Process Assessment Model
SPICE
for Mechanical Engineering

[FE1]

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Distribution

The SPICE for Mechanical Engineering process assessment model may only be obtained by download from the www.intacs.info web site.

Change requests

Any problems or change requests should be reported through the defined mechanism at the www.intacs.info web site.

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			• and typos corrected • "Proposal" in title removed[FE7]

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1 Introduction

1.1 Scope

The mechanical engineering processes define a process set for the development of pure mechanical systems (e.g. steering columns) and mechanical components (e.g. screws). These are linked to Automotive SPICE® according to the Plug-In Concept defined in Automotive SPICE v3.1.

Interfaces to the following processes are covered:

- Mechatronic processes (SYS.X)
- Production
- Development of test environment [FE8]

The entire development of production processes is not covered.

Management and supporting processes as well as generic practices of Automotive SPICE® shall be used as defined in the Automotive SPICE PAM v3.1 but have to be adapted to a mechanical context.

2 Process capability determination

The concept of process capability determination by using a process assessment model is based on a two-dimensional framework. The first dimension is provided by processes defined in a process reference model (process dimension). The second dimension consists of capability levels that are further subdivided into process attributes (capability dimension). The process attributes provide the measurable characteristics of process capability.
The process assessment model selects processes from a process reference model and supplements with indicators. These indicators support the collection of objective evidence which enable an assessor to assign ratings for processes according to the capability dimension.
The relationship is shown in Figure 1:

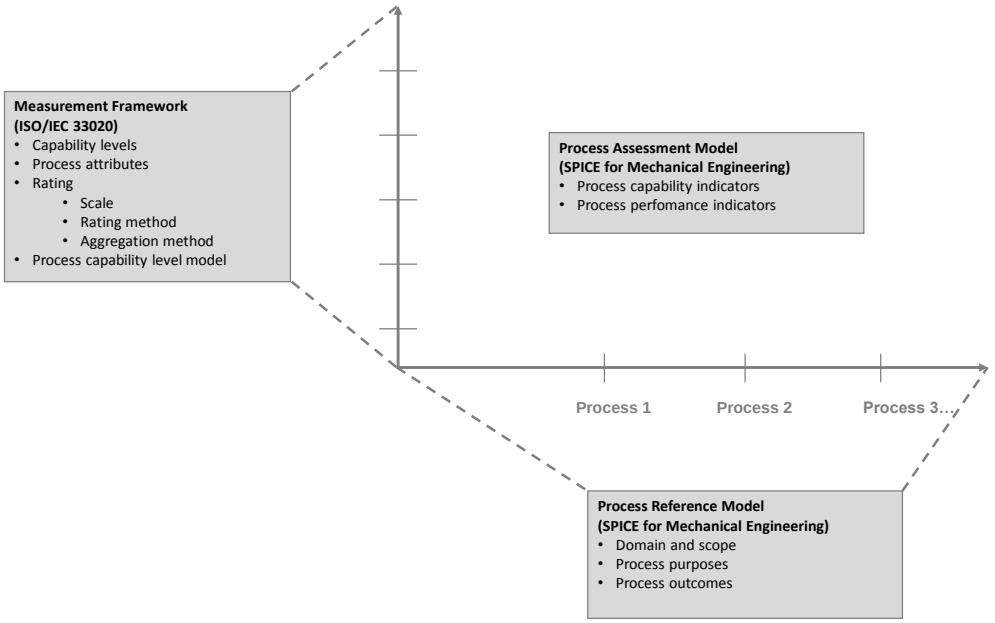


Figure 1 – Process assessment model relationship

2.1 Process reference model

Processes are grouped by process category and at a second level into process groups according to the type of activity they address.
There are 3 process categories: Primary life cycle processes, Organizational life cycle processes and Supporting life cycle processes.
Each process is described in terms of a purpose statement. The purpose statement contains the unique functional objectives of the process when performed in a particular environment. For each purpose statement a list of specific outcomes is associated, as a list of expected positive results of the process performance.
For the process dimension, SPICE for Mechanical Engineering reuses parts of the Automotive SPICE® process reference model to provide the set of processes shown in Figure 2.

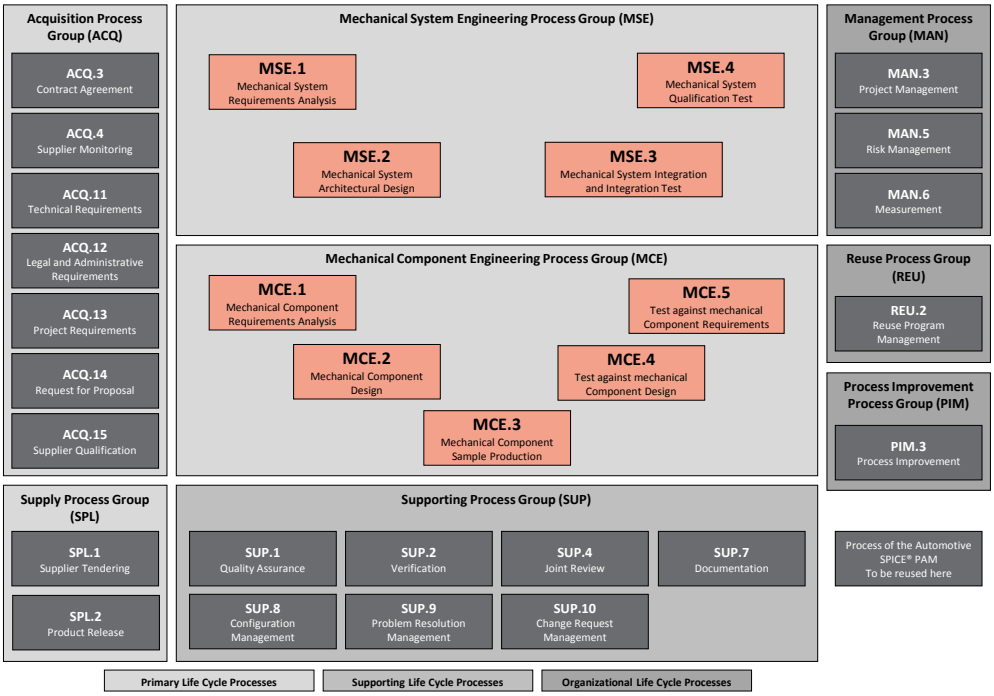


Figure 2 – SPICE for Mechanical Engineering process reference model – Overview

2.1.1 Primary life cycle processes category

The primary life cycle processes category consists of processes that may be used by the customer when acquiring products from a supplier, and by the supplier when responding and delivering products to the customer including the engineering processes needed for specification, design, development, integration and testing.
The primary life cycle processes category consists of the following groups:

- the Acquisition process group;
- the Supply process group;
- the System engineering process group;
- the Software engineering process group.

The Acquisition process group (ACQ) consists of processes that are performed by the customer, or by the supplier when acting as a customer for its own suppliers, in order to acquire a product and/or service. For details please refer to Automotive SPICE®.

The Supply process group (SPL) consists of processes performed by the supplier in order to supply a product and/or a service. For details please refer to Automotive SPICE®.

The Mechanical Systems Engineering Process Group (MSE) consists of processes addressing the management of customer and internal requirements on system level, the definition of the mechanical system architecture and the integration and testing on the mechanical system level.

MSE.1 Mechanical System Requirements Analysis
MSE.2 Mechanical System Architectural Design
MSE.3 Mechanical System Integration and Integration Test
MSE.4 Mechanical System Qualification Test

The Mechanical Component Engineering Process Group (MCE) consists of processes addressing the management of customer and internal requirements on component level, the definition of the mechanical component design, the production of the mechanical component, the test against the mechanical component design and requirements.

MCE.1	Mechanical Component Requirements Analysis
MCE.2	Mechanical Component Design
MCE.3	Mechanical Component Sample Production
MCE.4	Test against Mechanical Component Design
MCE.5	Test against Mechanical Component Requirements

2.1.2 Supporting life cycle processes category

The supporting life cycle processes category consists of processes that may be employed by any of the other processes at various points in the life cycle. For details please refer to Automotive SPICE®.

2.1.3 Organizational life cycle processes category

The organizational life cycle processes category consists of processes that develop process, product, and resource assets which, when used by projects in the organization, will help the organization achieve its business goals.
The organizational life cycle processes category consists of the following groups:

- the Management process group;
- the Process Improvement process group;
- the Reuse process group.

The Management process group (MAN) consists of processes that may be used by anyone who manages any type of project or process within the life cycle. For details please refer to Automotive SPICE®.

The Process Improvement process group (PIM) covers one process that contains practices to improve the processes performed in the organizational unit. For details please refer to Automotive SPICE®.

The Reuse process group (REU) covers one process to systematically exploit reuse opportunities in organization's reuse programs. For details please refer to Automotive SPICE®.

2.2 Measurement framework

The measurement framework provides the necessary requirements and rules for the capability dimension. It defines a schema which enables an assessor to determine the capability level of a given process. These capability levels are defined as part of the measurement framework.
To enable the rating, the measurement framework provides process attributes defining a measurable property of process capability. Each process attribute is assigned to a specific capability level. The extent of achievement of a certain process attribute is represented by means of a rating based on a defined rating scale. The rules from which an assessor can derive a final capability level for a given process are represented by a process capability level model.
Automotive SPICE 3.1 uses the measurement framework defined in ISO/IEC 33020:2015.
NOTE: Text incorporated from ISO/IEC 33020 within this chapter is written in italic font and marked with a left side bar.

2.2.1 Process capability levels and process attributes

The process capability levels and process attributes are identical to those defined in ISO/IEC 33020 clause 5.2. The detailed descriptions of the capability levels and the corresponding process attributes can be found in chapter 5.
Process attributes are features of a process that can be evaluated on a scale of achievement, providing a measure of the capability of the process. They are applicable to all processes.
A capability level is a set of process attribute(s) that work together to provide a major enhancement in the capability to perform a process. Each attribute addresses a specific aspect of the capability level. The levels constitute a rational way of progressing through improvement of the capability of any process.
According to ISO/IEC 33020 there are six capability levels, incorporating nine process attributes:

Level 0: Incomplete process	*The process is not implemented, or fails to achieve its process purpose.*
Level 1: Performed process	*The implemented process achieves its process purpose*
Level 2: Managed process	*The previously described performed process is now implemented in a managed fashion (planned, monitored and adjusted) and its work products are appropriately established, controlled and maintained.*
Level 3: Established process	*The previously described managed process is now implemented using a defined process that is capable of achieving its process outcomes.*
Level 4: Predictable process	*The previously described established process now operates predictively within defined limits to achieve its process outcomes. Quantitative management needs are identified, measurement data are collected and analyzed to identify assignable causes of variation. Corrective action is taken to address assignable causes of variation.*
Level 5: Innovating process	*The previously described predictable process is now continually improved to respond to organizational change.*

Table 10 — Process capability levels according to ISO/IEC 33020

Within this process assessment model, the determination of capability is based upon the nine process attributes (PA) defined in ISO/IEC 33020 and listed in Table 11.

Attribute ID	**Process Attributes**
Level 0: Incomplete process	
Level 1: Performed process	
PA 1.1	*Process performance process attribute*
Level 2: Managed process	
PA 2.1	*Performance management process attribute*
PA 2.2	*Work product management process attribute*
Level 3: Established process	
PA 3.1	*Process definition process attribute*
PA 3.2	*Process deployment process attribute*
Level 4: Predictable process	
PA 4.1	*Quantitative analysis process attribute*
PA 4.2	*Quantitative control process attribute*
Level 5: Innovating process	
PA 5.1	*Process innovation process attribute*
PA 5.2	*Process innovation implementation process attribute*

2.2.2 Process attribute rating

To support the rating of process attributes, the ISO/IEC 33020 measurement framework provides a defined rating scale with an option for refinement, different rating methods and different aggregation methods depending on the class of the assessment (e.g. required for organizational maturity assessments).

Rating scale

Within this process measurement framework, a process attribute is a measureable property of process capability. A process attribute rating is a judgement of the degree of achievement of the process attribute for the assessed process.

The rating scale is defined by ISO/IEC 33020 as shown in table 12

N	*Not achieved*	*There is little or no evidence of achievement of the defined process attribute in the assessed process.*
P	*Partially achieved*	*There is some evidence of an approach to, and some achievement of, the defined process attribute in the assessed process. Some aspects of achievement of the process attribute may be unpredictable.*
L	*Largely achieved*	*There is evidence of a systematic approach to, and significant achievement of, the defined process attribute in the assessed process. Some weaknesses related to this process attribute may exist in the assessed process.*
F	*Fully achieved*	*There is evidence of a complete and systematic approach to, and full achievement of, the defined process attribute in the assessed process. No significant weaknesses related to this process attribute exist in the assessed process.*

The ordinal scale defined above shall be understood in terms of percentage achievement of a process attribute.

The corresponding percentages shall be:

N	*Not achieved*	*0 to ≤ 15% achievement*
P	*Partially achieved*	*> 15% to ≤ 50% achievement*
L	*Largely achieved*	*> 50% to ≤ 85% achievement*
F	*Fully achieved*	*> 85% to ≤ 100% achievement*

Table 13 — Rating scale percentage values according to ISO/IEC 33020

The ordinal scale may be further refined for the measures P and L as defined below.

P-	*Partially achieved:*	*There is some evidence of an approach to, and some achievement of, the defined process attribute in the assessed process. Many aspects of achievement of the process attribute may be unpredictable.*
P+	*Partially achieved:*	*There is some evidence of an approach to, and some achievement of, the defined process attribute in the assessed process. Some aspects of achievement of the process attribute may be unpredictable.*
L-	*Largely achieved:*	*There is evidence of a systematic approach to, and significant achievement of, the defined process attribute in the assessed process. Many weaknesses related to this process attribute may exist in the assessed process.*
L+	*Largely achieved:*	*There is evidence of a systematic approach to, and significant achievement of, the defined process attribute in the assessed process. Some weaknesses related to this process attribute may exist in the assessed process.*

The corresponding percentages shall be:

P-	*Partially achieved -*	*> 15% to ≤ 32.5% achievement*
P+	*Partially achieved +*	*> 32.5 to ≤ 50% achievement*
L-	*Largely achieved -*	*> 50% to ≤ 67.5% achievement*
L+	*Largely achieved +*	*> 67.5% to ≤ 85% achievement*

Rating and aggregation method

ISO/IEC 33020 provides the following definitions:

A process outcome is the observable result of successful achievement of the process purpose.

A process attribute outcome is the observable result of achievement of a specified process attribute.

Process outcomes and process attribute outcomes may be characterised as an intermediate step to providing a process attribute rating.

When performing rating, the rating method employed shall be specified relevant to the class of assessment. The following rating methods are defined.

The use of rating method may vary according to the class, scope and context of an assessment. The lead assessor shall decide which (if any) rating method to use. The selected rating method(s) shall be specified in the assessment input and referenced in the assessment report.

ISO/IEC 33020 provides the following 3 rating methods:

Rating method R1

The approach to process attribute rating shall satisfy the following conditions:

a) Each process outcome of each process within the scope of the assessment shall be characterized for each process instance, based on validated data;

b) Each process attribute outcome of each process attribute for each process within the scope of the assessment shall be characterized for each process instance, based on validated data;

c) Process outcome characterizations for all assessed process instances shall be aggregated to provide a process performance attribute achievement rating;

d) Process attribute outcome characterizations for all assessed process instances shall be aggregated to provide a process attribute achievement rating.

Rating method R2

The approach to process attribute rating shall satisfy the following conditions:

a) Each process attribute for each process within the scope of the assessment shall be characterized for each process instance, based on validated data;

b) Process attribute characterizations for all assessed process instances shall be aggregated to provide a process attribute achievement rating.

Rating method R3

Process attribute rating across assessed process instances shall be made without aggregation.

