SPICE
for Mechanical Engineering
Process Reference Model [PRM]
Process Assessment Model [PAM]

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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.

Document history

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1.5	2018-12-06	Andre.Zeh@intacs.info	• Document History added • Sections "Process capability determination" and "Process capability levels and process attributes" added • Updated to IATF 16949 • Some editorial changes For more details see document revision "with Annotations".

1.6	2019-12-06	Andre.Zeh@intacs.info	• References to ISO/TS 16949 replaced by IATF 16949 • German parts of Annex E translated to English • Some minor formal inconsistencies and typos corrected • “Proposal” in title removed
1.7	2020-12-06	Andre.Zeh@intacs.info	Some formal inconsistencies removed: • MCE.4 Output Work Product 13-04 is related with OUTCOME 6 (instead of OUTCOME 5) • MCE.4 Output Work Product 08-52 is also related with OUTCOME 6 • MCE.5 BP7 references OUTCOME 6 (instead of OUTCOME 5) • MCE.5 Output Work Product 13-04 is related with OUTCOME 6 (instead of OUTCOME 5) • MCE.5 Output Work Product 08-52 is also related with OUTCOME 6 • MCE.5 Output Work Product 13-50 is also related with OUTCOME 6 • Term “mechanical” consequently used instead of “mechanic” • Name of intacs Working Group up-dated
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2.0	2024-03-27	Andre.Zeh@intacs.info	• PAM completely revised. Reduction to 5 processes. Merging and updating the base practices. Additional updates of the base practices in order to align with Automotive SPICE® 4.0

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1 Statement of Compliance

The SPICE for Mechanical Engineering process reference model and process assessment model are conformant with the ISO/IEC 33004:2015 and can be used as the basis for conducting an assessment of process capability.

An ISO/IEC 33003:2015 compliant Measurement Framework is defined in section 5.

A statement of compliance of the process assessment model and process reference model with the requirements of ISO/IEC 33004:2015 is provided in Annex A – Conformity of the process assessment and reference model

A statement of compliance of the measurement framework with the requirements of ISO/IEC 33003:2015 is provided in Annex A – Conformity of the process assessment and reference model.

2 Introduction

2.1 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® Version 4.0.

Interfaces to the following processes are covered:

- Mechatronic processes (SYS.X)
- Production
- Development of Verification Environment

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® Version 4.0 but need to be adapted to a mechanical context.

SPICE for Mechanical Engineering shall be applied for:

- Organization or supplier which <u>develops</u> or <u>changes</u> a system or component on basis of the Customer Requirements.
- Organization or supplier which <u>develops</u> a system or component based on "off the shelf" items.

SPICE for Mechanical Engineering is optional to be applied for:

- Organization or supplier which <u>delivers</u> a system or component, which is provided "off the shelf" to the customer.

3 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 level 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:

