**MG4-PR5, MG4-GR1**

Process Exit Criteria:

- Project is under QMS under control in terms of quality of work products and project activities
- Existing quality issues are identified, evaluated, and possible improvement actions in progress.

3.5 Sustenance Segment Processes

In the context of PISA Model, Sustenance Segment addresses the provision of support for the deployment of all the activities of the project and to the correct management of related work products.

Reference goals is:

- Provision of methodology, techniques and tools for the correct and consistent production and evolution of project work products and project releases.

The processes belonging to the Sustenance Segment are:

- SU1 – Configuration Management
- SU2 – Reuse Management
- SU3 – Documentation Management

TRACEABILITY TO IATF 16949:

The project management segment processes of the PISA Model target the following IATF 16949 requirements:

- Section 7.4: Communications
- Section 7.5: Documented Information

3.5.1 SU1 – Configuration Management process

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 phase.

Process Entry Criteria:

- Project kick-off

Input Work Products

- Project work-products

Process Requirements

SU1-PR1	Configuration control
Clause	Project Configuration Items shall be uniquely identified and made available in a controlled manner at any time, and the relations and differences between earlier and current versions shall be traced
Elaboration(s)	A unique identified shall be assigned to each configuration item. Different versions of a configuration item shall be uniquely identified. The contents of all the versions of configuration items shall be available at any time. 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. Versioning of configuration items shall allow the identification of the temporal sequence of versions.
Tip(s)	The use of naming conventions for configuration items and software identifiers and related versioning is beneficial.
Tailoring Criteria	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.

SU1-PR2	Project repositories
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(s)	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.
Tip(s)	1. Harmonized organization in federated repositories 2. Support balance between confidentiality and information exchange
Tailoring Criteria	-

Notes	The elaborations of this requirement can be effectively deployed with the use of a configuration management automatic tool.

SU1-PR3	Project baselines
Clause	Project baselines shall be identified and consolidated as appropriate during the project lifetime.
Elaboration(s)	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.
Tip(s)	Baselines should be established before a release to identify consistent and complete delivery.
Tailoring Criteria	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.

SU1-PR4	Project releases
Clause	Project releases (internal and external) shall be identified and verified in terms of configuration items versions and content before the release event.
Elaboration(s)	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
Tip(s)	Coordination with the QA function is beneficial.
Tailoring Criteria	-

Notes	-

Governance Requirements

SU1-GR1	Project Configuration Management Planning
Clause	Planning of Configuration Management shall be defined including scope, roles definition and responsibilities allocation, schedule, branching policy, and tools.
Elaboration(s)	The list of work products to be put under configuration management (i.e. 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.
Tip(s)	In the case of small team/project the configuration manager and project manager can be the same person.
Tailoring Criteria	-
Notes	-

SU1-GR2	Ensure suitable skills for configuration management
Clause	Personnel responsible for Configuration Management activities shall hold adequate technical skills.
Elaboration(s)	Demands in terms of personnel's training and expertise to use the Configuration Management tool activities are identified. Demands in terms of personnel's skills and expertise to supervise the Configuration Management activities and infrastructure and tools are identified.
Tip(s)	A database of personnel skills, training, and experience profiles is beneficial.
Tailoring Criteria	-
Notes	-

Technological Requirements

SU1-TR1	Automatic support for configuration management
Clause	Configuration management tools that are aligned with the state of the art and project needs shall be used.
Elaboration(s)	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 Documental configuration items shall benefit from the deployment of specific tools for documentation management, accessibility and collaboration.
Tip(s)	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 Criteria	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

SU1-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 • Baselines 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	**SU1-GR1, SU1-PR3**

SU1-OWP2	Configuration Item List
Expected Contents	• List of configuration items including the reference to the baselines they have to be included in.
Notes	**SU1-GR1, SU1-PR1, SU1-PR2**

SU1-OWP3	Project repository(ies)
Expected Contents	Collection of project work products (or references to them)
Notes	**SU1-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	**SU1-PR4**

SU1-OWP5	Release Check
Expected Contents	Check of: 1. the contents of the release 2. open issues of the release 3. the recipients Approval from the responsible person
Notes	**SU1-PR4**

Process Exit Criteria:

- Consistent configuration status
- Baselines released according to plans

3.5.2 SU2 – Reuse Management process

Context of process:

Reuse Management deals with the identification and evaluation of reuse opportunities, the planning and deployment of reuse.