In principle the three rating methods defined in ISO/IEC 33020 depend on

a) whether the rating is made only on process attribute level (Rating method 3 and 2) or – with more level of detail – both on process attribute and process attribute outcome level (Rating method 1); and

b) the type of aggregation ratings across the assessed process instances for each process

If a rating is performed for both process attributes and process attribute outcomes (Rating method 1), the result will be a process performance attribute outcome rating on level 1 and a process attribute achievement rating on higher levels.

Depending on the class, scope and context of the assessment an aggregation within one process (one-dimensional, vertical aggregation), across multiple process instances (one-dimensional, horizontal aggregation) or both (two-dimensional, matrix aggregation) is performed.

ISO/IEC 33020 provides the following examples:
When performing an assessment, ratings may be summarized across one or two dimensions.
For example, when rating a

- process attribute for a given process, one may aggregate ratings of the associated process (attribute) outcomes – such an aggregation will be performed as a vertical aggregation (one dimension).
- process (attribute) outcome for a given process attribute across multiple process instances, one may aggregate the ratings of the associated process instances for the given process (attribute) outcome such an aggregation will be performed as a horizontal aggregation (one dimension)
- process attribute *for a given process, one may aggregate the ratings of all the process (attribute) outcomes for all the processes instances – such an aggregation will be performed as a matrix aggregation across the full scope of ratings (two dimensions)*

The standard defines different methods for aggregation. Further information can be taken from ISO/IEC 33020.

2.2.3 Process capability level model

The process capability level achieved by a process shall be derived from the process attribute ratings for that process according to the process capability level model defined in Table 16.
The process capability level model defines the rules how the achievement of each level depends on the rating of the process attributes for the assessed and all lower levels.
As a general rule the achievement of a given level requires a largely achievement of the corresponding process attributes and a full achievement of any lower lying process attribute.

Scale	***Process attribute***	***Rating***
Level 1	***PA 1.1: Process Performance***	***Largely***
Level 2	*PA 1.1: Process Performance*	*Fully*
	PA 2.1: Performance Management	***Largely***
	PA 2.2: Work Product Management	***Largely***
Level 3	*PA 1.1: Process Performance*	*Fully*
	PA 2.1: Performance Management	*Fully*
	PA 2.2: Work Product Management	*Fully*
	PA 3.1: Process Definition	***Largely***
	PA 3.2: Process Deployment	***Largely***
Level 4	*PA 1.1: Process Performance*	*Fully*
	PA 2.1: Performance Management	*Fully*
	PA 2.2: Work Product Management	*Fully*
	PA 3.1: Process Definition	*Fully*
	PA 3.2: Process Deployment	*Fully*
	PA 4.1: Quantitative Analysis	***Largely***
	PA 4.2: Quantitative Control	***Largely***
Level 5	*PA 1.1: Process Performance*	*Fully*
	PA 2.1: Performance Management	*Fully*
	PA 2.2: Work Product Management	*Fully*
	PA 3.1: Process Definition	*Fully*
	PA 3.2: Process Deployment	*Fully*
	PA 4.1: Quantitative Analysis	*Fully*
	PA 4.2: Quantitative Control	*Fully*
	PA 5.1: Process Innovation	***Largely***

	PA 5.2: Process Innovation Implementation	***Largely***

Table 16 — Process capability level model according to ISO/IEC 33020

2.3 Process assessment model

The process assessment model offers indicators in order to identify whether the process outcomes and the process attribute outcomes (achievements) are present or absent in the instantiated processes of projects and organizational units. These indicators provide guidance for assessors in accumulating the necessary objective evidence to support judgments of capability. They are not intended to be regarded as a mandatory set of checklists to be followed.
In order to judge the presence or absence of process outcomes and process achievements an assessment obtains objective evidence. All such evidence comes from the examination of work products and repository content of the assessed processes, and from testimony provided by the performers and managers of the assessed processes. This evidence is mapped to the PAM indicators to allow establishing the correspondence to the relevant process outcomes and process attribute achievements.
There are two types of indicators:

- **Process performance indicators**, which apply exclusively to capability Level 1. They provide an indication of the extent of fulfillment of the process outcomes
- **Process capability indicators**, which apply to Capability Levels 2 to 5. They provide an indication of the extent of fulfillment of the process attribute achievements.

Assessment indicators are used to confirm that certain practices were performed, as shown by evidence collected during an assessment. All such evidence comes either from the examination of work products of the processes assessed, or from statements made by the performers and managers of the processes. The existence of base practices and work products provide evidence of the performance of the processes associated with them. Similarly, the existence of process capability indicators provides evidence of process capability.
The evidence obtained should be recorded in a form that clearly relates to an associated indicator, in order that support for the assessor's judgment can be confirmed or verified as required by ISO/IEC 33002.

2.3.1 Process performance indicators

Types of process performance indicators are

- Base practices (BP)
- Work products (WP).

Both BPs and WPs relate to one or more process outcomes. Consequently, BPs and WPs are always process-specific and not generic. BPs represent activity-oriented indicators. WPs represent result-oriented indicators. Both BP and WP are used for judging objective evidence that an assessor is to collect, and accumulate, in the performance of an assessment. In that respect BPs and WPs are alternative indicator sets the assessor can use.
The PAM offers a set of work product characteristics (WPC, see Annex B) for each WP. These are meant to offer a good practice and state-of-the-art knowledge guide for the assessor. Therefore, WP and WPC are supposed to be a quickly accessible information source during an assessment. In that respect WPs and WPCs represent an example structure only. They are neither a "strict must" nor are they normative

for organizations. Instead, the actual structure, form and content of concrete work products and documents for the implemented processes must be defined by the project and organization, respectively. The project and/or organization ensures that the work products are appropriate for the intended purpose and needs, and in relation to the development goals.

2.3.2 Process capability indicators

Types of process capability indicators are:

- Generic Practice (GP)
- Generic Resource (GR)

Both GPs and GRs relate to one or more PA Achievements. In contrast to process performance indicators, however, they are of generic type, i.e. they apply to any process.
The difference between GP and GR is that the former represent activity-oriented indicators while the latter represent infrastructure- oriented indicators for judging objective evidence. An assessor has to collect and accumulate evidence supporting process capability indicators during an assessment. In that respect GPs and GRs are alternative indicators sets the assessor can use.
In spite of the fact that level 1 capability of a process is only characterized by the measure of the extent to which the process outcomes are achieved the measurement framework (see chapter 3.2) requires each level to reveal a process attribute, and, thus, requires the PAM to introduce at least one process capability indicator. Therefore, the only process performance attribute for capability Level 1 (PA.1.1) has a single generic practice (GP 1.1.1) pointing as an editorial reference to the respective process performance indicators (see Figure 3).

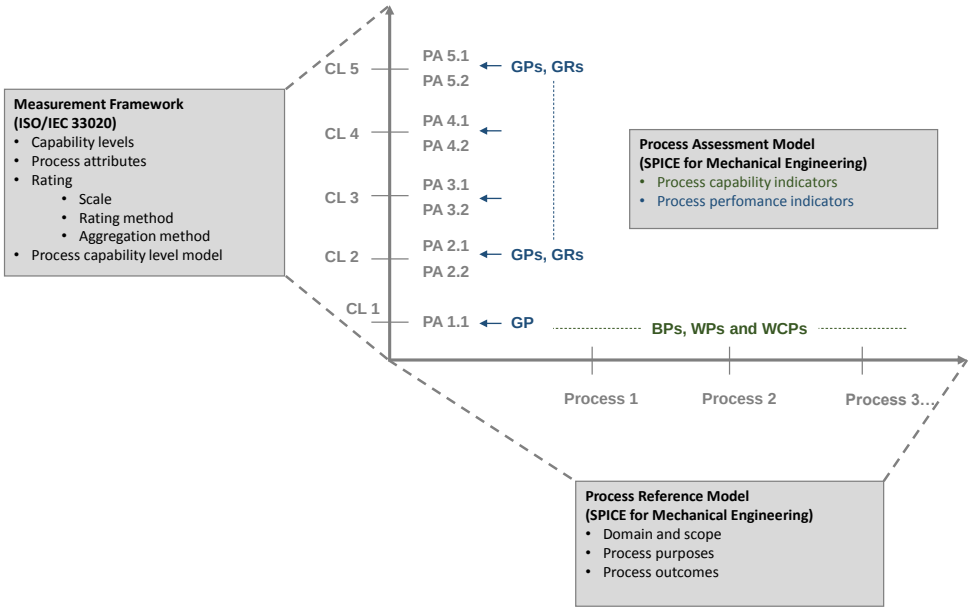


Figure 3 – Relationship between assessment indicators and process capability

2.3.3 Understanding the level of abstraction of a PAM

The term "process" can be understood at three levels of abstraction. Note that these levels of abstraction are not meant to define a strict black-or-white split, nor is it the aim to provide a scientific classifica-

tion schema – the message here is to understand that, in practice, when it comes to the term "process" there are different abstraction levels, and that a PAM resides at the highest.

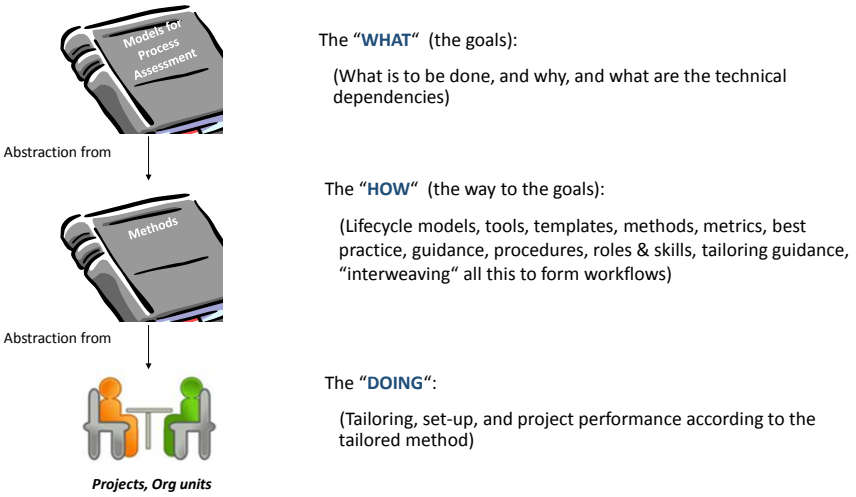


Figure 4 – Possible levels of abstraction for the term "process"

Capturing experience acquired during product development (i.e. at the DOING level) in order to share this experience with others means creating a HOW level. However, a HOW is always specific to a particular context such as a company, an organizational unit, or a product line. For example, the HOW of a project, organizational unit, or company A is potentially not applicable as is to a project, organizational unit, or company B. However, both might be expected to adhere the principles represented by PAM indicators for process outcomes and process attribute achievements. These indicators are at the WHAT level while deciding on solutions for concrete templates, proceedings, and tooling etc. is left to the HOW level.

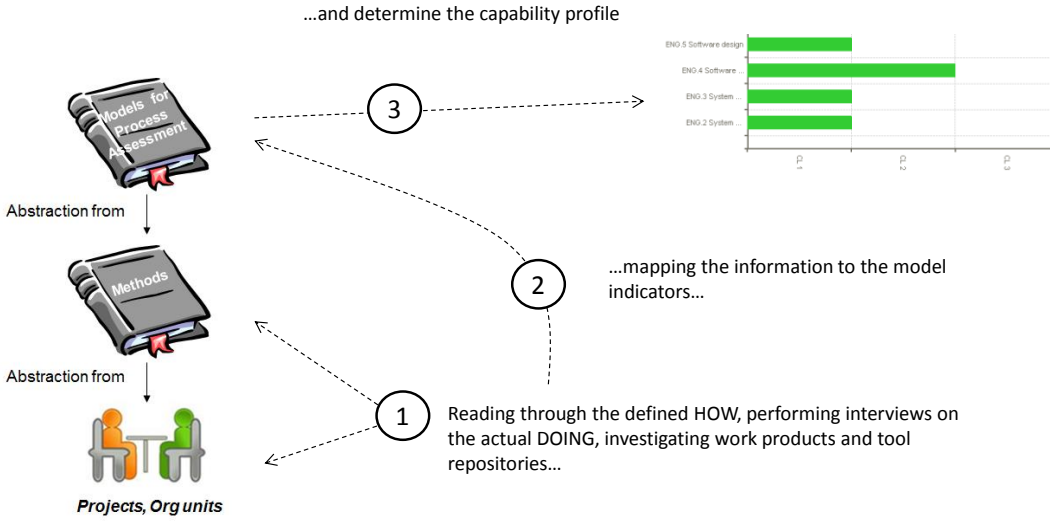


Figure 5 – Performing a process assessment for determining process capability

3 Process reference model and performance indicators (Level 1)

The processes in the process dimension can be drawn from the Automotive SPICE process reference model, which is incorporated in the tables below indicated by a red bar at the left side.

Each table related to one process in the process dimension contains the process reference model (indicated by a red bar) and the process performance indicators necessary to define the process assessment model. The process performance indicators consist of base practices (indicated by a green bar) and output work products (indicated by a blue bar).

Process reference model	**Process ID**	The individual processes are described in terms of process name, process purpose, and process outcomes to define the Automotive SPICE process reference model. Additionally a process identifier is provided.
	Process name	
	Process purpose	
	Process outcomes	
Process performance indicators	**Base practices**	A set of base practices for the process providing a definition of the tasks and activities needed to accomplish the process purpose and fulfill the process outcomes
	Output work products	A number of output work products associated with each process *NOTE: Refer to Annex B for the characteristics associated with each work product.*

Table 17 — Template for the process description

3.1 Mechanical Systems Engineering Process Group

3.1.1 Mechanical System Requirements Analysis

ID
MSE.1
Process Name
Mechanical System Requirements Analysis
Process Purpose
The purpose of the Mechanical System Requirements Analysis process is to derive the mechanical system requirements from the upper system requirements together with all affected stakeholders.
Process Outcomes
As a result of successful implementation of this process: 1) the mechanical system requirements are derived from the upper system requirements and the upper system architecture; Note: If the mechanical system is the highest system the source of these requirements are the only the stakeholders, in other cases the requirements' source is the upper system requirements and the upper system architecture. 2) the mechanical system requirements are categorized and analyzed for correctness and verifiability; 3) the impact of mechanical system requirements on the operating environment is analyzed and communicated; 4) prioritization for implementing the mechanical system requirements is defined; 5) the mechanical system requirements are updated as needed; 6) consistency and bidirectional traceability are established between upper system requirements and mechanical system requirements; and consistency and bidirectional traceability are established between upper system architecture and mechanical system requirements; 7) the mechanical system requirements are evaluated for cost, schedule and technical impact; and 8) the mechanical system requirements are agreed and communicated to all affected stakeholders.
Base Practices
BP1: Specify mechanical system requirements. Use the upper system requirements and the upper system architecture as well as changes to the upper system requirements and architecture to identify the required functions and capabilities of the mechanical system. Specify functional and non-functional mechanical system requirements in a mechanical system requirements specification. [OUTCOME 1, 5, 7] NOTE 1: Non-functional requirements may include e.g. production, maintenance, exchangeability of systems and components in the field, logistic, packaging, sizing, weight, price per unit, producibility, environmental, design guidelines, modelling guidelines and patents. NOTE 2: Mechanical system requirements should include tolerances as necessary. **BP2: Structure mechanical system requirements.** Structure the mechanical system requirements in the mechanical system requirements specification by e.g. • grouping to project relevant clusters like architecture elements, • sorting in a logical order for the project,

- categorizing based on relevant criteria for the project,
- prioritizing according to stakeholder needs.

[OUTCOME 2, 4]

NOTE 3: Prioritizing typically includes the assignment of mechanical content to planned releases. Refer to SPL.2 BP1.

BP3: Analyze mechanical system requirements.