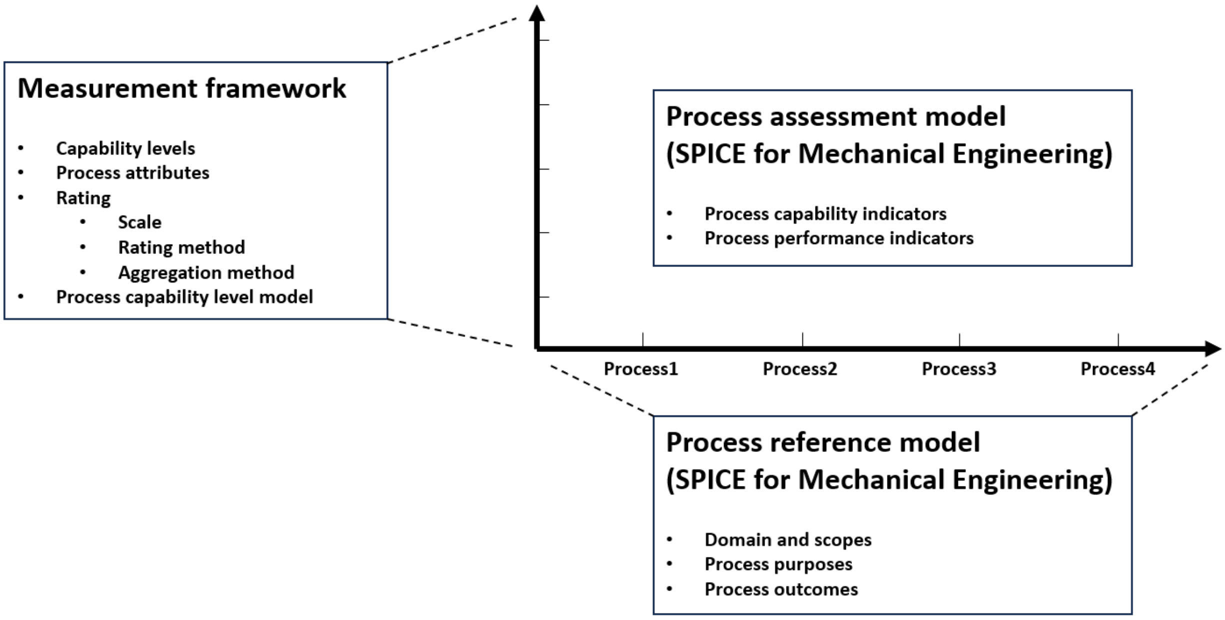


Figure 1 – Process assessment model relationship

3.1 Process reference model

Processes are collected into process groups according to the domain of activities they address.
These process groups are organized into 3 process categories: Primary life cycle processes, Organizational life cycle processes and Supporting life cycle processes.
For each process a purpose statement is formulated that 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.

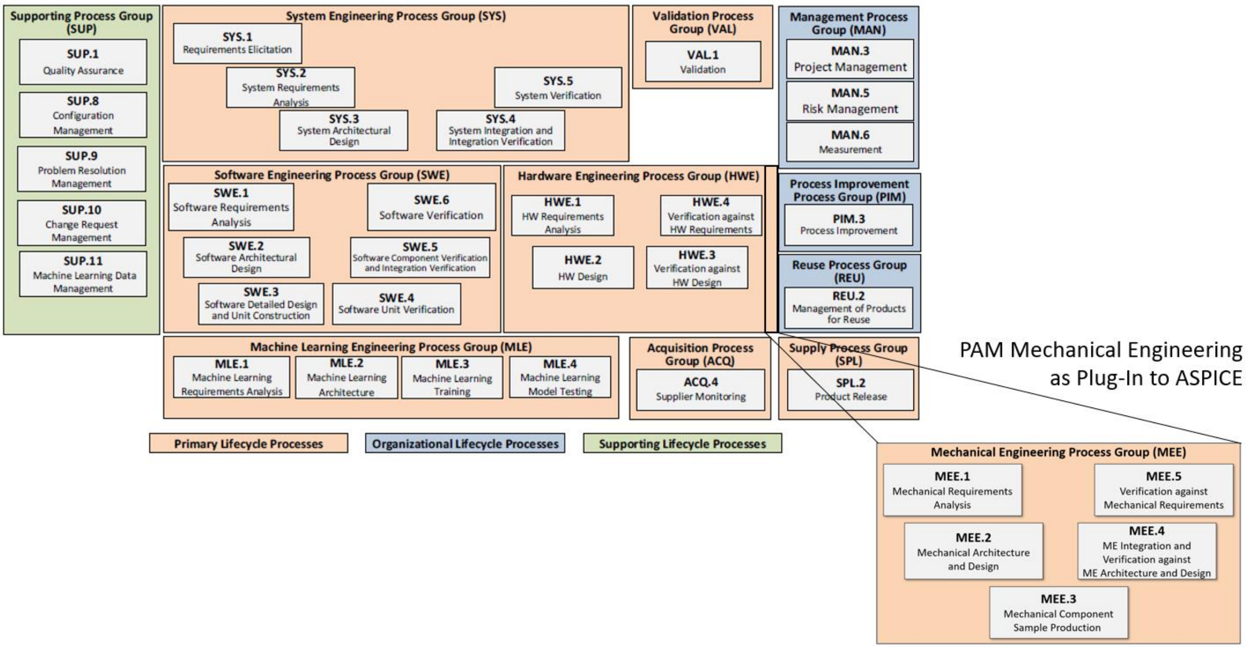


Figure 2 – SPICE for Mechanical Engineering process reference model as Plug-In to Automotive SPICE®

3.1.1 Primary life cycle processes category

The primary life cycle processes category consists of processes that may apply for an acquirer of products from a supplier or may apply for product development when responding to stakeholder needs and delivering products including the engineering processes needed for specification, design, implementation, integration, and verification.
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 Validation process group
- the Software engineering process group
- the Machine learning engineering process group
- the Hardware engineering process group
- the Mechanical engineering process group

For details of all other process groups than Mechanical Engineering process group please refer to Automotive SPICE®.