Process Entry Criteria:

- The technical concept is defined

Input Work Products

- Project Plan
- Quality Plan
- Project requirements (at system, hardware, software level) as appropriate
- System design

Process Requirements

SU2-PR1	Evaluate reuse opportunities
Clause	Opportunities to exploit reuse within the project scope shall explored and evaluated.
Elaboration(s)	Reuse opportunities are explored taking into account the system concept, the hardware design, and the software high-level design. Reuse includes: - Forward reuse (i.e. development for reuse) - Backward reuse (i.e. 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.
Tip(s)	Build a reuse catalog in order to organize the descriptive information of reuse items.
Tailoring Criteria	In the case of a development according to a Product Family (or Product line) approach, hardware-level and software-level reuse opportunities are already defined by design.
Notes	At hardware-level reuse items are standard hardware components; at software-level reuse items are software libraries, software units or elements. Project work products as system design, hardware design or software architectural design can be evaluated for reuse.

SU2-PR2	Reuse deployment
Clause	Selected reuse opportunities shall be planned and deployed.
Elaboration(s)	Reuse items shall be uniquely identified. Reuse items shall be documented in terms of technical and functional characteristics. Selected reuse items are integrated in the system.
Tip(s)	-
Tailoring Criteria	-
Notes	-

Governance Requirements

SU2-GR1	Manage reuse activities
Clause	Provide a planning of the reuse activities in the project.
Elaboration(s)	Responsibilities are allocated and authority is assigned for reuse opportunity exploration and evaluation. Resources and infrastructure necessary to deploy reuse are identified. Evaluation criteria for reuse items are defined Selection criteria for reuse item are defined. The validity and suitability of integrated reuse items when changes in specifications occur are evaluated.
Tip(s)	-
Tailoring Criteria	-
Notes	-

Technological Requirements

SU2-TR1	Reusable configuration items repository
Clause	An environment for storage and retrieval of data on reuse items shall be provided.
Elaboration(s)	A repository containing the specifications and constraints of reuse items shall be provided. Information about technical and functional characteristics and constraints shall be associated to each reuse item in the repository. The search in the repository is automatic.
Tip(s)	-
Tailoring Criteria	-
Notes	-

Output Work Products

SU2-OWP1	Inventory for Reuse
Expected Contents	List of items for reuse and related specifications and constraints
Notes	**SU2-PR1, SU2-TR1**

SU2-OWP2	Reuse Planning
Expected Contents	Document the extent of the reuse to be applied in the project in terms of: - Reused elements and criteria for selection - Development for reuse - Risks
Notes	**SU2-PR1, SU2-GR1**

Process Exit Criteria:

- Reuse opportunities are explored, evaluated, and applied as appropriate in the project
- Reuse items are available

3.5.3 SU3 – Documentation Management process

Context of process:

Documentation 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 changes and the correct distribution.

Process Entry Criteria:

- Project Kick-off

Input Work Products

- Configuration Management Plan
- Configuration Item List

Process Requirements

SU3-PR1	Document templates
Clause	Project documents shall be identified and related expected formats and contents identified.
Elaboration(s)	Each project document shall be identified by a unique name, 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.
Tip(s)	The use of customer templates may facilitate the compliance to this requirement.
Tailoring Criteria	-
Notes	Verification of the existence and consistency of expected information is performed by Quality Assurance too.

SU3-PR2	Documentation workflow
Clause	Documents shall be reviewed before release
Elaboration(s)	A review strategy 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.
Tip(s)	Plan and execute reviews before document major releases.
Tailoring Criteria	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, …).