Analyze the specified mechanical system requirements including their interdependencies to ensure correctness, technical feasibility and verifiability, and to support risk identification. Analyze the impact on cost, schedule and the technical impact. [OUTCOME 2, 7]

NOTE 4: The analysis of impact on cost, schedule and quality supports the adjustment of project estimates. Refer to MAN.3 BP5.

BP4: Analyze the impact on the operating environment.

Analyze the impact that the mechanical system requirements will have on upper system elements and the operating environment. [OUTCOME 3, 7]

BP5: Develop verification criteria.

Develop the verification criteria for each mechanical system requirement that define the qualitative and quantitative measures for the verification of a requirement. [OUTCOME 2, 7]

NOTE 5: Verification criteria demonstrate that a requirement can be verified within agreed constraints and is typically used as the input for the development of the test cases or other verification measures that should demonstrate compliance with the mechanical system requirements.

NOTE 6: Verification which cannot be covered by testing is covered by SUP.2.

BP6: Establish bidirectional traceability.

1. Establish bidirectional traceability between upper system requirements and mechanical system requirements.
2. Establish bidirectional traceability between the upper system architecture and mechanical system requirements.

[OUTCOME 6]

NOTE 7: Bidirectional traceability supports coverage, consistency and impact analysis.

BP7: Ensure consistency.

1. Ensure consistency between upper system requirements and mechanical system requirements.
2. Ensure consistency between the upper system architecture and mechanical system requirements.

[OUTCOME 6]

NOTE 8: Consistency is supported by bidirectional traceability and can be demonstrated by review records.

NOTE 9: In case of mechanical development only, the upper system requirements and upper system architecture refer to a given operating environment. In that case, consistency and bidirectional traceability has to be ensured between stakeholder requirements and mechanical system requirements.

BP8: Communicate agreed mechanical requirements.

Communicate the agreed mechanical system requirements and updates to mechanical system requirements to all relevant stakeholders. [OUTCOME 8]

Output Work Products

01-51	Application parameter [OUTCOME 1]
13-04	Communication record [OUTCOME 8]

13-19	Review record [OUTCOME 6]
13-21	Change control record [OUTCOME 5, 7]
13-22	Traceability record [OUTCOME 1, 6]
15-01	Analysis report [OUTCOME 2, 3, 4, 7]
17-08	Interface requirements specification [OUTCOME 1]
17-ME01	Mechanical system requirements specification [OUTCOME 1]
17-50	Verification criteria [OUTCOME 2]

3.1.2 Mechanical System Architectural Design

ID
MSE.2
Process Name
Mechanical System Architectural Design
Process Purpose
The purpose of the Mechanical System Architectural Design Process is to establish an architectural design and to identify which mechanical system requirements are to be allocated to which elements of the mechanic, and to evaluate the mechanical system architectural design against defined criteria.
Process Outcomes
As a result of successful implementation of this process: 1) a mechanical system architectural design is defined that identifies the elements of the mechanical system; 2) the mechanical system requirements are allocated to the elements of the mechanical system; 3) the interfaces of each mechanical system elements are defined; 4) the static and dynamic behaviour and design constraints of the mechanical system elements are defined; 5) consistency and bidirectional traceability are established between mechanical system requirements and mechanical system architectural design; and 6) the mechanical system architectural design is agreed and communicated to all affected stakeholders.
Base Practices
BP.1: Develop mechanical system architectural design. Develop and document the mechanical system architectural design that specifies the elements of the mechanical system with respect to functional and non-functional mechanical system requirements. [OUTCOME 1] NOTE 1: The mechanical system is decomposed into elements across appropriate hierarchical levels down to the mechanical components (the elements on the lowest level of the mechanical system architectural design) that are described in the mechanical component design. NOTE 2: Consider make, buy and reuse options. NOTE 3: Model-based development (e.g. FEM, SysML) may facilitate the collaboration of the different engineering domains. **BP.2: Allocate mechanical system requirements.** Allocate all mechanical system requirements to the elements of the mechanical system architectural design. [OUTCOME 2] **BP.3: Define interfaces of mechanical elements.** Identify, develop and document the interfaces of each mechanical system element. [OUTCOME 3] **BP.4: Identify special characteristics.** Identify and document special characteristics of the mechanical system elements. [OUTCOME 1] NOTE 4: The identification of special characteristics is supported by e.g. simulation, risk analyses, sizing calculations. **BP.5: Describe dynamic and static behavior.**

Evaluate and document the dynamic and static behavior of and the interaction between mechanical system elements. [OUTCOME 4]

NOTE 5: Static and dynamic behavior is determined by e.g. stress, force, pressure, strain, temperature, operating modes (open, closed, in motion, misuse, emergency, etc.)

BP.6: Consider, determine, and document design constraints.

Determine and document design constraints for all mechanical system elements and take them into account for creating the mechanical system architecture. [OUTCOME 4]

BP7: Evaluate alternative mechanical system architectures.

Define evaluation criteria for architectural design. Evaluate alternative mechanical system architectures according to the defined criteria. Record the rationale for the chosen mechanical system architecture. [OUTCOME 1, 2, 3, 4, 5]

NOTE 6: Evaluation criteria may include quality characteristics (cost, weight, packaging, modularity, maintainability, expandability, scalability, reliability, safety and usability) and results of make-buy-reuse analysis.

BP8: Verify mechanical system architectural design.

Ensure that the mechanical system architectural design meets all mechanical system requirements. [Outcomes 4, 5]

NOTE 7: Verification of mechanical system architectural design may include FEA, simulation, or Product FMEA.

BP9: Establish bidirectional traceability.

1. Establish bidirectional traceability between mechanical system requirements and elements of the mechanical system architectural design.
2. Establish bidirectional traceability between elements of the mechanical system architectural design and elements of the system architectural design.

[OUTCOME 5]

NOTE 8: Bidirectional traceability covers allocation of mechanical system requirements to the elements of the mechanical system architectural design.

NOTE 9: Bidirectional traceability supports coverage, consistency and impact analysis.

BP10: Ensure consistency.

1. Ensure consistency between mechanical system requirements and the mechanical system architectural design.
2. Ensure consistency between elements of the mechanical system architectural design and elements of the system architectural design.

[OUTCOME 1, 2, 5, 6]

NOTE 10: Consistency is supported by bidirectional traceability and can be demonstrated by review records.

NOTE 11: Mechanical system requirements include mechanical system architectural requirements, refer to BP7.

BP11: Communicate agreed mechanical system architectural design.

Communicate the agreed mechanical system architectural design and updates to mechanical system architectural design to all relevant stakeholders. [OUTCOME 6]

Output Work Products

04-ME01	Mechanical system architectural design [OUTCOME 1, 2, 3, 4, 5]
13-04	Communication record [OUTCOME 6]
13-19	Review record [OUTCOME 5]

13-22	Traceability record [OUTCOME 5]
17-08	Interface requirement specification [OUTCOME 3]
13-ME01	Characteristics classification record [OUTCOME 1]

3.1.3 Mechanical System Integration and Integration Test

ID
MSE.3
Process Name
Mechanical System Integration and Integration Test
Process Purpose
The purpose of the Mechanical System Integration and Integration Test Process is to integrate the mechanical items (mechanical component items and/or mechanical system items) into larger mechanical items up to a complete integrated mechanical system item consistent with the mechanical system architectural design and to ensure that the mechanical items are tested to provide evidence for compliance of the integrated mechanical items with the mechanical system architectural design, including the interfaces between the mechanical items.
Process Outcomes
As a result of successful implementation of this process: 1) a mechanical system integration strategy consistent with the project plan, release plan and the mechanical system architectural design is developed to integrate the mechanical items; 2) a mechanical system integration test strategy including the regression test strategy is developed to test the mechanical items interactions; 3) a specification for mechanical system integration test according to the mechanical system integration test strategy is developed that is suitable to provide evidence for compliance of the integrated mechanical items with the mechanical system architectural design, including the interfaces between the mechanical items; 4) mechanical items are integrated up to a complete integrated mechanical system according to the integration strategy; 5) test cases included in the mechanical system integration test specification are selected according to the mechanical system integration test strategy, and the release plan; 6) integrated mechanical items are tested using the selected test cases and the results of mechanical system integration testing are recorded; 7) consistency and bidirectional traceability are established between the elements of the mechanical system architectural design and the test cases included in the mechanical system integration test specification, between test cases and test results and between integrated mechanic items and recorded process data; and 8) the results of the mechanical system integration test are summarized and communicated to all affected stakeholders.
Base Practices
BP1: Develop mechanical system integration strategy. Develop a strategy for integrating mechanical sub-systems consistent with the project plan and the release plan. Identify mechanical sub-systems based on the mechanical system architectural design and define a sequence for integrating them. [OUTCOME 1] **BP2: Develop mechanical system integration test strategy including regression test strategy.** Develop a strategy for testing the integrated mechanical item following the mechanical system integration strategy. This includes a regression test strategy for re-testing integrated mechanical item if a me-

chanical item is changed. [OUTCOME 2]

BP3: Develop specification for mechanical system integration test.

Develop the test specification for mechanical system integration test including the test cases according to the mechanical system integration test strategy for each integrated mechanical item. The test specification shall be suitable to provide evidence for compliance of the integrated mechanical items with the mechanical system architectural design. [OUTCOME 3]

NOTE 1: Compliance to the architectural design means that the specified integration tests are suitable to prove that the interfaces between the mechanical items fulfill the specification (e.g. special characteristics) given by the mechanical system architectural design.

BP4: Integrate mechanical items.

Integrate the mechanical items to integrated mechanical system item according to the mechanical system integration strategy and record process data according to the integration strategy. [OUTCOME 4]

BP5: Select test cases.

Select test cases from the mechanical system integration test specification. The selection of test cases shall have sufficient coverage according to the mechanical system integration test strategy and the release plan. [OUTCOME 5]

BP6: Perform mechanical system integration test.

Perform the mechanical system integration test using the selected test cases. Record the integration test results and logs. [OUTCOME 6]

NOTE 2: See SUP.9 for handling of non-conformances

NOTE 3: Capable test environment as defined in the test strategy needs to be available for performing mechanical system integration and integration test.

BP7: Establish bidirectional traceability.

1. Establish bidirectional traceability between elements of the mechanical system architectural design and test cases included in the mechanical system integration test specification.
2. Establish bidirectional traceability between test cases included in the mechanical system integration test specification and mechanical system integration test results.
3. Establish bidirectional traceability between integrated mechanical items and recorded process data according to the mechanical system integration strategy.
4. Establish bidirectional traceability between integrated mechanical items and the considered mechanical system item.
5. Establish bidirectional traceability between the mechanical integration test results and the integrated mechanical systems.

[OUTCOME 7]

NOTE 4: Bidirectional traceability supports coverage, consistency and impact analysis.

BP8: Ensure consistency.

1. Ensure consistency between elements of the mechanical system architectural design and test cases included in the mechanical system integration test specification.
2. Ensure consistency between test cases included in the mechanical system integration test specification and mechanical system integration test results.
3. Ensure consistency between integrated mechanical items and recorded process data according to the mechanical system integration strategy.
4. Ensure consistency between integrated mechanical items and the considered mechanical system item.
5. Ensure consistency between the mechanical integration test results and the integrated mechanical systems.

[OUTCOME 7]

NOTE 5: Consistency is supported by bidirectional traceability and can be demonstrated by review records.

BP9: Summarize and communicate results.

Summarize the mechanical system integration test results and communicate them to all affected stakeholders. [OUTCOME 8]

NOTE 6: Providing all necessary information (e.g. test results, recorded process data) from the test case execution in a summary enables stakeholders to judge the consequences.

Output Work Products	
08-ME01	Sample control plan [OUTCOME 1, 2]
17-ME02	Assembly instruction [OUTCOME 1]
13-ME02	Assembly record [OUTCOME 4]
08-50	Test specification [OUTCOME 3,5]
13-50	Test result [OUTCOME 6, 8]
13-22	Traceability record [OUTCOME 7]
17-ME03	Bill of material (BOM, Build list) [OUTCOME 3, 4, 7]
11-ME01	Mechanical System [OUTCOME 4]
13-04	Communication record [OUTCOME 8]
13-19	Review record [OUTCOME 7]

3.1.4 Mechanical System Qualification Test

ID
MSE.4
Process Name
Mechanical System Qualification Test
Process Purpose
The purpose of the Mechanical System Qualification Test Process is to ensure that the integrated mechanical system is tested to provide evidence for compliance with the mechanical system requirements.
Process Outcomes
As a result of successful implementation of this process: 1) a mechanical system qualification test strategy including regression test strategy consistent with the project plan and the release plan is developed to test the integrated mechanical system; 2) a specification for mechanical system qualification test of the integrated mechanical system according to the mechanical system qualification test strategy is developed that is suitable to provide evidence for compliance with the mechanical system requirements; 3) test cases included in the mechanical system qualification test specification are selected according to the mechanical system qualification test strategy and the release plan; 4) the integrated mechanical system is tested using the selected test cases and the results of mechanical system qualification test are recorded; 5) consistency and bidirectional traceability are established between mechanical system requirements and mechanical system qualification test specification including test cases and between test cases and test results; and 6) results of the mechanical system qualification test are summarized and communicated to all affected stakeholders.
Base Practices
BP1: Develop mechanical system qualification test strategy including a regression test strategy. Develop a strategy for mechanical system qualification testing consistent with the project plan and the release plan. This includes a regression test strategy for re-testing the integrated mechanical system if a mechanical sub-system is changed. [OUTCOME 1] **BP2: Develop specification for mechanical system qualification test.** Develop the specification for mechanical system qualification testing including test cases based on the verification criteria according to the mechanical system test strategy. The test specification shall be suitable to provide evidence for compliance of the integrated mechanical system with the mechanical system requirements. [OUTCOME 2] **BP3: Select test cases.** Select test cases from the mechanical system qualification test specification. The selection of test cases shall have sufficient coverage according to the mechanical system qualification test strategy and the release plan. [OUTCOME 3] **BP4: Test the integrated mechanical system.** Test the mechanical system using the selected test cases. Record the mechanical system qualification test results and logs. [OUTCOME 4] NOTE 1: See SUP.9 for handling of non-conformances

NOTE 2: Capable test environment as defined in the test strategy needs to be available for performing mechanical system qualification testing.

BP5: Establish bidirectional traceability.

1. Establish bidirectional traceability between mechanical system requirements and test cases included in the mechanical system qualification test specification.
2. Establish bidirectional traceability between test cases included in the mechanical system qualification test specification and mechanical system qualification test results.
3. Establish bidirectional traceability between the mechanical system qualification test results and the integrated mechanical systems.

[OUTCOME 5]

NOTE 3: Bidirectional traceability supports coverage, consistency and impact analysis.

BP6: Ensure consistency.

1. Ensure consistency between mechanical system requirements and test cases included in the mechanical system qualification test specification.
2. Ensure consistency between test cases included in the mechanical system qualification test specification and mechanical system qualification test results.
3. Ensure consistency between the mechanical system qualification test results and the integrated mechanical systems.

[OUTCOME 5]

NOTE 4: Consistency is supported by bidirectional traceability and can be demonstrated by review records.

BP7: Summarize and communicate results.

Summarize the mechanical system qualification test results and communicate them to all affected stakeholders. [OUTCOME 6]

NOTE 5: Providing all necessary information from the test case execution in a summary enables stakeholders to judge the consequences.