The Mechanical Engineering Process Group (MEE) consists of processes addressing the management of mechanical requirements, the development of the corresponding mechanical architecture and design, the mechanical component sample production as well as the integration and verification of the mechanical components and systems.

MEE.1 Mechanical Requirements Analysis
MEE.2 Mechanical Architecture and Design
MEE.3 Mechanical Component Sample Production
MEE.4 Mechanical Integration and Verification against Mechanical Architecture and Design
MEE.5 Verification against Mechanical Requirements

3.1.2 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®.

3.1.3 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, may 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.

For details, please refer to Automotive SPICE®.

3.2 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.

SPICE for Mechanical Engineering uses the measurement framework defined by Automotive SPICE®.

Note: The Automotive SPICE® measurement framework is an adaption of ISO/IEC 33020:2019. Text incorporated from ISO/IEC 33020 within this chapter is written in italic font and marked with a left side bar.

3.2.1 Process capability levels and process attributes

The process capability levels, and process attributes are identical to those defined in Automotive SPICE®. Process attributes are features of a process that can be evaluated on a scale of achievement, providing a measurement of the capability of the process. They are applicable to all processes.

A capability level is characterized by one or more process attributes whose implementation results in a significant improvement 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.

There are six capability levels as listed in Table 1, 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 1 – Process capability levels

Within this process assessment model, the determination of capability is based upon the nine process attributes (PA) as listed in Table 2.

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	*Process 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*

Table 2 – Process attributes

3.2.2 Process attribute rating

To support the rating of process attributes, the 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).

3.2.2.1 Rating scale

> *Within this process measurement framework, a process attribute is a measurable 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 shown in Table 3 – Rating scale.

Note: The rating scale is identical to ISO/IEC 33020:2019

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.*

Table 3 – Rating scale

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 4 – Rating scale percentage values

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.*

Table 5 – Refinement of rating scale

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*

Table 6 – Refined rating scale percentage values

3.2.3 Rating and aggregation method

Rating and aggregation methods are taken from ISO/IEC 33020:2019, which 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 characterized 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 33020:2019 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 33020:2019 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 33020:2019 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 33020:2019.

3.2.4 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 7.
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 or fully 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 process attribute***	***Largely or fully***
Level 2	*PA 1.1: Process performance process attribute*	*Fully*
	PA 2.1: Process performance management process attribute	***Largely or fully***
	PA 2.2: Work product management process attribute	***Largely or fully***
Level 3	*PA 1.1: Process performance process attribute*	*Fully*
	PA 2.1: Process performance management process attribute	*Fully*
	PA 2.2: Work product management process attribute	*Fully*
	PA 3.1: Process definition process attribute	***Largely or fully***
	PA 3.2: Process deployment process attribute	***Largely or fully***
Level 4	*PA 1.1: Process performance process attribute*	*Fully*
	PA 2.1: Process performance management process attribute	*Fully*
	PA 2.2: Work product management process attribute	*Fully*
	PA 3.1: Process definition process attribute	*Fully*
	PA 3.2: Process deployment process attribute	*Fully*
	PA 4.1: Quantitative analysis process attribute	***Largely or fully***
	PA 4.2: Quantitative control process attribute	***Largely or fully***

Level 5	*PA 1.1: Process performance process attribute* *PA 2.1: Process performance management process attribute* *PA 2.2: Work product management process attribute* *PA 3.1: Process definition process attribute* *PA 3.2: Process deployment process attribute* *PA 4.1: Quantitative analysis process attribute* *PA 4.2: Quantitative control process attribute* ***PA 5.1: Process innovation process attribute*** ***PA 5.2: Process innovation implementation process attribute***	*Fully* *Fully* *Fully* *Fully* *Fully* *Fully* *Fully* ***Largely or fully*** ***Largely or fully***

Table 7 – Capability levels and corresponding process attribute ratings

3.3 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.