SU3-PR3	Documents distribution
Clause	Access to document shall be under control.
Elaboration(s)	The document stakeholders shall be able to get the current version of documents at any time. Document access rights and limitations shall be defined.
Tip(s)	It is important to make sure that addressees are informed timely of documents availability.
Tailoring Criteria	-
Notes	This requirement can be satisfied by the use of a configuration management tool (see SU1.TR1)

Governance Requirements

SU3-GR1	Documentation management resources
Clause	Resources and responsibilities for naming, setup and review of project documents shall be identified and made available.
Elaboration(s)	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.
Tip(s)	Checklists are effective and easy means to provide review criteria and guidelines
Tailoring Criteria	-
Notes	This requirement may be integrated with the MG2-PR1

For governance and technological requirements refer to configuration management process (SU1).

Output Work Products

SU3-OWP1	Document review report
Expected Contents	- Object of the review (document identification) - Review criteria (e.g. checklist used) - Reviewer(s) name and role - Effort spent for review - Date of review - Review findings: defect found and possible classification by severity - Ownership of corrective actions, and due date for closing the corrective action
Notes	**SU3-PR1, SU3-PR2**

Process Exit Criteria:

- Project document set is defined.
- Document versioning is under control
- Document approval mechanism is applied

4. PISA Model Rating System

In this section the evaluation and rating of the Adequacy attribute of a development project is addressed.

PISA-RS provides a stepwise bottom-up approach to perform project evaluation. This approach is based on process-specific sets of requirements belonging to 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.
Demonstration of compliance is provided in Annex A.

The rating process is composed of the following steps:

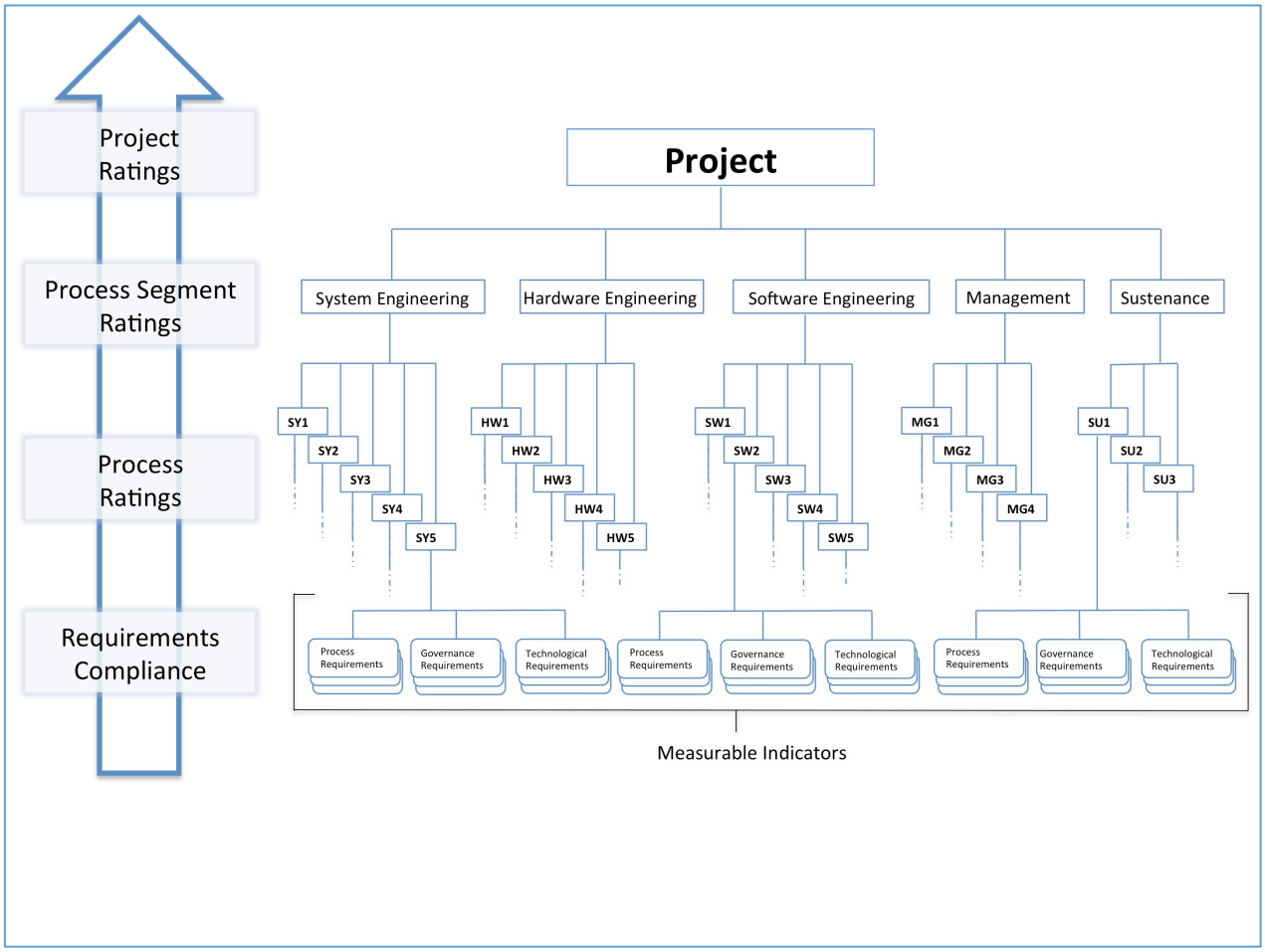
Step 1: using the work products of the project (as well as and other available objective evidences) the compliance to the requirements (process, governance, and technological requirements) associated to each process is evaluated. Compliance is a binary property (requirements compliance level).