Output Work Products

08-52	Test plan (Design Verification Plan, DVP) [OUTCOME 1, 2, 6]
08-50	Test specification [OUTCOME 2, 3]
13-50	Test result [OUTCOME 4, 6]
13-22	Traceability record [OUTCOME 5]
13-04	Communication record [OUTCOME 6]
13-19	Review record [OUTCOME 5]

3.2 Mechanical Component Engineering Process Group

3.2.1 Mechanical Component Requirements Analysis

ID
MCE.1
Process Name
Mechanical Component Requirements Analysis
Process Purpose
The purpose of the Mechanical Component Requirements Analysis process is to establish the requirements for the mechanical component.
Process Outcomes
As a result of successful implementation of this process: 1) the mechanical component requirements are derived from the upper system requirements and upper system architecture; 2) mechanical component requirements are categorized and analyzed for completeness, correctness, and verifiability; 3) the impact of mechanical component requirements on the operating environment is analyzed; 4) prioritization for implementing the mechanical component requirements is defined; 5) the mechanical component requirements are updated as needed; 6) consistency and bidirectional traceability are established between upper system requirements and mechanical component requirements; and consistency and bidirectional traceability are established between upper system architectural design and mechanical component requirements; 7) the mechanical component requirements are evaluated for cost, schedule and technical impact; and 8) the mechanical component requirements are agreed and communicated to all affected stakeholders.
Base Practices
BP.1: Specify mechanical component requirements. Use the upper system requirements and the upper system architecture and changes to the upper system requirements and the upper system architecture to identify the required functions and capabilities of the mechanical component. Specify functional and non-functional mechanical component requirements in a mechanical component requirements specification. [OUTCOME 1, 5, 7] NOTE 1: If the system requirements and the system architectural design refer to a given operating environment, then the stakeholder requirements should be used as the basis for identifying the required functions and capabilities of the mechanic component. NOTE 2: Non-functional requirements may include e.g. production, maintenance, logistic, environmental. **BP2: Structure mechanical component requirements.** Structure the mechanical component requirements in the mechanical component requirements specification by e.g. • grouping to project relevant clusters, • sorting in a logical order for the project, • categorizing based on relevant criteria for the project, • prioritizing according to stakeholder needs.

[OUTCOME 2, 4]

NOTE 3: Prioritizing typically includes the assignment of mechanical content to planned releases. Refer to SPL.2 BP1.

BP.3: Analyze mechanical component requirements.

Analyze the specified mechanical component requirements including their interdependencies to ensure correctness, technical feasibility, producibility and verifiability, and to support risk identification. Analyze the impact on cost, schedule and the technical impact. [OUTCOME 2, 7]

NOTE 4: The analysis of impact on cost, schedule and quality supports the adjustment of project estimates. Refer to MAN.3 BP5.

BP4: Analyze the impact on the operating environment.

Analyze the impact that the mechanical component requirements will have on interfaces of system elements and the operating environment. [OUTCOME 3, 7]

BP5: Develop verification criteria.

Develop the verification criteria for each mechanical component requirement that define the qualitative and quantitative measures for the verification of a requirement. [OUTCOME 2, 7]

NOTE 5: Verification criteria demonstrate that a requirement can be verified within agreed constraints and are typically used as the input for the development of the test cases or other verification measures that should demonstrate compliance with the mechanic component requirements.

NOTE 6: Verification which cannot be covered by testing is covered by SUP.2.

BP6: Establish bidirectional traceability.

1. Establish bidirectional traceability between upper system requirements and mechanical component requirements.
2. Establish bidirectional traceability between the upper system architecture and mechanical component requirements.

[OUTCOME 6]

NOTE 7: Redundancy should be avoided by establishing a combination of the approaches BP6.1 and BP6.2 that covers the project and the organizational needs.

NOTE 8: Bidirectional traceability supports coverage, consistency and impact analysis.

BP7: Ensure consistency.

1. Ensure consistency between upper system requirements and mechanical component requirements.
2. Ensure consistency between the upper system architecture and mechanical component requirements.

[OUTCOME 6]

NOTE 9: Consistency is supported by bidirectional traceability and can be demonstrated by review records.

NOTE 10: If the system requirements and the system architectural design refer to a given operating environment, then the stakeholder requirements should be used as the basis for identifying the required functions and capabilities of the mechanic component.

BP8: Communicate agreed mechanical component requirements.

Communicate the agreed mechanical component requirements and updates to mechanical component requirements to all relevant stakeholders. [OUTCOME 8]

Output Work Products

13-04	Communication record [OUTCOME 8]
13-19	Review record [OUTCOME 6]

13-21	Change control record [OUTCOME 5, 7]
13-22	Traceability record [OUTCOME 1, 6]
15-01	Analysis report [OUTCOME 2, 3, 4, 7]
17-08	Interface requirements specification [OUTCOME 1]
17-ME04	Mechanical component requirements specification [OUTCOME 1]
17-50	Verification criteria [OUTCOME 2]

3.2.2 Mechanical Component Design

ID
MCE.2
Process Name
Mechanical Component Design
Process Purpose
The purpose of the Mechanical Component Design process is to provide an evaluated design for the mechanical component.
Process Outcomes
As a result of successful implementation of this process: 1) a design is developed that describes the mechanical component; 2) interfaces of the mechanical component are defined; 3) consistency and bidirectional traceability are established between mechanical component requirements and mechanical component design; and consistency and bidirectional traceability are established between upper system architecture and mechanical component design; and 4) the mechanical component design is agreed and communicated to all affected stakeholders.
Base Practices
BP.1: Develop mechanical component design. Develop a design for the mechanical component using the functional and non-functional mechanical component requirements including interfaces. [OUTCOME 1] While developing the mechanical component design the requirements and data relevant for production are identified and documented. NOTE 1: Non-functional requirements may include e.g. price per unit, maintenance, logistic, packaging, size, weight, manufacturability, environmental constraints, design guidelines, modelling guidelines, failure times. NOTE 2: Design for Manufacturing and Design for Assembly may be used to ensure manufacturability. **BP2: Evaluate mechanical component design.** Evaluate the mechanical component design in terms of interaction, criticality, technical complexity, risks, measurability and verifiability. [OUTCOME 1,2] NOTE 3: The results of the evaluation can be used as input for test against mechanical component design. **BP3: Verify mechanical component design.** Ensure that the mechanical component design meets all mechanical component requirements. [Outcomes 4] NOTE 4: Verification of mechanical component design may include FEA, simulation, or Product FMEA. **BP4: Establish bidirectional traceability.** 1. Establish bidirectional traceability between mechanical component requirements and mechanical component design. 2. Establish bidirectional traceability between the mechanical system architectural design and mechanical component design. [OUTCOME 3]

NOTE 5: Redundancy should be avoided by establishing a combination of the approaches BP4.1 and BP4.2 that covers the project and the organizational needs.

NOTE 6: Bidirectional traceability supports coverage, consistency and impact analysis.

BP5: Ensure consistency.

1. Ensure consistency between mechanical component requirements and mechanical component design.
2. Ensure consistency between the mechanical system architectural design and mechanical component design.

[OUTCOME 3]

NOTE 7: Consistency is supported by bidirectional traceability and can be demonstrated by review records.

BP6: Communicate agreed mechanical component design.

Communicate the agreed mechanical component design and updates to the mechanical component design to all relevant stakeholders. [OUTCOME 4]

Output Work Products	
04-ME02	Mechanical component design [OUTCOME 1, 2]
13-22	Traceability record [OUTCOME 3]
13-04	Communication record [OUTCOME 4]

3.2.3 Mechanical Component Sample Production

ID
MCE.3
Process Name
Mechanical Component Sample Production
Process Purpose
The purpose of the Mechanical Component Sample Production process is to produce a mechanical component item that reflects properly the mechanical component design and mechanical component production strategy.
Process Outcomes
As a result of successful implementation of this process: 1) a mechanical component production strategy is developed, communicated to, and agreed on with all affected stakeholders, 2) mechanical component items are produced according to the mechanical component design, 3) bidirectional traceability are established between the produced mechanical component and recorded process data according to the mechanical component production strategy; and consistency and bidirectional traceability are established between recorded process data and the mechanical component production strategy (control plan), and 4) information gathered during production is communicated to all affected stakeholders.
Base Practices
BP1: Develop mechanical component production strategy. Develop a strategy for production of the mechanical component item. The mechanical component production strategy shall be consistent with the mechanical component design, project plan (e.g. estimation of number of built items needed), release plan (e.g. definition of releases and their content), and test strategy (e.g. mapping of test methods to releases). [OUTCOME 1] The mechanical component production strategy may contain the definition of the production method(s), verification method(s) (control plan). **BP.2: Agree on mechanical component production strategy.** Communicate the agreed mechanical component production strategy between all involved stakeholders (e.g. engineering, sample shop, production). [OUTCOME 1] NOTE 1: The communication of the mechanical component production strategy to suppliers is handled by ACQ.4 Supplier monitoring. **BP.3: Ensure and support production of mechanical components.** Ensure and support production of mechanical component items according to: • the mechanical component design • mechanical component production strategy • the requirements and data relevant for production. Record process data according to the mechanical component production strategy. [OUTCOME 2, 4] NOTE 2: Production here means only sample phases (e.g. prototype building, pre-series production) and does not cover the process of industrialization. **BP.4: Establish bidirectional traceability.**

1. Establish bidirectional traceability between mechanical component production strategy and mechanical component design.
2. Establish bidirectional traceability between the produced mechanical component item and production record according to the mechanical component production strategy.
3. Establish bidirectional traceability between recorded process data and mechanical component production strategy (control plan).

[OUTCOME 3]

NOTE 3: Bidirectional traceability supports coverage, consistency and impact analysis.

BP.5: Ensure consistency.

1. Ensure consistency between mechanical component production strategy and mechanical component design.
2. Ensure consistency between produced mechanical component item and recorded process data according to the mechanical component production strategy.
3. Ensure consistency between production record and mechanical component production strategy (control plan).

[OUTCOME 3]

NOTE 4: Consistency is supported by bidirectional traceability and can be demonstrated by review records.

BP.6: Provide feedback to all affected stakeholders.[FE9]

Communicate information gathered during the production of the mechanical component to all affected stakeholders. [OUTCOME 4]

These information may contain:

- Capability of chosen production method
- Manufacturability of the mechanical component
- Improvement potentials for future releases
- Process data and information

NOTE 5: See SUP.9 for handling of non-conformances

NOTE 6: The communication of information mentioned above is handled by ACQ.4 Supplier monitoring in case of production at a supplier's site.

Affected stakeholders may be:

- Industrialization
- Series production
- Mechanical engineering
- Project management

Output Work Products

11-ME02 Mechanical Component [OUTCOME 2]

19-ME01 Production strategy [OUTCOME 1]

13-ME03 Production record [OUTCOME 2, 4]

13-22 Traceability record [OUTCOME 3]

13-04 Communication record [OUTCOME 4]

15-01 Analysis report (Containing analyses results of e.g. suitability of chosen production method regarding effectiveness, timing, cost) [OUTCOME 4]

3.2.4 Test against Mechanical Component Design

ID
MCE.4
Process Name
Test against Mechanical Component Design
Process Purpose
The purpose of the Test against mechanical component design process is to test the mechanical component item to provide evidence for compliance of the mechanical component item with the mechanical component design.
Process Outcomes
As a result of successful implementation of this process: 1) a strategy for test against mechanical component design including regression test strategy is developed; 2) a specification for test against mechanical component design is developed according to the strategy for test against mechanical component design that is suitable to provide evidence for compliance of the mechanical component item with the mechanical component design; 3) test cases included in the test specification for test against mechanical component design are selected according to the test strategy for test against the mechanical component design and the release plan; 4) the mechanical component item is tested according to the strategy for test against mechanical component design and the test specification for test against mechanical component design and the results are recorded; 5) consistency and bidirectional traceability are established between the mechanical component design and the test specification for test against mechanical component design as well as between the test specification for test against mechanical component design and test results; and 6) results of the test against mechanical component design are summarized and communicated to all affected stakeholders.
Base Practices
BP.1: Develop strategy for test against mechanical component design including regression test strategy. Develop a strategy for test against mechanical component design including regression test strategy for re-test if the mechanical component design is changed. The test strategy shall define how to provide evidence for compliance of the mechanical component item with the mechanical component design. [OUTCOME 1] NOTE 1: The test strategy shall contain a planning of needed items for testing and the allocation of tests to be performed within different releases. The needed amount of items for dedicated tests shall consider that random and systematic faults have to be detected. **BP.2: Develop test specification for test against mechanical component design.** Develop test specification for test against mechanical component design including test cases that are suitable to provide evidence for compliance of the mechanical component item with the mechanical component design according to the test strategy. [OUTCOME 2] **BP.3: Select test cases.** Select test cases from the test specification for test against mechanical component design. The selection

of test cases shall have sufficient coverage according to the test strategy for test against mechanical component design and the release plan. [OUTCOME 3]

BP.4: Test mechanical component item.

Test the mechanical component item using the test specification for test against mechanical component design according to the strategy for test against mechanical component design. Record the test results and measured values. [OUTCOME 4]

NOTE 2: See SUP.9 for handling of non-conformances.

NOTE 3: Capable test environment as defined in the test strategy needs to be available for performing test against mechanical component design.

BP5: Establish bidirectional traceability.

1. Establish bidirectional traceability between the mechanical component design and the mechanical component test specification for test against mechanical component design.
2. Establish bidirectional traceability between the test results and tested mechanical component items.
3. Establish bidirectional traceability between test cases included in the mechanical component test specification and mechanical component test results.

[OUTCOME 5]

NOTE 4: Bidirectional traceability supports coverage, consistency and impact analysis.

BP6: Ensure consistency.

1. Ensure consistency between the mechanical component design and the test specification for test against mechanical component design.
2. Ensure consistency between the test results and tested mechanical component items.
3. Ensure consistency between test cases included in the mechanical componenttest specification and mechanical component test results.

[OUTCOME 5]

NOTE 5: Consistency is supported by bidirectional traceability and can be demonstrated by review records.

BP7: Summarize and communicate results.

Summarize the test results and communicate them to all affected stakeholders. [OUTCOME 6]

NOTE 6: Providing all necessary information from the test case execution in a summary enables stakeholders to judge the consequences.

Output Work Products

08-50	Test specification [OUTCOME 2]
08-52	Test plan [OUTCOME 1]
13-04	Communication record [OUTCOME 5]
13-19	Review record [OUTCOME 3, 4]
13-22	Traceability record [OUTCOME 4]
13-50	Test result [OUTCOME 3, 5, 6]

3.2.5 Test against Mechanical Component Requirements

ID
MCE.5
Process Name
Test against Mechanical Component Requirements
Process Purpose
The purpose of the Test against Mechanical Component Requirements process is to test the mechanical component to provide evidence for compliance of the mechanical component with the mechanical component requirements.
Process Outcomes
As a result of successful implementation of this process: 1) a strategy for the test against mechanical component requirements including regression test strategy consistent with the project plan and the release plan is developed; 2) a specification for the test against mechanical component requirements is developed according to the strategy for the test against mechanical component requirements that is suitable to provide evidence for compliance of the mechanical component with the mechanical component requirements; 3) test cases included in the test specification for the test against mechanical component requirements are selected according to the test strategy for the test against mechanical component requirements and the release plan 4) the mechanical component is tested according to the strategy for the test against mechanical component requirements and the test specification for the test against mechanical component requirements, and the results are recorded; 5) consistency and bidirectional traceability are established between the mechanical component requirements and the test specification for the test against mechanical component requirements as well as between the test specification for the test against mechanical component requirements and test results; and 6) results of the test against mechanical component requirements are summarized and communicated to all affected stakeholders.
Base Practices
BP.1: Develop strategy for the test against mechanical component requirements including regression test strategy. Develop a strategy for the test against mechanical component requirements consistent with the project plan and the release plan. This includes a regression test strategy for re-testing the mechanical component if it has been changed. [OUTCOME 1] NOTE 1: The test strategy shall include a plan of which items need to be tested and the allocation of tests to be performed within different releases. The needed amount of items for dedicated tests shall consider that random and systematic faults have to be detected. **BP.2: Develop test specification for the test against mechanical component requirements.** Develop test specification including test cases for the test against mechanical component requirements that are suitable to provide evidence for compliance of the mechanical component with the mechanical component requirements according to the test strategy. [OUTCOME 2] **BP.3: Select test cases.**

Select test cases from the test specification for the test against mechanical component requirements. The selection of test cases shall have sufficient coverage according to the test strategy for the test against mechanical component requirements and the release plan. [OUTCOME 5]

BP.4: Test the mechanical component.