3.3.1 Assessment indicators

According to ISO/IEC 33004, a process assessment model needs to define a set of assessment indicators:

> ***Assessment Indicators:***
> *A process assessment model shall be based on a set of assessment indicators that:*
> *a) explicitly address the purpose and process outcomes, as defined in the selected process reference model, of each of the processes within the scope of the process assessment model;*
> *b) demonstrate the achievement of the process attributes within the scope of the process assessment model;*
> *c) demonstrate the achievement (where relevant) of the process quality levels within the scope of the process assessment model.*
> *The assessment indicators generally fall into three types:*
> *a) practices that support achievement of either the process purpose or the specific process attribute.*
> *b) information items and their characteristics that demonstrate the respective achievements.*
> *c) resources and infrastructure that support the respective achievements.*
> *[ISO/IEC 33004:2015, 6.3.1].*

As in Automotive SPICE® also in this assessment model, only practices and information items are used.

Practices are representing activity-oriented indicators, where Information items are representing result-oriented indicators. Both practices and information items are used for judging objective evidence to be collected and accumulated in the performance of an assessment.

As a first type of assessment indicator, practices are provided, which can be divided into two types:

1. Base practices (BP), applying to capability level 1

They provide an indication of the extent of achievement of the process outcomes. base practices relate to one or more process outcomes, thus being always process-specific and not generic.

2. Generic practices (GP), applying to capability levels 1 to 5

They provide an indication of the extent of process attribute achievement. Generic practices relate to one or more process attribute achievements, thus applying to any process.

As a second type of assessment indicators, **information items (II)** including their **characteristics (IIC)** are provided in Annex A.

These are meant to offer a good practice and state-of-the-art knowledge guide for the assessor. Therefore, information items including their characteristics are supposed to be a quickly accessible information source during an assessment.

Information item characteristics shall not be interpreted as a required structure of a corresponding work products, which is defined by the project and organization, respectively.

Please refer to chapter 3.3.2 for understanding the difference between information items and work products.

ISO 33004:2015 requires the mapping of assessment indicators to process attributes as shown in Figure 3.

The capability of a process on level 1 is only characterized by the measure of the extent to which the process outcomes are achieved. According to ISO 33003:2015, a measurement framework requires each level to reveal a process attribute. 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 and Chapter 4).

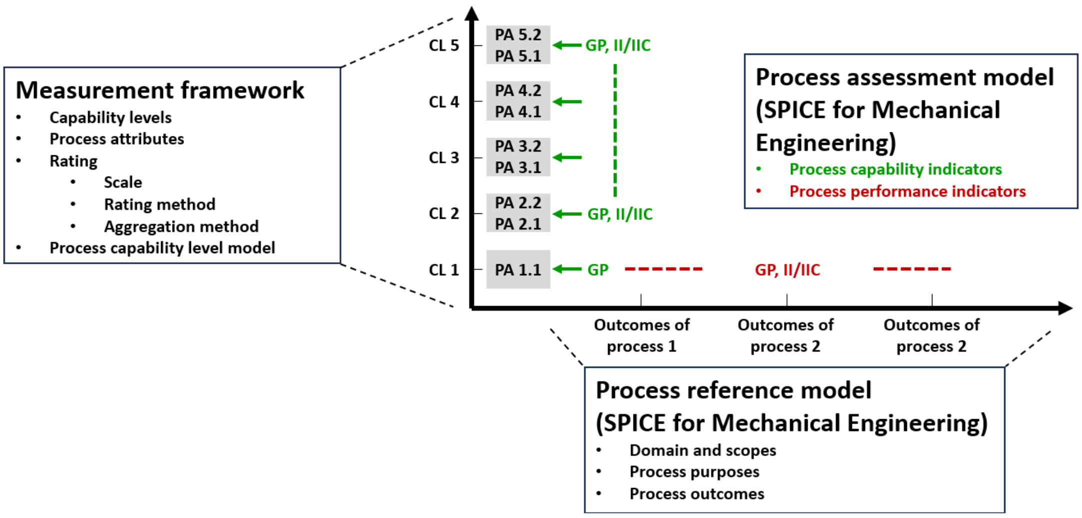


Figure 3 – Relationship between assessment indicators and process capability

The detailed mapping of base practices / indicators and generic practices / indicators to process outcomes and achievements, is provided in corresponding tables in Chapter 4 and Chapter 5, respectively.