Step 2: based on the requirements compliance rating and the weight of the requirements categories, the process rating in terms of ADEQUACY is established (process rating level).

Step 3: the aggregation of process ratings determines the relevant process segment rating in terms of ADEQUACY attribute (segment rating level).

Step 4: the weighted aggregation of the process segments ratings determines the project rating in terms of ADEQUACY attribute (project rating level).

The following picture shows the conceptual path towards the project evaluation in terms of project ADEQUACY attribute.



4.1 ADEQUACY 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 a characteristic is called process ADEQUACY.

4.2 Rules to make project adequacy rating

In this section the rules to apply for rating a project in terms of Adequacy are provided. The following sub-sections show, according to a bottom-up approach, how to proceed for establish the Adequacy rate of a project.

4.2.1 Rating at Requirement Compliance level

A set of requirements are associated to each PISA Model's process. The requirements belong to three categories:

- Process requirements
- Governance requirements
- Technological requirements

Independently of the category, a requirement is satisfied if work products or any other evidence demonstrating the fulfillment of the requirement itself exist.

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.

The rating rules at Requirement Level (Process, Governance, and Technological requirements) are based on the self-explanatory **4P scale:**

1.POOR -> 2.PARTIAL -> 3.PERFORMED -> 4.PROFICIENT

A Requirement, independently of its category, is considered satisfied if it is rated as PROFICIENT or PERFORMED.

4.2.2 Rating at Process level

A Process can be rated according to a four (4) Levels rating scale:
A (Full), S (Sufficient), I (Incomplete), N (Poor).

The meaning of the ratings is summarized in the following Table:

ADEQUACY Attribute	
FULL	Project is deployed in a sound fashion and project objectives are not at risk. Process improvement opportunities are limited in scope and criticality.
SUFFICIENT	Project is deployed satisfactorily and project objectives are largely not at risk. Process improvement opportunities are present.
INCOMPLETE	Project is deployed nearly satisfactorily and project objectives are exposed to some noteworthy risk. Significant Process improvement opportunities are present.
POOR	Project objectives are at risk. Process improvement opportunities are important and require immediate improvement action items.

The rating rules at Process Level are:

- A Process is rated as “Full” if all the High Priority Requirements (Process, Governance, and Technological) are satisfied.
- A Process is rated as “Sufficient” if it is not rated as “Full” and all the High Priority Process Requirements are satisfied and if one or more High Priority 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 High Priority requirements per each requirement category are satisfied.
- A Process is rated as “Inadequate” otherwise.