Test the mechanical component using the test specification for the test against mechanical component requirements according to the strategy for the test against mechanical component requirements. Record the test results and measured values. [OUTCOME 3]

NOTE 2: See SUP.9 for handling of non-conformances.

NOTE 3: Capable test environment as defined in the test strategy needs to be available for performing test against mechanical component requirements.

BP5: Establish bidirectional traceability.

1. Establish bidirectional traceability between the mechanical component requirements and the test specification for test against mechanical component requirements.
2. Establish bidirectional traceability between the test specification for the test against mechanical component requirements and test results.
3. Establish bidirectional traceability between the mechanical component qualification test results and the tested mechanical component items.

[OUTCOME 4]

NOTE 4: Bidirectional traceability supports coverage, consistency and impact analysis.

BP6: Ensure consistency.

1. Ensure consistency between the mechanical component requirements and the test specification for the test against mechanical component requirements.
2. Ensure consistencybetween the test specification for the test against mechanical component requirements and test results.
3. Ensure consistency between the mechanical component qualification test results and the tested mechanical component items.

[OUTCOME 4]

NOTE 5: Consistency is supported by bidirectional traceability and can be demonstrated by review records.

BP7: Summarize and communicate results.

Summarize the test results and communicate them to all affected stakeholders. [OUTCOME 5]

NOTE 6: Providing all necessary information from the test case execution in a summary enables stakeholders to judge the consequences.

Output Work Products

08-50	Test specification [OUTCOME 2]
08-52	Test plan [OUTCOME 1]
13-04	Communication record [OUTCOME 5]
13-19	Review record [OUTCOME 3, 4]
13-22	Traceability record [OUTCOME 4]
13-50	Test result [OUTCOME 3, 5]

4 Process capability levels and process attributes

Process capability indicators are the means of achieving the capabilities addressed by the considered process attributes. Evidence of process capability indicators supports the judgment of the degree of achievement of the process attribute.
The capability dimension of the process assessment model consists of six capability levels matching the capability levels defined in ISO/IEC 33020. The process capability indicators for the 9 process attributes included in the capability dimension for process capability level 1 to 5 are described.
Each of the process attributes in this process assessment model is identical to the process attribute defined in the process measurement framework. The generic practices address the characteristics from each process attribute. The generic resources relate to the process attribute as a whole.
Process capability level 0 does not include any type of indicators, as it reflects a non-implemented process or a process which fails to partially achieve any of its outcomes.
NOTE: ISO/IEC 33020 process attribute definitions and attribute outcomes are duplicated from ISO/IEC 33020 in italic font and marked with a left side bar.

4.1 Process capability Level 0: Incomplete process

The process is not implemented, or fails to achieve its process purpose. At this level there is little or no evidence of any systematic achievement of the process purpose.

4.2 Process capability Level 1: Performed process

The implemented process achieves its process purpose. The following process attribute demonstrates the achievement of this level

4.2.1 PA 1.1 Process performance process attribute

The process performance process attribute is a measure of the extent to which the process purpose is achieved. As a result of full achievement of this attribute:

a) the process achieves its defined outcomes

Generic practices	**GP 1.1.1 Achieve the process outcomes** [ACHIEVEMENT a] Achieve the intent of the base practices. Produce work products that evidence the process outcomes.
Generic resources	**Resources are used to achieve the intent of process specific base practices** [ACHIEVEMENT a]

4.3 Process capability Level 2: Managed process

The previously described Performed process is now implemented in a managed fashion (planned, monitored and adjusted) and its work products are appropriately established, controlled and maintained.
The following process attributes, together with the previously defined process attribute, demonstrate the achievement of this level:

4.3.1 PA 2.1 Performance management process attribute

The performance management process attribute is a measure of the extent to which the performance of the process is managed. As a result of full achievement of this process attribute:
a) Objectives for the performance of the process are identified;
b) Performance of the process is planned;
c) Performance of the process is monitored;
d) Performance of the process is adjusted to meet plans;
e) Responsibilities and authorities for performing the process are defined, assigned and communicated;
f) Personnel performing the process are prepared for executing their responsibilities;
g) Resources and information necessary for performing the process are identified, made available, allocated and used;
h) Interfaces between the involved parties are managed to ensure both effective communication and clear assignment of responsibility.

Generic practices	**GP 2.1.1 Identify the objectives for the performance of the process.** [ACHIEVEMENT a] Performance objectives are identified based on process requirements. The scope of the process performance is defined. Assumptions and constraints are considered when identifying the performance objectives. *NOTE 1: Performance objectives may include* *(1) timely production of artifacts meeting the defined quality criteria,* *(2) process cycle time or frequency* *(3) resource usage; and* *(4) boundaries of the process.* *NOTE 2: At minimum, process performance objectives for resources, effort and schedule should be stated.* **GP 2.1.2 Plan the performance of the process to fulfill the identified objectives.** [ACHIEVEMENT b] Plan(s) for the performance of the process are developed. The process performance cycle is defined. Key milestones for the performance of the process are established. Estimates for process performance attributes are determined and maintained. Process activities and tasks are defined. Schedule is defined and aligned with the approach to performing the process. Process work product reviews are planned. **GP 2.1.3 Monitor the performance of the process against the plans.** [ACHIEVEMENT c] The process is performed according to the plan(s). Process performance is monitored to ensure planned results are achieved and to identify possible deviations **GP 2.1.4 Adjust the performance of the process.** [ACHIEVEMENT d] Process performance issues are identified. Appropriate actions are taken when planned results and objectives are not achieved. The plan(s) are adjusted, as necessary. Rescheduling is performed as necessary. **GP 2.1.5 Define responsibilities and authorities for performing the process.** [ACHIEVEMENT e] Responsibilities, commitments and authorities to perform the process are defined, assigned and communicated. Responsibilities and authorities to verify process work products are defined

	and assigned. The needs for process performance experience, knowledge and skills are defined. **GP 2.1.6 Identify, prepare, and make available resources to perform the process according to plan.** [ACHIEVEMENT f, g] The human and infrastructure resources, necessary for performing the process are identified made available, allocated and used. The individuals performing and managing the process are prepared by training, mentoring, or coaching to execute their responsibilities. The information necessary to perform the process is identified and made available. **GP 2.1.7 Manage the interfaces between involved parties.** [ACHIEVEMENT h] The individuals and groups involved in the process performance are determined. Responsibilities of the involved parties are assigned. Interfaces between the involved parties are managed. Communication is assured between the involved parties. Communication between the involved parties is effective.
Generic resources	**Human resources with identified objectives, responsibilities and authorities** [ACHIEVEMENT e, f, h] **Facilities and infrastructure resources** [ACHIEVEMENT g, h] **Project planning, management and control tools, including time and cost reporting** [ACHIEVEMENT a, b, c, d] **Workflow management system** [ACHIEVEMENT d, f, g, h] **Human resources with identified objectives, responsibilities and authorities** [ACHIEVEMENT e, f, h] **Facilities and infrastructure resources** [ACHIEVEMENT g, h] **Project planning, management and control tools, including time and cost reporting** [ACHIEVEMENT a, b, c, d] **Workflow management system** [ACHIEVEMENT d, f, g, h] **Email and/or other communication mechanisms** [ACHIEVEMENT b, c, d, f, g, h] **Information and/or experience repository** [ACHIEVEMENT b, d, e] **Problem and issues management mechanisms** [ACHIEVEMENT c]

4.3.2 PA 2.2 Work product management process attribute

The work product management process attribute is a measure of the extent to which the work products produced by the process are appropriately managed. As a result of full achievement of this process attribute:
a) Requirements for the work products of the process are defined;
b) Requirements for documentation and control of the work products are defined;
c) Work products are appropriately identified, documented, and controlled;
d) Work products are reviewed in accordance with planned arrangements and adjusted as necessary to meet requirements.

NOTE 1: Requirements for documentation and control of work products may include requirements for the identification of changes and revision status, approval and re-approval of work products, distribution of work products, and for making relevant versions of applicable work products available at points of use.
NOTE 2: The work products referred to in this clause are those that result from the achievement of the process purpose through the process outcomes.

Generic practices	**GP 2.2.1 Define the requirements for the work products.** [ACHIEVEMENT a] The requirements for the work products to be produced are defined. Requirements may include defining contents and structure. Quality criteria of the work products are identified. Appropriate review and approval criteria for the work products are defined. **GP 2.2.2 Define the requirements for documentation and control of the work products.** [ACHIEVEMENT b] Requirements for the documentation and control of the work products are defined. Such requirements may include requirements for (1) distribution, (2) identification of work products and their components and (3) traceability. Dependencies between work products are identified and understood. Requirements for the approval of work products to be controlled are defined. **GP 2.2.3 Identify, document and control the work products.** [ACHIEVEMENT c] The work products to be controlled are identified. Change control is established for work products. The work products are documented and controlled in accordance with requirements. Versions of work products are assigned to product configurations as applicable. The work products are made available through appropriate access mechanisms. The revision status of the work products may readily be ascertained. **GP 2.2.4 Review and adjust work products to meet the defined requirements.** [ACHIEVEMENT d] Work products are reviewed against the defined requirements in accordance with planned arrangements. Issues arising from work product reviews are resolved
Generic resources	**Requirement management method/toolset** [ACHIEVEMENT a, b, c] **Configuration management system** [ACHIEVEMENT b, c] **Documentation elaboration and support tool** [ACHIEVEMENT b, c] **Document identification and control procedure** [ACHIEVEMENT b, c] **Work product review methods and experiences** [ACHIEVEMENT d] **Review management method/toolset** [ACHIEVEMENT d] **Intranets, extranets and/or other communication mechanisms** [ACHIEVEMENT b, c] **Problem and issue management mechanisms** [ACHIEVEMENT d]

4.4 Process capability Level 3: Established process

The previously described Managed process is now implemented using a defined process that is capable of achieving its process outcomes.
The following process attributes, together with the previously defined process attributes, demonstrate the achievement of this level:

4.4.1 PA 3.1 Process definition process attribute

The process definition process attribute is a measure of the extent to which a standard process is maintained to support the deployment of the defined process. As a result of full achievement of this process attribute:

a) A standard process, including appropriate tailoring guidelines, is defined and maintained that describes the fundamental elements that must be incorporated into a defined process;
b) The sequence and interaction of the standard process with other processes is determined.
c) Required competencies and roles for performing the process are identified as part of the standard process;
d) Required infrastructure and work environment for performing the process are identified as part of the standard process;
e) Suitable methods and measures for monitoring the effectiveness and suitability of the process are determined.

Generic practices	**GP 3.1.1 Define and maintain the standard process that will support the deployment of the defined process.** [ACHIEVEMENT a] A standard process is developed and maintained that includes the fundamental process elements. The standard process identifies the deployment needs and deployment context. Guidance and/or procedures are provided to support implementation of the process as needed. Appropriate tailoring guideline(s) are available as needed. **GP 3.1.2 Determine the sequence and interaction between processes so that they work as an integrated system of processes.** [ACHIEVEMENT b] The standard process's sequence and interaction with other processes are determined. Deployment of the standard process as a defined process maintains integrity of processes. **GP 3.1.3 Identify the roles and competencies, responsibilities, and authorities for performing the standard process.** [ACHIEVEMENT c] Process performance roles are identified Competencies for performing the process are identified. Authorities necessary for executing responsibilities are identified. **GP 3.1.4 Identify the required infrastructure and work environment for performing the standard process.** [ACHIEVEMENT d] Process infrastructure components are identified (facilities, tools, networks, methods, etc.). Work environment requirements are identified. **GP 3.1.5 Determine suitable methods and measures to monitor the effectiveness and suitability of the standard process.** [ACHIEVEMENT e] Methods and measures for monitoring the effectiveness and suitability of the process are determined. Appropriate criteria and data needed to monitor the effectiveness and suitability of the process are defined. The need to conduct internal audit and management review is established. Process changes are implemented to maintain the standard process.
Generic resources	**Process modeling methods/tools** [ACHIEVEMENT a, b, c, d] **Training material and courses** [ACHIEVEMENT a, b, c, d] **Resource management system** [ACHIEVEMENT d] **Process infrastructure** [ACHIEVEMENT a, b, d] **Audit and trend analysis tools** [ACHIEVEMENT e] **Process monitoring method** [ACHIEVEMENT e]

4.4.2 PA 3.2 Process deployment process attribute

The process deployment process attribute is a measure of the extent to which the standard process is deployed as a defined process to achieve its process outcomes. As a result of full achievement of this process attribute:
a) A defined process is deployed based upon an appropriately selected and/or tailored standard process;
b) Required roles, responsibilities and authorities for performing the defined process are assigned and communicated;
c) Personnel performing the defined process are competent on the basis of appropriate education, training, and experience;
d) Required resources and information necessary for performing the defined process are made available, allocated and used;
e) Required infrastructure and work environment for performing the defined process are made available, managed and maintained;
f) Appropriate data are collected and analyzed as a basis for understanding the behavior of the process, to demonstrate the suitability and effectiveness of the process, and to evaluate where continual improvement of the process can be made.

Generic practices	**GP 3.2.1 Deploy a defined process that satisfies the context specific requirements of the use of the standard process.** [ACHIEVEMENT a] The defined process is appropriately selected and/or tailored from the standard process. Conformance of defined process with standard process requirements is verified. **GP 3.2.2 Assign and communicate roles, responsibilities and authorities for performing the defined process.** [ACHIEVEMENT b] The roles for performing the defined process are assigned and communicated. The responsibilities and authorities for performing the defined process are assigned and communicated. **GP 3.2.3 Ensure necessary competencies for performing the defined process.** [ACHIEVEMENT c] Appropriate competencies for assigned personnel are identified. Suitable training is available for those deploying the defined process. **GP 3.2.4 Provide resources and information to support the performance of the defined process.** [ACHIEVEMENT d] Required human resources are made available, allocated and used. Required information to perform the process is made available, allocated and used. **GP 3.2.5 Provide adequate process infrastructure to support the performance of the defined process.** [ACHIEVEMENT e] Required infrastructure and work environment is available. Organizational support to effectively manage and maintain the infrastructure and work environment is available. Infrastructure and work environment is used and maintained. **GP 3.2.6 Collect and analyze data about performance of the process to demonstrate its suitability and effectiveness.** [ACHIEVEMENT f] Data required to understand the behavior, suitability and effectiveness of the defined process are identified. Data is collected and analyzed to understand the behavior, suitability and effectiveness of the defined process. Results of the analysis are used to identify where continual improvement of the standard and/or defined process can be made.

	NOTE 1: Data about process performance may be qualitative or quantitative.
Generic resources	**Feedback mechanisms** (customer, staff, other stakeholders) [ACHIEVEMENT f] **Process repository** [ACHIEVEMENT a] **Resource management system** [ACHIEVEMENT b, c, d] **Knowledge management system** [ACHIEVEMENT a, b, d, f] **Problem and change management system** [ACHIEVEMENT f] **Working environment and infrastructure** [ACHIEVEMENT d, e] **Data collection analysis system** [ACHIEVEMENT f] **Process assessment framework** [ACHIEVEMENT f] **Audit/review system** [ACHIEVEMENT f]

4.5 Process capability Level 4: Predictable process

The previously described Established process now operates predictively within defined limits to achieve its process outcomes. Quantitative management needs are identified, measurement data are collected and analyzed to identify assignable causes of variation. Corrective action is taken to address assignable causes of variation.
The following process attributes, together with the previously defined process attributes, demonstrate the achievement of this level:

4.5.1 PA 4.1 Quantitative analysis process attribute

The quantitative analysis process attribute is a measure of the extent to which information needs are defined, relationships between process elements are identified and data are collected. As a result of full achievement of this process attribute:
a) The process is aligned with quantitative business goals;
b) Process information needs in support of relevant defined quantitative business goals are established;
c) Process measurement objectives are derived from process information needs;
d) Measurable relationships between process elements that contribute to the process performance are identified;
e) Quantitative objectives for process performance in support of relevant business goals are established;
f) Appropriate measures and frequency of measurement are identified and defined in line with process measurement objectives and quantitative objectives for process performance;
g) Results of measurement are collected, validated and reported in order to monitor the extent to which the quantitative objectives for process performance are met.