3.3.2 Understanding information Items and work products

In order to judge the presence or absence of process outcomes and process attribute achievements an assessment obtains objective evidence. All such evidence comes either from the examination of work products related to a specific output of the processes assessed, or from statements made by the performers and managers of the processes. Sources for such evidence is either repository content of the assessed processes, or testimony provided by the performers and managers of the assessed processes.

As described in Chapter 3.3.1, this process assessment model provides information items serving as indicators to guide the assessor when judging a process attribute achievement.

3.3.2.1 Information items versus work products

Both terms are used in different context in an assessment:

- Information items are defining relevant pieces of information used by the assessors to judge the achievement of process attributes.
- work products are produced by the organization assessed when performing, managing, establishing, analyzing, and innovating processes.

Information Items (together with their characteristics) are provided as guidance for “what to look for” when examining the work products available in the assessed organization. The extent of implementation of an information item (in line with its defined characteristics) in a related work product serves as objective evidence supporting the assessment of a particular process. A documented process and assessor 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.

Information items shall therefore not be mistaken for the work product generated by the assessed organization itself. There is no 1:1 relationship between an information item and the work product taken as sample evidence by the assessor when assessing the achievement of a process outcome and process attribute achievements. An output generated by a process may comprise multiple information item characteristics and multiple outputs may also contain the same information item characteristics.

Information item characteristics should be considered as indicators when considering whether, given the context, a work product is contributing to the intended purpose of the process. Context-sensitivity means that assessor judgment is needed to ensure that the actual context (application domain, business purpose, development methodology, size of the organization, etc.) is considered when using the information items.

3.3.2.2 Types of work products

A work product to be considered as evidence when rating a process attribute may not necessary be outputs from the processes assessed but can also be originated from other processes of the organization. Once such a work product is used in the performance of a process under assessment, it may be considered by the assessor as objective evidence.

In a lot of cases work products are comprising documentation aspects, such as specifications, reports, records, architectural designs, drawings etc.

An example of work products not comprising any documentation aspects are produced samples.