The following table summarizes the rating rules at Process Level:

PROCESS RATING

Process Requirements		Governance Requirements		Technological Requirements		PROCESS RATING
HIGH PRIORITY	LOW PRIORITY	HIGH PRIORITY	LOW PRIORITY	HIGH PRIORITY	LOW PRIORITY	
ALL	*	ALL	*	ALL	*	A
ALL	*	>0	*	>0	*	S
>0	*	>0	*	>0	*	I
otherwise						N

Note:
Low Priority Requirements do not contribute in process rating. Low Priority requirements are indicators for process improvement.

4.2.3 Rating at Process Segment level

A Process Segment can be rated according to a four (4) Levels rating scale: A (Full), S (Sufficient), I (Incomplete), N (Poor).

It is possible that not all the processes belonging to a Process Segment are applicable (i.e. it is possible that, because the project characteristics, some activities are not executed and, consequently, some evidences are not available for rating a process). According to that, N_p represents the number of applicable processes in a Process Segment.

The rules to rate the System Engineering, Hardware Engineering, and Software Engineering Process Segments are:

- A Process Segment is rated as “Adequate” if:
  - N_p processes belonging to that Process Segment are rated as “Full”
  - N_p *-1* processes belonging to that Process Segment are rated as “Full” and one (1) is rated as “Sufficient”.
- A Process Segment is rated as “Sufficient” if:
  - one (1) process belonging to that Process Segment are rated as “Incomplete” and no process is rated as “Inadequate”,
  - two (2) or more Processes belonging to that Process Segment are rated as “Sufficient” and no Process belonging to that Process Segment is rated as “Incomplete” or “Poor”.
- A Process Segment is rated as “Incomplete” if:
  - two (2) or more Processes belonging to that Process Segment are rated as “Incomplete” and no Process belonging to that Process Segment is rated as “Poor”
  - one (1) Process belonging to that Process Segment is rated as “Poor” and no processes are rated as “Incomplete”.
- A Process Segment is rated as “Poor” if:
  - one (1) process belonging to that Process Segment is rated “Poor” and one (1) or more process belonging to that Process Segment is rated “Incomplete”
  - two (2) or more Processes belonging to that Process Segment are rated as “Poor”.

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

For Management Process Segment if N_p <3 the whole Process Segment is not applicable and, consequently, it cannot be rated.

For sustenance Process Segment if N_p <2 the whole Process Segment is not applicable and, consequently, it cannot be rated.

The following table summarizes the rating rules at for a Process Segment:

number of occurrences of process ratings				SEGMENT RATING
A	S	I	N	
N_p	0	0	0	A
N_p - 1	1	0	0	
*	>1	0	0	S
*	*	1	0	
*	*	>1	0	I
*	*	0	1	
*	*	>0	1	N
*	*	*	>1	

4.2.4 Rating at Project level

A Project can be rated according to a four (4) Levels rating scale: A (Full), S (Sufficient), I (Incomplete), N (Poor).

The Rating of a Project in terms Adequacy is based on the ratings of the three (3) Technical Segments (System Engineering, Hardware Engineering, Software Engineering) and on the ratings of the two (2) Coordination Segments (Management and Sustenance).

It is possible that not all the Technical Process Segments are applicable (i.e. it is possible that, because the project characteristics, some activities are not executed and, consequently, some processes are not performed).

The PISA –RS allows to evaluate a project in terms of Adequacy also in the case of one or two Technical Process Segments are not applicable.

Argumentation in support of the reduction of the Process Segment scope shall be provided.

The rules for rating a Project in terms of Adequacy in the case of three, two or just one Technical Process Segment applicable are reported in the following Table.

The following table contains the rating rules at project level:

Processes Segments								RESULTING RATING
TECHNICAL SEGMENTS number of occurrences				COORDINATION SEGMENTS number of occurrences				
A	S	I	N	A	S	I	N	
*	0	0	0	2	0	0	0	A
				1	1	0	0	A
				1	0	1	0	A
				1	0	0	1	I
				0	2	0	0	A
				0	1	1	0	S
				0	1	0	1	I
				0	0	2	0	S
				0	0	1	1	I
				0	0	0	2	Z
0	*	0	0	2	0	0	0	S
				1	1	0	0	S
				1	0	1	0	S
				1	0	0	1	S
				0	2	0	0	S
				0	1	1	0	S
				0	1	0	1	I
				0	0	2	0	I
				0	0	1	1	Z
				0	0	0	2	Z
0	0	*	0	2	0	0	0	I
				1	1	0	0	I
				1	0	1	0	I
				1	0	0	1	Z
				0	2	0	0	I
				0	1	1	0	I
				0	1	0	1	Z
				0	0	2	0	I
				0	0	1	1	Z
				0	0	0	2	Z
0	0	0	*	*	*	*	*	Z
*	1	0	0	2	0	0	0	A
				1	1	0	0	S
				1	0	1	0	S
				1	0	0	1	I
				0	2	0	0	S
				0	1	1	0	S
				0	1	0	1	I
				0	0	2	0	S
				0	0	1	1	I
				0	0	0	2	Z
*	*	1	0	2	0	0	0	S
				1	1	0	0	I
				1	0	1	0	I
				1	0	0	1	I
				0	2	0	0	I
				0	1	1	0	I
				0	1	0	1	Z
				0	0	2	0	I
				0	0	1	1	Z
				0	0	0	2	Z
*	*	*	1	2	0	0	0	I
				1	1	0	0	I
				1	0	1	0	Z
				1	0	0	1	Z
				0	2	0	0	I
				0	1	1	0	Z
				0	1	0	1	Z
				0	0	2	0	Z
				0	0	1	1	Z
				0	0	0	2	Z
*	2	0	0	2	0	0	0	S
				1	1	0	0	S
				1	0	1	0	S
				1	0	0	1	I
				0	2	0	0	S
				0	1	1	0	S
				0	1	0	1	I
				0	0	2	0	I
				0	0	1	1	Z
				0	0	0	2	Z
*	*	2	0	2	0	0	0	I
				1	1	0	0	I
				1	0	1	0	I
				1	0	0	1	Z
				0	2	0	0	I
				0	1	1	0	I
				0	1	0	1	Z
				0	0	2	0	I
				0	0	1	1	Z
				0	0	0	2	Z
*	*	*	2	*	*	*	*	Z

ANNEX A

Demonstration of Compliance of PISA-RS with respect ISO/IEC 33003

Assumptions:

The ISO/IEC 33003 standard addresses the following concepts:

- Construct
- Process quality characteristic
- Process attribute

The previous three concepts can be mapped on the PISA Model as follows:

- the construct is the general idea underlying the model itself, it represents “what” is intended to be measured. It corresponds to the responsiveness of process to automotive demands from technical and organizational perspectives;
- the process quality characteristic is the process adequacy defined in Section 2.1.1. It is defined as the degree of satisfaction of the requirements included in the process definitions;
- the process attributes of the process adequacy are the requirements described in the process definitions (see Section 3).

Requirements	Claim of conformity	Ref. PISA Model
Conceptualization Requirements (4.1.1)		
A measurement framework shall identify and address a single process quality characteristic	The addressed process quality characteristic is Adequacy	2.1.1
A process quality characteristic in a process measurement framework shall be defined on the basis of a multidimensional construct	Dimensions of the construct are the three classes of requirements (process, governance, technological).	2.1.1
A process quality characteristic in a process measurement framework shall be defined as a set of process attributes;	The process attributes are the requirements associated to a process	3.
Each process attribute shall define a property of the process quality characteristic;	Defined in the PISA Model by construction	3.
Each process attribute that is not directly measurable shall be considered as a construct;	None in the PISA Model	
Process attributes in a process measurement framework shall be defined as either reflective or formative.	In PISA Model the process attribute is formative	
The measurement framework shall document the policies and assumptions underlying its use and application;	Provided in the PISA Model	4.
Construct Definition Requirements (4.2.1)		
The construct definition shall define the meaning of the process quality characteristic and its process attributes in a process measurement framework;	Provided by the PISA Model	2.1.1 4.1
The construct definition shall clarify the specification of the process quality characteristic and its process attributes as dimensions;	Provided by the PISA Model See above	2.1.1
The construct definition shall provide a guide for the operationalization of the process quality characteristic and its process attributes;	Provided by the PISA Model See: requirements in process definitions	3.
The construct definition shall state the scales of composite measures such as categorical (e.g., a series of ordinal values such as capability level) or numeric;	Provided by the PISA Model	4.2.2
At least one of the process attributes shall comprise the achievement of the defined process purpose and process outcomes for the process; this is termed the process performance attribute;	Provided by the PISA Model	2.3.2 (for process purpose) 3. (for process outcomes)
Operationalization (4.3.1)		
All process attributes shall be defined according to their construct specification;	Provided by the PISA Model	3.
Achievement of process attributes shall be verifiable through objective evidence.	Provided by the PISA Model	3.
Construct specification examination (4.4.1)		
Construct specifications of the process quality characteristic and its associated process attributes shall be examined through operationalization and with rationale.	The PISA Model complies with the decision rules to examine the measurement model (formative) in Table 1 of ISO 33003	4.
Scoring process attributes (4.5.1)		
The process attributes shall be scored;	Provided by the PISA Model	4.2
A measurement scale, i.e., nominal, ordinal, interval, or ratio, shall be defined for the process attributes;	Provided by the PISA Model	4.2