NOTE 1: Information needs typically reflect management, technical, project, process or product needs.

Generic practices	**GP 4.1.1 Identify business goals.** [ACHIEVEMENT a] Business goals are identified that are supported by the quantitatively measured process. **GP 4.1.2 Establish process information needs.** [ACHIEVEMENT a, b] Stakeholders of the identified business goals and the quantitatively measured process, and their information needs are identified, defined and agreed. **GP 4.1.3 Derive process measurement objectives from process information needs.** [ACHIEVEMENT a, c] The process measurement objectives to satisfy the established process information needs are derived. **GP 4.1.4 Identify measurable relationships between process elements.** [ACHIEVEMENT a, d] Identify the relationships between process elements, which contribute to the derived measurement objectives. **GP 4.1.5 Establish quantitative objectives.** [ACHIEVEMENT a, e] Establish quantitative objectives for the identified measurable process elements and their relationships. Agreement with process stakeholders is established. **GP 4.1.6 Identify process measures that support the achievement of the quantitative objectives.** [ACHIEVEMENT a, f] Detailed measures are defined to support monitoring, analysis and verification needs of the quantitative objectives. Frequency of data collection is defined. Algorithms and methods to create derived measurement results from base measures are defined, as appropriate. Verification mechanism for base and derived measures is defined. *NOTE 1: Typically, the standard process definition is extended to include the collection of data for process measurement.* **GP 4.1.7 Collect product and process measurement results through performing the defined process.** [ACHIEVEMENT a, g] Data collection mechanism is created for all identified measures. Required data is collected within the defined frequency, and recorded. Measurement results are analyzed, and reported to the identified stakeholders. *NOTE 2: A product measure can contribute to a process measure, e.g. the productivity of testing characterized by the number of defects found in a given timeframe in relation to the product defect rate in the field.*
Generic resources	**Management information** (cost, time, reliability, profitability, customer benefits, risks etc.) [ACHIEVEMENT a, b, c, d, e, f] **Applicable measurement techniques** [ACHIEVEMENT a, d] **Product and Process measurement tools and results databases** [ACHIEVEMENT a, d, e, f, g] **Process measurement framework** [ACHIEVEMENT a, d, e, f, g] **Tools for data analysis and measurement** [ACHIEVEMENT a, b, c, d, e, f]

4.5.2 PA 4.2 Quantitative control process attribute

The quantitative control process attribute is a measure of the extent to which objective data are used to manage process performance that is predictable. As a result of full achievement of this process attribute:
a) Techniques for analyzing the collected data are selected;
b) Assignable causes of process variation are determined through analysis of the collected data;
c) Distributions that characterize the performance of the process are established;
d) Corrective actions are taken to address assignable causes of variation;

e) Separate distributions are established (as necessary) for analyzing the process under the influence of assignable causes of variation.

Generic practices	**GP 4.2.1 Select analysis techniques.** [ACHIEVEMENT a] Analysis methods and techniques for control of the process measurements are defined. **GP 4.2.2 Establish distributions that characterize the process performance.** [ACHIEVEMENT c] Expected distributions and corresponding control limits for measurement results are defined. **GP 4.2.3 Determine assignable causes of process variation.** [ACHIEVEMENT b] Each deviation from the defined control limits is identified and recorded. Determine assignable causes of these deviations by analyzing collected data using the defined analysis techniques. All deviations and assigned causes are recorded. **GP 4.2.4 Identify and implement corrective actions to address assignable causes.** [ACHIEVEMENT d] Corrective actions are determined, recorded, and implemented to address assignable causes of variation. Corrective action results are monitored and evaluated to determine their effectiveness. **GP 4.2.5 Establish separate distributions for analyzing the process** [ACHIEVEMENT e] Separate distributions are used to quantitatively understand the variation of process performance under the influence of assignable causes.
Generic resources	**Process control and analysis techniques** [ACHIEVEMENT a, c] **Statistical analysis tools/applications** [ACHIEVEMENT a, b, c, e] **Process control tools/applications** [ACHIEVEMENT d, e]

4.6 Process capability Level 5: Innovating process

The previously described Predictable process is now continually improved to respond to change aligned with organizational goals.
The following process attributes, together with the previously defined process attributes, demonstrate the achievement of this level:

4.6.1 PA 5.1 Process innovation process attribute

The process innovation process attribute is a measure of the extent to which changes to the process are identified from investigations of innovative approaches to the definition and deployment of the process.
As a result of full achievement of this process attribute:
a) Process innovation objectives are defined that support the relevant business goals;
b) Appropriate data are analyzed to identify opportunities for innovation;
c) Innovation opportunities derived from new technologies and process concepts are identified;
d) An implementation strategy is established to achieve the process innovation objectives.

Generic practices	**GP 5.1.1 Define the process innovation objectives for the process that support the relevant business goals.** [ACHIEVEMENT a] New business visions and goals are analyzed to give guidance for new process objectives and potential areas of process innovation.

	GP 5.1.2 Analyze data of the process to identify opportunities for innovation. [ACHIEVEMENT b] Common causes of variation in process performance are identified and analyzed to get a quantitative understanding of their impact. Identify opportunities for innovation based on the quantitative understanding of the analyzed data. **GP 5.1.3 Analyze new technologies and process concepts to identify opportunities for innovation.** [ACHIEVEMENT c] Industry best practices, new technologies and process concepts are identified and evaluated. Feedback on opportunities for innovation is actively sought. Emergent risks are considered in evaluating improvement opportunities. **GP 5.1.4 Define and maintain an implementation strategy based on innovation vision and objectives.** [ACHIEVEMENT d] Commitment to innovation is demonstrated by organizational management including the process owner(s) and other relevant stakeholders. Define and maintain an implementation strategy to achieve identified opportunities for innovation and objectives. Based on implementation strategy process changes are planned, prioritized based on their impact on defined innovations. Measures that validate the results of process changes are defined to determine the expected effectiveness of the process changes and the expected impact on defined business objectives.
Generic resources	**Process improvement framework** [ACHIEVEMENT a, c, d] **Process feedback and analysis system** (measurement data, causal analysis results etc.) [ACHIEVEMENT b, c] **Piloting and trialing mechanism** [ACHIEVEMENT c, d]

4.6.2 PA 5.2 Process innovation implementation process attribute

The process innovation process implementation attribute is a measure of the extent to which changes to the definition, management and performance of the process achieves the relevant process innovation objectives. As a result of full achievement of this process attribute:
a) Impact of all proposed changes is assessed against the objectives of the defined process and standard process;
b) Implementation of all agreed changes is managed to ensure that any disruption to the process performance is understood and acted upon;
c) Effectiveness of process change on the basis of actual performance is evaluated against the defined product requirements and process objectives.

Generic practices	**GP 5.2.1 Assess the impact of each proposed change against the objectives of the defined and standard process.** [ACHIEVEMENT a] Objective priorities for process innovation are established. Specified changes are assessed against product quality and process performance requirements and goals. Impact of changes to other defined and standard processes is considered. **GP 5.2.2. Manage the implementation of agreed changes.** [ACHIEVEMENT b] A mechanism is established for incorporating accepted changes into the defined and standard process(es) effectively and completely. The factors that impact the effectiveness and full deployment of the process change are identified and managed, such as:

	• Economic factors (productivity, profit, growth, efficiency, quality, competition, resources, and capacity); • Human factors (job satisfaction, motivation, morale, conflict/cohesion, goal consensus, participation, training, span of control); • Management factors (skills, commitment, leadership, knowledge, ability, organizational culture and risks); • Technology factors (sophistication of system, technical expertise, development methodology, need of new technologies). Training is provided to users of the process. Process changes are effectively communicated to all affected parties. Records of the change implementation are maintained. **GP 5.2.3 Evaluate the effectiveness of process change.** [ACHIEVEMENT c] Performance and capability of the changed process are measured and evaluated against process objectives and historical data. A mechanism is available for documenting and reporting analysis results to management and owners of standard and defined process. Measures are analyzed to determine whether the process performance has improved with respect to common causes of variations. Other feedback is recorded, such as opportunities for further innovation of the predictable process.
Generic resources	**Change management system** [ACHIEVEMENT a, b, c] **Process evaluation system (impact analysis, etc.)** [ACHIEVEMENT a, c]

Annex A – Conformity of the process assessment and reference model

A1. Introduction

The SPICE for Mechanical Engineering process assessment and process reference model are meeting the requirements for conformance defined in ISO/IEC 33004. The process assessment model can be used in the performance of assessments that meet the requirements of ISO/IEC 33002.
This clause serves as the statement of conformance of the process assessment and process reference models to the requirements defined in ISO/IEC 33004.
[ISO/IEC 33004, 5.5 and 6.4]
Due to copyright reasons each requirement is only referred by its number. The full text of the requirements can be drawn from ISO/IEC 33004.

A2. Conformance to the requirements for process reference models

Clause 5.3, "Requirements for process reference models"

The following information is provided in chapter 1 and 3 of this document:

- the declaration of the domain of this process reference model;
- the description of the relationship between this process reference model and its intended context of use; and
- the description of the relationship between the processes defined within this process reference model.

The descriptions of the processes within the scope of this process reference model meeting the requirements of ISO/IEC 33004 clause 5.4 is provided in chapter 4 of this document.
[ISO/IEC 33004, 5.3.1]

The relevant communities of interest and their mode of use and the consensus achieved for this process reference model is documented in the copyright notice and the scope of this document.
[ISO/IEC 33004, 5.3.2]

The process descriptions are unique. The identification is provided by unique names and by the identifier of each process of this document.
[ISO/IEC 33004, 5.3.3]

Clause 5.4, "Process descriptions"

These requirements are met by the process descriptions in chapter 4 of this document.
[ISO/IEC 33004, 5.4]

A3. Conformance to the requirements for process assessment models

Clause 6.1, "Introduction"

The purpose of this process assessment model is to support assessment of process capability within the automotive domain using the process measurement framework defined in ISO/IEC 33020.
[ISO/IEC 33004, 6.1]

Clause 6.2, "Process assessment model scope"

The process scope of this process assessment model is defined in the process reference model included in chapter 3.1 of this document. The SPICE for Mechanical Engineering process reference model is satisfying the requirements of ISO/IEC 33004, clause 5 as described in Annex A.2.
The process capability scope of this process assessment model is defined in the process measurement framework specified in ISO/IEC 33020, which defines a process measurement framework for process capability satisfying the requirements of ISO/IEC 33003.
[ISO/IEC 33004, 6.2]

Clause 6.3, "Requirements for process assessment models"

The SPICE for Mechanical Engineering process assessment model is related to process capability.
[ISO/IEC 33004, 6.3.1]
This process assessment model incorporates the process measurement framework specified in ISO/IEC 33020, which satisfies the requirements of ISO/IEC 33003.
[ISO/IEC 33004, 6.3.2]
This process assessment model is based on the SPICE for Mechanical Engineering Reference Model included in this document.
This process assessment model is based on the Measurement Framework defined in ISO/IEC 33020.
[ISO/IEC 33004, 6.3.3]
The processes included in this process assessment model are identical to those specified in the Process Reference Model
[ISO/IEC 33004, 6.3.4]
For all processes in this process assessment model all levels defined in the process measurement framework from ISO/IEC 33020 are addressed.
[ISO/IEC 33004, 6.3.5]
This process assessment model defines

- the selected process quality characteristic;
- the selected process measurement framework;
- the selected process reference model(s);
- the selected processes from the process reference model(s)

in chapter 3 of this document.
[ISO/IEC 33004, 6.3.5 a-d]
In the capability dimension, this process assessment model addresses all of the process attributes and capability levels defined in the process measurement framework in ISO/IEC 33020.
[ISO/IEC 33004, 6.3.5 e]

Clause 6.3.1, "Assessment indicators"

NOTE: Due to an error in numbering in the published version of ISO/IEC 33004 the following reference numbers are redundant to those stated above. To refer to the correct clauses from ISO/IEC 33004, the text of clause heading is additionally specified for the following three requirements.

The SPICE for Mechanical Engineering process assessment model provides a two-dimensional view of process capability for the processes in the process reference model, through the inclusion of assessment indicators as defined in chapter 3.3. The assessment indicators used are:

- Base practices and output work products

[ISO/IEC 33004, 6.3.1 a, "Assessment indicators"]

- Generic practices and Generic resources

[ISO/IEC 33004, 6.3.1 b, "Assessment indicators"]

Clause 6.3.2, "Mapping process assessment models to process reference models"

The mapping of the assessment indicators to the purpose and process outcomes of the processes in the process reference model is included in each description of the base practices in chapter 4.
The mapping of the assessment indicators to the process attributes in the process measurement framework including all of the process attribute achievements is included in each description of the generic practices in chapter 5.
Each mapping is indicated by a reference in square brackets.
[ISO/IEC 33004, 6.3.2, "Mapping process assessment models"]

Clause 6.3.3, "Expression of assessment results"

The process attributes and the process attribute ratings in this process assessment model are identical to those defined in the measurement framework. As a consequence, results of assessments based upon this process assessment model are expressed directly as a set of process attribute ratings for each process within the scope of the assessment. No form of translation or conversion is required.
[ISO/IEC 33004, 6.3.3, "Expression of assessment results"]

Annex B – Work Product Characteristics

Work product characteristics listed in this Annex can be used when reviewing potential outputs of process implementation. The characteristics are provided as guidance for the attributes to look for, in a particular sample work product, to provide objective evidence supporting the assessment of a particular process.

A documented process and assessor's judgment is needed to ensure that the process context (application domain, business purpose, development methodology, size of the organization, etc.) is considered when using this information.

Work products are defined using the schema in table B.1.
Work products and their characteristics should be taken as a starting point for evaluating whether work products are contributing to the intended purpose of the process in a given context, and not as a checklist of what every organization must have.

Table 1 – B.1 Structure of WPC tables

Work product identifier	A unique identifier for the work product which is used to reference the work product.
Work product name	Provides an example of a typical name associated with the work product characteristics. This name is provided as an identifier for the type of work product the practice or process might produce. Organizations may call these work products different names. The name of the work product within the organization is not significant. Similarly, organizations may have several equivalent work products which contain the characteristics defined in one work product type. The formats for the work products can vary. It is up to the assessor and the organizational unit coordinator to map the actual work products produced in their organization to the examples given here.
Work product characteristics	Provides examples of the potential characteristics associated with the work product types. The assessor may look for these in the samples provided by the organizational unit.

The work products defined in table B.2 extend the work products listed in Annex B of Automotive SPICE. The generic work products (ID nn-00) stay the same. To avoid confusion, IDs of work products listed in this annex have been extended by ME (ID nn-MExx).