3.3.3 Understanding the level of abstraction of a PAM

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

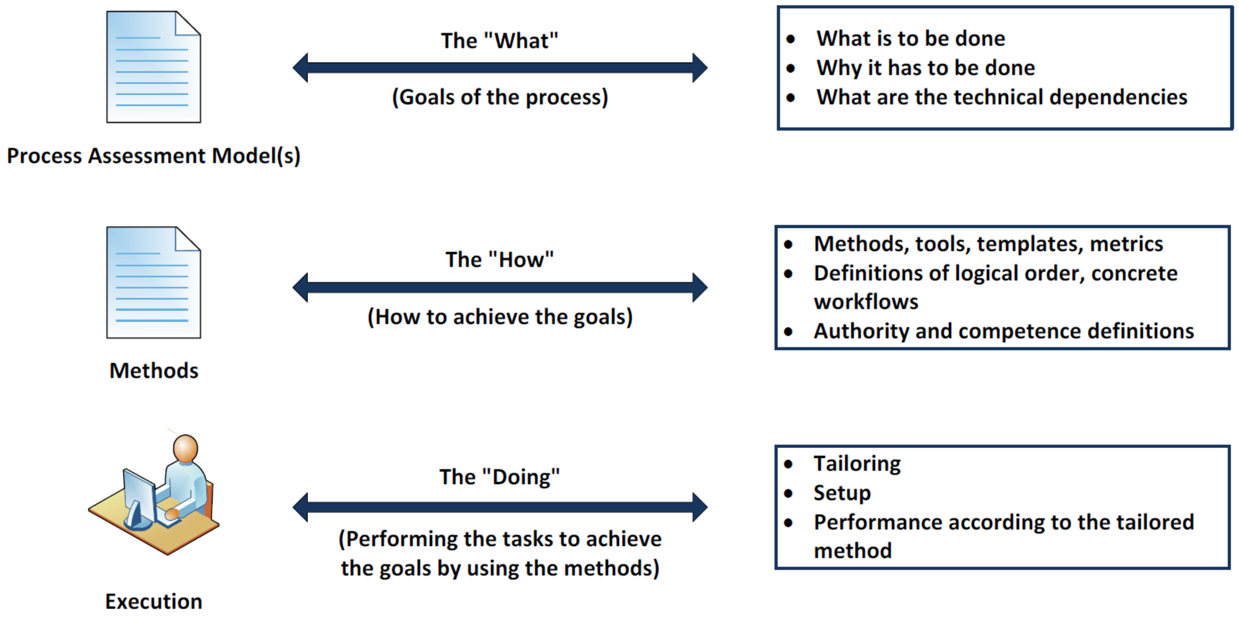


Figure 4 – Possible levels of abstraction for the term "process"

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.

3.3.4 Why a PRM and PAM are not a lifecycle model or development process blueprint

A lifecycle model defines phases and activities in a logical timely order, possibly including cycles or loops, and parallelization. For example, some standards such as ISO 26262 or ISO/SAE 21434 are centered around a lifecycle model (neither of these standards in fact represents a PRM according to ISO/IEC 33004). Companies, organizational units, or projects will interpret such general lifecycle models given in standards, and then detail it out into roles, organizational interactions and interfaces, tools or tool chains, work instructions, and artifacts.

Lifecycle models therefore are a concept at the HOW level (see Chapter 3.3.3).

In contrast, a PRM/PAM according to ISO/IEC 33004 (formerly ISO/IEC 15504-2) is at the level of the WHAT by abstracting from any HOW level, see Figure 4 in Chapter 3.3.3. In Automotive SPICE®, this has been, and is, indicated by the process MAN.3 Project Management requiring in BP2 “Define project life cycle”. A PRM/PAM groups a set of coherent and related characteristics of a particular technical topic and calls it ‘process’. In different terms, a process in a PRM represents a ‘distinct conceptual silo’. In this respect, a PRM/PAM

- neither predefines, nor discourages, any order in which PRM processes or base practices are to be performed. Ultimately, in SPICE for Mechanical Engineering consistency must be fulfilled as required by the traceability/consistency base practices in MEE.x;
- does not predefine any particular work product structure, or work product blueprints. For example, the process MEE.1 does not mean that there shall be exactly one mechanical requirements specification containing everything provided by upper (Mechanical) System Requirements and upper (Mechanical) Architecture.

As a consequence, it is the assessor's responsibility to perform a mapping of elements in such a HOW level to the Assessment Indicators in the PAM, see Figure 5.

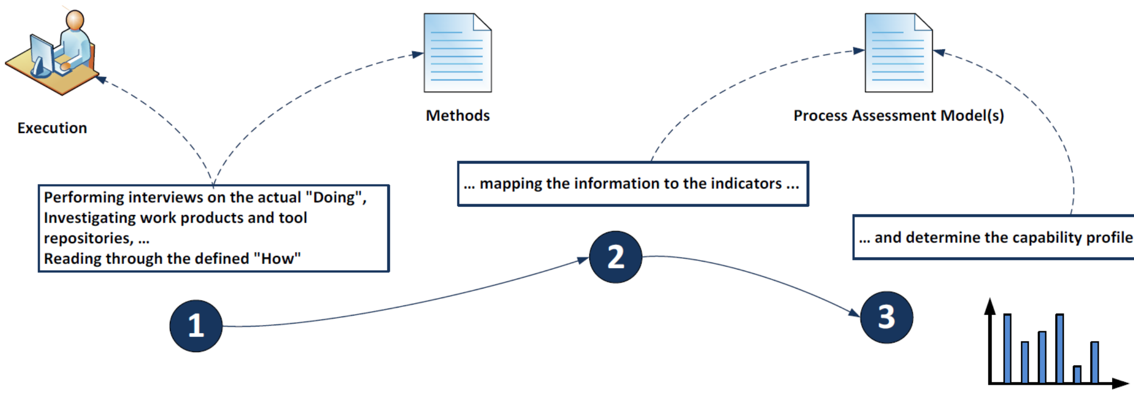


Figure 5 – Performing a process assessment for determining process capability

In this respect, a PRM or PAM further is not supposed to represent a product element hierarchy either.