A measurement method shall be identified that objectively assigns a value to each process attribute.	Provided by the PISA Model	4.2
Aggregation (4.6.1)	*Aggregation derives a composite value or rating by combining a set of measurement values.*	
All aggregations required within the measurement framework shall be identified;	Provided by the PISA Model	4.
Aggregation methods shall be specified;	Provided by the PISA Model	4.
Aggregation methods shall be statistically valid.	Statistical proof of validity will be addresses starting from the application of the PISA Model in practice	
Aggregation methods shall utilize consistent measurement scales;	Provided by the PISA Model by construction	4.2
Aggregation methods shall be consistent with the measurement framework policies and assumptions;	Provided by the PISA Model by construction	4.2
Aggregation methods shall be consistent with construct specifications.	Provided by the PISA Model by construction	4.2
Sensitivity analysis (4.7.1)	*Sensitivity analysis aims to examine the robustness of the composite value. The kinds and methods of sensitivity analysis depend on scoring and aggregation method in process measurement frameworks.*	
Sensitivity analysis shall be performed for measurement scales of process attributes;	Provided by the PISA Model by construction	4.2.2
Sensitivity analysis shall be performed for aggregation methods;	Provided by the PISA Model by construction	4.2.4
Sensitivity analysis shall be performed for weights, if applicable.	Provided by the PISA Model by construction Weights are expressed by priority	4.2.2

ANNEX B

Ratings at Organizational Level

In this Annex, a possible mechanism to extend the Adequacy rating to the whole organization is provided. This mechanism can be used to qualify an organization, and consequently as a mean for benchmarking.

The mechanism is based on the concept of project representativeness.

Given $\{T_1, T_2, T_3, \dots, T_n\}$ the types of projects an organization carries on. Typically, a project type corresponds to a product line (i.e. the products having similar characteristics).

Given $P_{Ti\ (1=1,\dots,n)}$ the percentage of the organizational business given by the projects belonging to $T_{i\ (1=1,\dots,n)}$ with respect the whole organizational business.

Given a development project identified as D_x belonging to T_y , the representativeness of D_x is P_{Ty} .

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

- Project Representativeness is High (H) if the project under evaluation is a sample of a business line covering at least the 80% of the projects performed in the last 2 years
- Project Representativeness is Medium (M) if the project is a sample of a business line covering a range between 50% and 79% of the projects performed in the last 2 years
- Project Representativeness is Low (L) if the project under evaluation is a sample of a business line covering less than the 50% the projects performed in the last 2 years

The following table indicates the criteria to determine whether a Requirement is satisfied or not.

Project Adequacy Rating	Project Representativeness		
	H	M	L
Full	**Yes**	**Yes**	**Yes**
Sufficient	**Yes**	Not	Not
Incomplete	Not	Not	Not
Poor	Not	Not	Not

In summary, an Organization is considered qualified according to the PISA model if:

- The project rating is Full, or if
- The project rating is Sufficient and the Project Representativeness is rated as High.

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