Table 2 – B.2 Work product characteristics

WP ID	WP Name	WP Characteristics

04-ME01	Mechanical system architectural design	• Describes the overall mechanical structure
		• Identifies the required mechanical elements
		• Identifies own developed and supplied mechanical elements
		• Identifies the relationships and dependencies between mechanical elements
		• Describes how variants for different model series or configurations are derived
		• Describes the dynamic behavior of the mechanic
		• Consideration is given to:
		  ○ any required mechanical performance characteristics
		  ○ any required mechanical interfaces
		  ○ any required critical characteristics
		• E.g. block diagram, P diagram/boundary diagram (Interface control document), system structure, 3D model

04-ME02	Mechanical component design	Provides detailed design (could be represented as a drawing, CAD model, data sheet, requirements and data relevant for production, handmade prototype)
08-ME01	Sample control plan	A control plan shall contain: • specifications to be verified • process parameters to be verified • verification methods to be used • a procedure how to handle non-conformances • verification infrastructure/equipment to be used
11-ME01	Mechanical System	• Mechanical System is a group of at least two mechanical elements (e.g. Mechanical Components, Mechanical Systems) of the architecture. • Mechanical System is an integration of at least two mechanical items (e.g. Mechanical Components, Mechanical Systems)
11-ME02	Mechanical Component	• Mechanical Components are the lowest level of mechanical elements of the architecture. • The produced lowest level of mechanical elements of the architecture is also called Mechanical Component.
13-ME01	Characteristics classification record	List of all identified characteristics including classification of the characteristics

13-ME02	Assembly record	Identification of the used BOM Identification of assembled items (e.g. serial number, batch number, lot number) Records related: • findings • observations • deviations from the plans (e.g. assembly plan, control plan etc.)
13-ME03	Production record	Identification of the used BOM Identification of assembled items (e.g. serial number, batch number, lot number) Records related: • findings • observations • deviations from the plans (e.g. assembly plan, control plan etc.)
17-ME01	Mechanical system requirements specification	Identifies standards to be used Identifies any structure considerations/constraints Identifies the required elements Identifies the relationships between elements Consideration is given to: • any required performance characteristics • any required interfaces • any required characteristics (critical, safety etc.)
17-ME02	Assembly instruction	Is based on the architecture and contains a description of the steps how the mechanical items shall be assembled/integrated to a mechanical system according to the release plan. Assembly instruction and control plan are elements of the integration plan. An assembly instruction contains: • assembly steps • order of the assembly steps • process parameters • required infrastructure (e.g. fixtures, tools, jigs) for the assembly/integration
17-ME03	Bill of material	The bill of material (BOM) is a list of all elements of the system including: • ID of the elements • ID of the BOM • Number of instances of elements • Version of elements

17-ME04	Mechanical component requirements specification	Identifies standards to be used Identifies any considerations/constraints Consideration is given to: • any required performance characteristics • any required interfaces • any required characteristics (critical, safety etc.) • any design requirements
19-ME01	Production strategy	Identifies what needs and objectives or goals are to be satisfied Establishes the options and approaches for satisfying the needs, objectives, or goals Establishes the evaluation criteria against which the strategic options are evaluated Identifies any constraints/risks and how these will be addressed The development of the production strategy is carried out by definition the following fields of production: • process design • locations • vertical range of manufacture • manufacturing equipment • structure and logistics of manufacturing • suppliers • staff structure • reference to release plan • reference to project plan • reference to test strategy

Annex C – Terminology

Table C.3 lists the definition of some terms considered to be helpful for understanding the mechanical extension of Automotive SPICE. It lists some mechanical related terms as well as the interpretation of some terms taken from Automotive SPICE and used in the mechanical context.

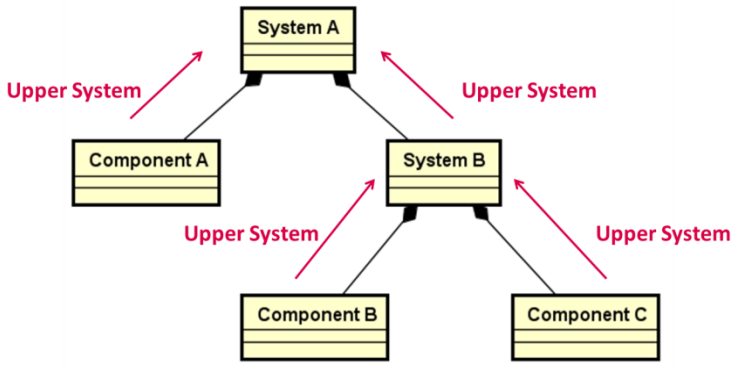
Table 3 – C.3 Terminology

Term	Origin	Description
Application parameter	Automotive SPICE® 3.1	An application parameter is specifying design characteristics of mechanical components or systems determining functions, behavior or properties. The notion of application parameter is expressed in two ways: • the logical specification (including name, description, unit, value domain or threshold values or characteristic curves, respectively), and • the actual quantitative data value it receives based on the selected variant / application.
Assembly instruction	n/a	Is based on the architecture and contains a description of the steps how the mechanical items shall be assembled/integrated to a mechanical system considering the release plan. Assembly instruction and control plan are elements of the integration strategy. An assembly instruction contains: • assembly steps • order of the assembly steps • process parameters • required infrastructure (e.g. fixtures, tools, jigs) for the assembly/integration
Bill of material	n/a	The **bill of material (BOM)** is a list of all elements of the system including: • ID of the elements • Number of instances of elements • Version of elements
Capable test environment	n/a	Documented, qualified (e.g. gauge repeatability and reproduceability [R&R]) and released test infrastructure.
Component	n/a	The components are the lowest level elements of the mechanical system architectural design for which finally the component design is defined.
Consistency	Automotive SPICE® 3.1	Consistency addresses content and semantics and ensures that work products are not in contradiction to each other. Consistency is supported by bidirectional traceability. See also chapter D.4.

Control plan	IATF16949 Appendix A[FE10]	Is a plan which ensures that the processes are defined and implemented and that the assembled system fulfills the respective specifications. A control plan shall contain: • specifications to be verified • process parameters to be verified • verification methods to be used • a procedure how to handle non-conformances • verification infrastructure/equipment to be used
Coverage	n/a	There are: • all objects, • relevant objects, • mapped objects. Coverage is a measure used to describe the ratio of mapped objects to relevant objects for a specific purpose. For instance: • Requirements coverage: ratio of mapped system requirements versus relevant system requirements • Dimensional test coverage: ratio of tested dimensions versus total numbers of dimensions • Item test coverage: degree of tested items versus all created items • Verification coverage for critical characteristics: ratio of tested or verified (e.g. production process capability – cpk) critical characteristics based on control plan
Design constraints	n/a	Limits which must be considered when designing elements. Limit the number of design variants. Examples: packaging, costs
Dynamic behavior	n/a	Time dependent physical behavior of system/components, e.g. thermal behavior, deformation, motion, vibration, fluid mechanics.
Integration strategy	n/a	Defines the order of assembly steps of items based on the release plan.
Integration test	n/a	The emphasis of integration testing is on the interfaces and interactions between the different items.
Interaction	n/a	Interaction occurs between elements of the respective system or between elements of the respective system and the operating environment.
Model-based development	n/a	Development which is based on models (e.g. analytical, numerical) that represent the reality of the respective element in a sufficient way and that are used for sizing, design, simulation, optimization and validation. Note: The sufficient representation of reality shall be verified with tests.

Operating environment	n/a	Operating environment is the context in which the considered system works.
Production	n/a	Production is defined as component manufacturing or system assembly or the combination of both.
Production relevant requirements and data	n/a	Identifies requirements and data related to production, like: • process parameters • guidelines • maintenance requirements • required technologies
Production strategy	Automotive SPICE® 3.1 Wikipedia	ASPICE 3.1 WP 19-00 Strategy • Identifies what needs and objectives or goals there are to be satisfied • Establishes the options and approach for satisfying the needs, objectives, or goals • Establishes the evaluation criteria against which the strategic options are evaluated • Identifies any constraints/risks and how these will be addressed in the context of production. Wikipedia [05.03.2017] https://de.wikipedia.org/wiki/Produktionsstrategie The production strategy is the fundamental setup of a production system to create goods. The development of the production strategy is carried out by definition the following fields of production: • process design • locations • vertical range of manufacture • manufacturing equipment • structure and logistics of manufacturing • suppliers • staff structure • reference to release plan • reference to project plan • reference to test strategy • make or buy decision • production process parameters (e.g. pressure, rates, calibration data)

Regression test strategy	Automotive SPICE® 3. 1	ASPICE 3. 1 WP 19-00 Strategy • Identifies what needs and objectives or goals there are to be satisfied • Establishes the options and approaches for satisfying the needs, objectives, or goals • Establishes the evaluation criteria against which the strategic options are evaluated • Identifies any constraints/risks and how these will be addressed in the context of regression testing. A regression test strategy shall define: • when to perform regression tests • how to identify and select effective tests for regression testing • how to identify the possible impact of a change that needs regression testing 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 its specified requirements. (See ASPICE 3. 1 Glossary)
Release plan	n/a	• Identifies the functionality and features to be included in each release • Identifies the associated elements required (i.e., hardware, software, documentation etc.) • Mapping of the customer requests and requirements to be satisfied to particular releases of the product Release can be sample phases (e.g. A0, A1, B, C, D) Purpose of releases can be concept verification, design verification, design validation, process verification, process validation
Releases	n/a	A release is an approved baseline of versions of elements and other configuration artifacts (e.g. documents, process descriptions, test reports, records). A release shall have a purpose. The purpose of releases can be concept verification, design verification, design validation, process verification, process validation

Special characteristics	n/a	Special characteristics are e.g.: • Significant characteristics having high impact on designed function and on customer satisfaction. • Critical characteristics having high impact on safety and/or legal aspects of the designed function. Note: A proper method to identify and rate special characteristics is an FMEA. Further details can be found in • IATF 16949:2016 8.3.3.3[FE11] • VDA 4
Stakeholder	PMBoK Guide Third Edition	Persons and organizations such as customers, sponsors, the performing organization or the public who are actively involved in the project or whose interests are positively or negatively affected by the performance or completion of the project. They may also exert influence over the project and its deliverables.
Static behaviour	n/a	Time independent physical behavior of items over required life time, e.g. transmission ratio, weight, mass, geometry.
Test case	IEEE 1012-2004	(A) A 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. (B) Documentation specifying inputs, predicted results, and a set of execution conditions for a test item.
Test specification	n/a	The test specification is the container in which all test cases are listed.
Traceability	n/a	Traceability refers to the existence of references or links between work products. Traceability supports coverage analysis, impact analysis, requirements implementation status tracking etc. See also chapter D.4.
Upper system	n/a	The system is broken down into its constituent elements (systems and components) in a tree like structure. The Upper System is one level above the level in focus. 

Verification criteria	n/a	Verification criteria define the qualitative and quantitative criteria for verification of a requirement. Verification criteria demonstrate that a requirement can be verified within agreed constraints. (Additional Requirement to 17-00 Requirements specification)
Verification method	IEEE 1012-2004	Each requirement must be verifiable. Methods for qualitative or quantitative verification of objects or artifacts, like: • tests • reviews • simulations • calculation • tolerance analysis Verification (A) The process of evaluating a system or component to determine whether the products of a given development phase satisfy the conditions imposed at the start of that phase. (B)The process of providing objective evidence that the software and its associated products conform to requirements (e.g., for correctness, completeness, consistency, accuracy) for all life cycle activities during each life cycle process (acquisition, supply, development, operation, and maintenance); satisfy standards, practices, and conventions during life cycle processes; and successfully complete each life cycle activity and satisfy all the criteria for initiating succeeding life cycle activities (e.g., building the software correctly).

Annex D – Key Concepts

The following sections refer the key concepts that have been introduced in the Automotive SPICE PRM resp. PAM 3.1 and describe the adaptations performed in order to create SPICE for Mechanical Engineering.

D.1 The "Plug-in" Concept

The process interfaces provided by Automotive SPICE are used to extend the process scope as shown in the following picture.

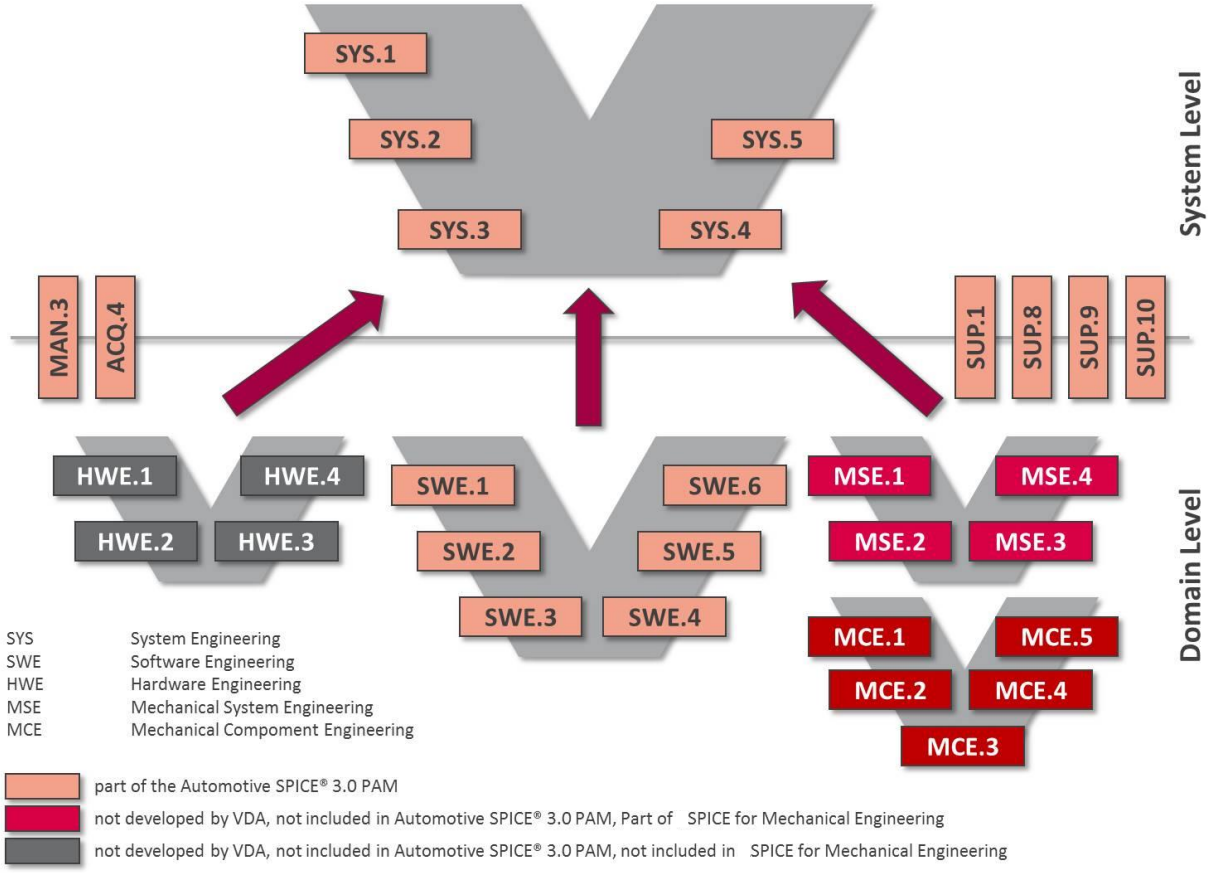


Figure 6 – D.1 The “Plug-in” concept

D.2 The Tip of the "V"

Automotive SPICE has reorganized the software processes to have per process on the left side of the V one corresponding process on the right side. SPICE for Mechanical Engineering takes this concept but splits SWE.3 Software Detailed Design and Unit Construction into two processes: MCE.2 Mechanical Component Design and MCE.3 Mechanical Component Sample Production. This separates the engineering activities in MCE.2 from the physical production of the product in MCE.3 to reflect the actual proceeding in the industry in a better way (see Figure D.2).

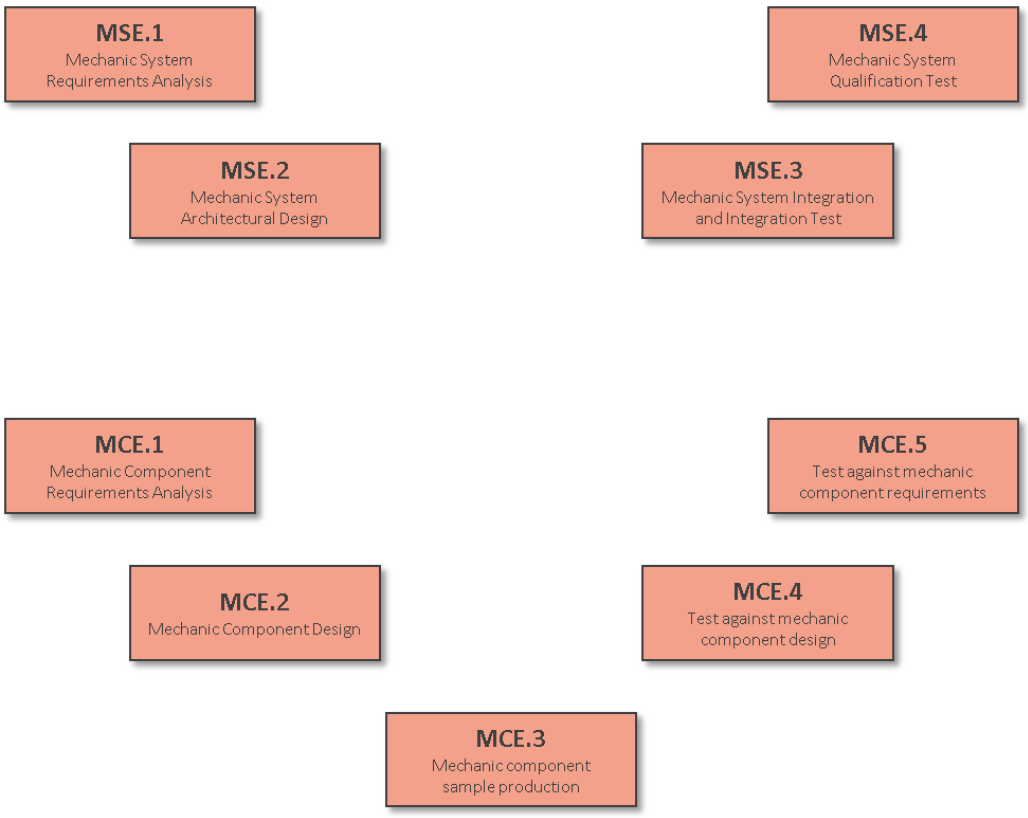


Figure 7 - D.2 The tip of the “V”

D.3 Terms “Element”, “Component", “Unit” and “Item”

The definition of element, component and item can be seen in the following picture. Unit – as term from Software engineering – is not used in this standard.

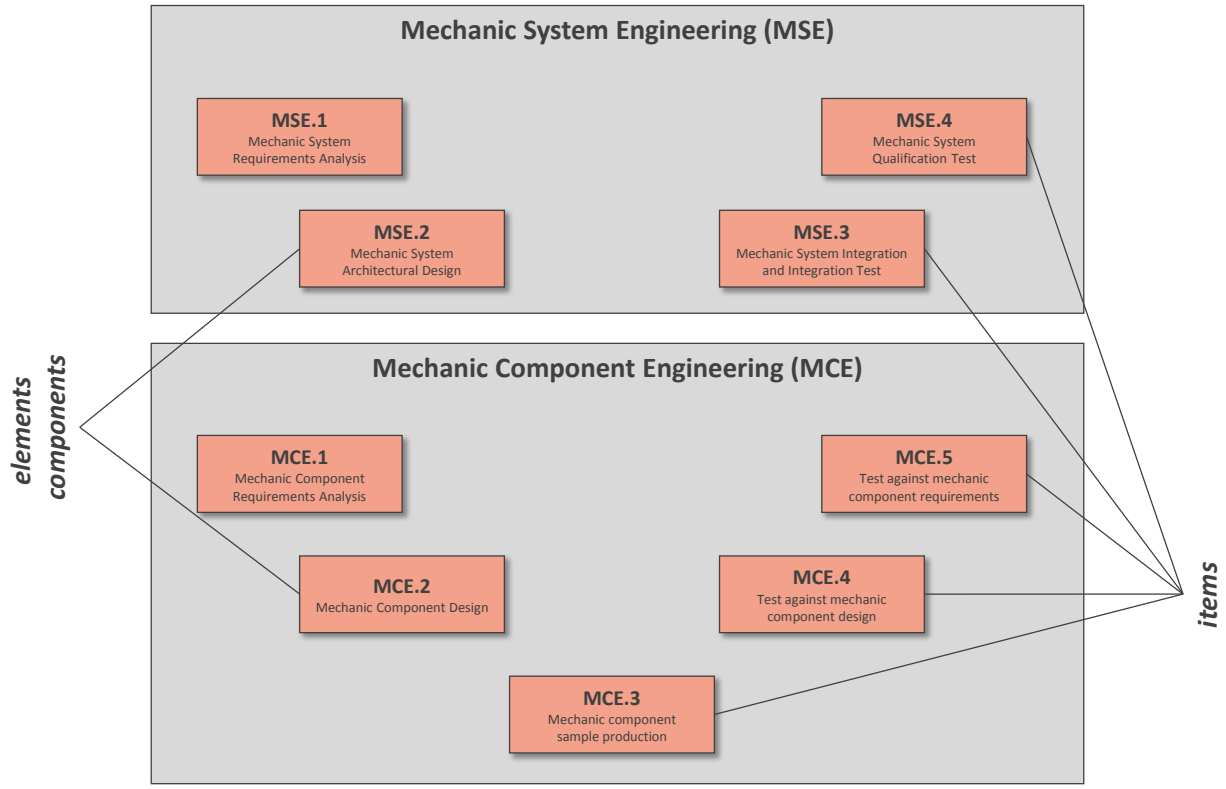


Figure 8 – D.3 The terms “element”, “component” and “item”

Elements are all structural objects on architectural and design level on the left side of the "V".
An architecture specifies the elements of the system.

Elements are hierarchically decomposed into smaller elements down to the components which are at the lowest level of the architecture.

Components are the lowest level elements of the mechanical system architectural design for which in the end the component design is defined.

Items exist only on the right side of the V-model. They are the implemented / produced counterparts of a corresponding element. This constitutes an n:1 relationship between item(s) and element.

D.4 Traceability and Consistency

Traceability and consistency as defined in Automotive SPICE 3.1 have been adopted as is but extended with traceability and consistency between the built product and corresponding test reports and traceability and consistency between built components and systems to reflect compliance with the bill of material.

The complete traceability and consistency requirements of SPICE for Mechanical Engineering is shown in the following picture.

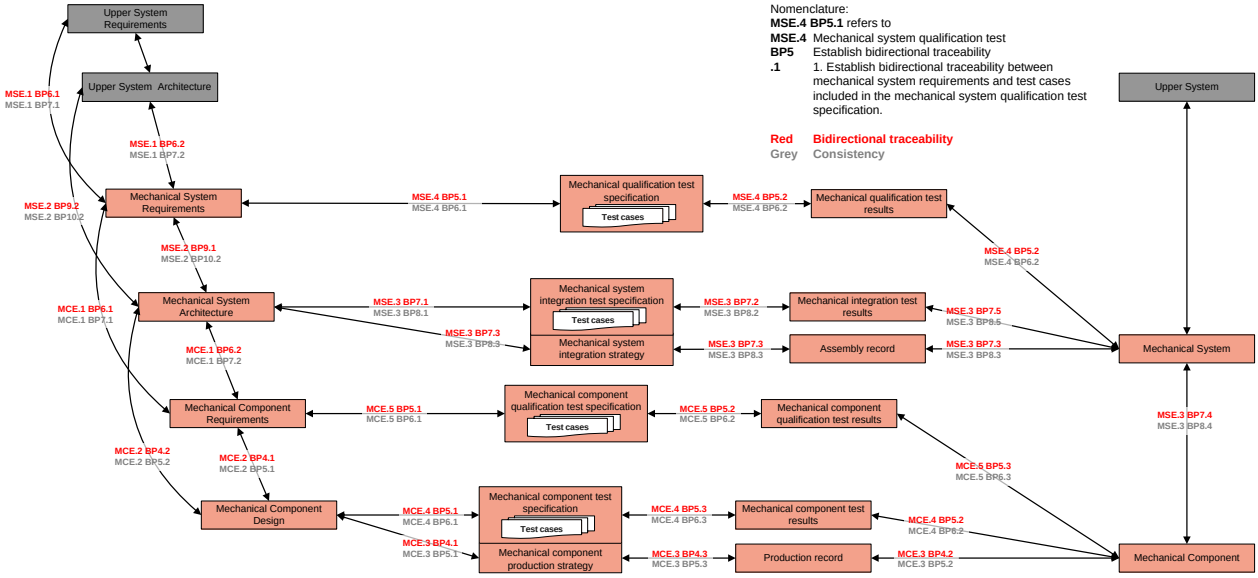


Figure 9 – D.4 Traceability and consistency

D.5 “Agree” and “Summarize and Communicate”

This concept has been adopted from Automotive SPICE 3.1 without changes.

D.6 “Evaluate”, “Verification Criteria” and “Ensuring compliance”

This concept has been adopted from Automotive SPICE 3.1 without changes.

D.7 The Relation between “Strategy” and “Plan”

This concept has been adopted from Automotive SPICE 3.1 without changes.

Annex E – Mapping to ISO 9001:2015 und IATF 16949:2016

This chapter maps the processes of SPICE for Mechanical Engineering on Base Practice level to the different chapters of ISO 9001:2015 and [FE12]IATF 16949:2016.

Table 4 – E.4 Mapping to ISO 9001:2015 and [FE13]IATF 16949:2016

Chapter SPICE for Mechanical - System Level		**Content DIN EN ISO 9001:2015 and IATF 16949:2016**[FE14]	
3	**Mechanical System Engineering**	**8**	**Operation**
3.1	**Mechanical System Requirements Analysis**	**8.2**	**Requirements for products and services**
BP1	Specify mechanical system requirements	8.2.2	Determining the requirements for products and services
BP2	Structure mechanical system requirements	8.2.3	Review of the requirements for products and services
BP3	Analyze mechanical system requirements	8.2.3.1.3	Organization manufacturing feasibility
BP4	Analyze the impact on the operating environment	7.1.4	Environment for operation of processes
BP5	Develop verification criteria	8.3.4 & 8.3.5	Design and development controls & Design and development outputs
BP6	Establish bidirectional traceability	8.5.2	Identification and tracebility
BP7	Ensure consistency	8.3.6	Design and development changes
BP8	Communicate agreed mechanical requirements	8.2.1	Customer communication
3.2	**Mechanical System Architectural Design**	**8.3**	**Design and development of products and services**
BP1	Develop mechanical system architectural design	8.3.3	Design and development inputs
BP2	Allocate mechanical system requirements	8.3.3.1	Product design input
BP3	Define interfaces of mechanic elements	8.3.3.1	Product design input
BP4	Identify special characteristics	8.3.3.3	Special characteristics
BP5	Describe dynamic and static behavior	8.3.5	Design and development outputs
BP6	Consider, determine, and document design constraints	8.3.5.1	Design and development outputs - supplemental
BP7	Evaluate alternative mechanical system architectures	8.3.5.1	Design and development outputs - supplemental
BP8	Verify mechanical system architectural design	8.3.5.1	Design and development outputs - supplemental
BP9	Establish bidirectional traceability	8.5.2	Identification and tracebility
BP10	Ensure consistency	8.3.6	Design and development changes
BP11	Communicate agreed mechanical system architectural design	8.2.1	Customer communication
3.3	**Mechanical System Integration and Integration Test**	**8.3.5**	**Design and development outputs**
BP1	Develop mechanical system integration strategy	8.3.3.1	Product design input
BP2	Develop mechanical system integration test strategy including regression test strategy	8.5.1.1	Control plan
BP3	Develop specification for mechanical system integration test	8.3.3.2	Manufacturing process design input
BP4	Integrate mechanical items	8.3.4.3	Prototype programme
BP5	Select test cases	8.3.4 & 8.3.5	Design and development controls & Design and development outputs
BP6	Perform mechanic system integration test	9.1.1.1	Monitoring and measurement of manufacturing processes
BP7	Establish bidirectional traceability	8.5.2	Identification and tracebility

BP8	Ensure consistency	8.3.6	Design and development changes
BP9	Summarize and communicate results	8.2.1	Customer communication
3.4	**Mechanical System Qualification Test**	**8.3**	**Design and development of products and services**
BP1	Develop mechanical system qualification test strategy including a regression test strategy	8.3.3.1	Product design input
BP2	Develop specification for mechanical system qualification test	8.3.5.1	Design and development outputs - supplemental
BP3	Select test cases	8.3.4 & 8.3.5	Design and development controls & Design and development outputs
BP4	Test the integrated mechanical system	8.3.4.3 & Anhang A	Prototype programme & Control plan
BP5	Establish bidirectional traceability	8.5.2	Identification and tracebility
BP6	Ensure consistency	8.3.6	Design and development changes
BP7	Summarize and communicate results	8.2.1	Customer communication
4	**Mechanical Component Engineering**	**8**	**Operation**
4.1	**Mechanical Component Requirements Analysis**	**8.2**	**Requirements for products and services**
BP1	Specify mechanical component requirements	8.2.2	Determining the requirements for products and services
BP2	Structure mechanical component requirements	8.2.3	Review of the requirements for products and services
BP3	Analyze mechanical component requirements	8.2.3.1.3	Organization manufacturing feasibility
BP4	Analyze the impact on the operating environment	7.1.4	Environment for the operation process
BP5	Develop verification criteria	8.3.4 & 8.3.5	Design and development controls & Design and development outputs
BP6	Establish bidirectional traceability	8.5.2	Identification and tracebility
BP7	Ensure consistency	8.3.6	Design and development changes
BP8	Communicate agreed mechanical component requirements	8.2.1	Customer communication
4.2	**Mechanical component design**	**8.3**	**Design and development of products and services**
BP1	Develop mechanical component design	8.3.3	Design and development inputs
BP2	Evaluate mechanical component design	8.3.5.1	Design and development outputs - supplemental
BP3	Verify mechanical component design	8.3.5.1	Design and development outputs - supplemental
BP4	Establish bidirectional traceability	8.5.2	Identification and tracebility
BP5	Ensure consistency	8.3.6	Design and development changes
BP6	Communicate agreed mechanical component design	8.2.1	Customer communication
4.3	**Mechanical Component Sample Production**	**8.3.4.3**	**Prototype programme**
BP1	Develop mechanical component production strategy	8.3.3.2	Manufacturing process design input
BP2	Agree on mechanical component production strategy	8.3.5.2	Manufacturing process design output
BP3	Ensure and support production of mechanical components	8.5.1	Control of production and service provision
BP4	Establish bidirectional traceability	8.5.2	Identification and tracebility
BP5	Ensure consistency	8.3.6	Design and development changes
BP6	Provide feedback to all affected stakeholders	8.2.1	Customer communication
4.4	**Test against Mechanical Component Design**	**8.3.4**	**Design and development controls**
BP1	Develop strategy for test against mechanical component design including regression test strategy	8.5.1.1	Control plan
BP2	Develop test specification for test against mechanical component design	8.3.5.1	Design and development outputs - supplemental

BP3	Select test cases	9.2.2.4	Product audit
BP4	Test mechanical component item	8.6	Release of products and services
BP5	Establish bidirectional traceability	8.5.2	Identification and tracebility
BP6	Ensure consistency	8.3.6	Design and development changes
BP7	Summarize and communicate results	8.2.1	Customer communication
4.5	**Test against Mechanical Component Requirements**	**8.3.4**	**Design and development controls**
BP1	Develop strategy for the test against mechanical component requirements including regression test strategy	8.5.1.1	Control plan
BP2	Develop test specification for the test against mechanical component requirements	8.3.5.1	Design and development outputs - supplemental
BP3	Select test cases	9.2.2.4	Product audit
BP4	Test the mechanical component	8.6	Release of products and services
BP5	Establish bidirectional traceability	8.5.2	Identification and tracebility
BP6	Ensure consistency	8.3.6	Design and development changes
BP7	Summarize and communicate results	8.2.1	Identification and tracebility