4 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 information items (indicated by a blue bar).

Process reference model	**Process ID** **Process name** **Process purpose** **Process outcomes**	The individual processes are identified with a unique process identifier and a process name. A process purpose statement is provided, and process outcomes are defined to represent the process dimension of the SPICE for Mechanical Engineering process reference model. The background coloring of process ID's and names are indicating the assignment to the corresponding process group.
Process performance indicators	**Base practices**	A set of base practices for the process providing a definition of the activities to be performed to accomplish the process purpose and fulfill the process outcomes. The base practice headers are summarized at the end of a process to demonstrate their relationship to the process outcomes.
	Output information items	The output information items that are relevant to accomplish the process purpose and fulfill the process outcomes summarized at the end of a process to demonstrate their relationship to the process outcomes. *Note: Refer to Annex B for the characteristics associated with each information item.*

Table 8 – Template for the process description

4.1 Mechanical Engineering Process Group (MEE)

4.1.1 MEE.1 Mechanical Requirements Analysis

Process ID
MEE.1
Process name
Mechanical Requirements Analysis
Process purpose
The purpose is to transform the mechanic related parts of the defined upper (Mechanical) System Requirements and the upper (Mechanical) System Architecture into Mechanical Requirements that will guide the design of the Mechanical System and the Mechanical Components.
Process outcomes
1) The Mechanical System Requirements and Mechanical Component Requirements are specified. 2) The Mechanical System Requirements and Mechanical Component Requirements are structured and prioritized. 3) The Mechanical System Requirements and Mechanical Component Requirements are analyzed for correctness, verifiability, and technical feasibility. 4) The impact of Mechanical System Requirements and Mechanical Component Requirements on the Operating Environment is analyzed. 5) Consistency and bidirectional traceability are established between the Mechanical System Requirements and the Upper System Requirements and/or Upper System Architecture. 6) Consistency and bidirectional traceability are established between the Mechanical Component Requirements and the Mechanical System Requirements and/or Mechanical System Architecture. 7) The Mechanical System Requirements and Mechanical Component Requirements are agreed and communicated to all affected parties.

Base practices
MEE.1.BP1: Specify Mechanical Requirements. Use the Upper (Mechanical) System Requirements and the Upper (Mechanical) System Architecture as well as changes to the Upper (Mechanical) System Requirements and Upper (Mechanical) Architecture to identify and document functional and non-functional Mechanical System Requirements and Mechanical Component Requirements according to defined characteristics for requirements. *Note 1: Characteristics of requirements are defined in standards such as ISO IEEE 29148, ISO/IEC IEEE 24765, ISO 26262-8:2018, or the INCOSE Guide for Writing Requirements.* *Note 2: Mechanical Requirements should include tolerances as necessary.*

Note 3: Examples for defined characteristics of requirements shared by technical standards are verifiability (i.e., verification criteria being inherent in the requirements text), unambiguity/comprehensibility, freedom from design and implementation, and not contradicting any other requirement).

Note 4: In case of mechanical-only development, the System Requirements and the System Architecture refer to a given operating environment. In that case, stakeholder requirements can be used as the basis for identifying the required functions and capabilities of the mechanic.

MEE.1.BP2: Structure Mechanical Requirements.
Structure and prioritize the Mechanical System Requirements and Mechanical Component Requirements.

Note 5: Examples for structuring criteria can be grouping, e.g., by functionality or expressing product variants.
Note 6: Prioritization can be done according to project or stakeholder needs via e.g., definition of release scopes (e.g. A-/B-/C-Sample). Refer to Automotive SPICE® 4.0 (SPL.2).

MEE.1.BP3: Analyze Mechanical Requirements.
Analyze the specified Mechanical System Requirements and Mechanical Component Requirements including their interdependencies to ensure correctness, technical feasibility, verifiability and to support project management regarding project estimates.

Note 7: See MAN.3 for project feasibility and project estimates.

Note 8: Technical feasibility can be done based on given System Architectures (e.g., platform or standard product kits) or by means of prototype development.

MEE.1.BP4: Analyze the impact on the Operating Environment.
Analyze the impact that the Mechanical Requirements will have on elements in the Operating Environment.

MEE.1.BP5: Ensure consistency and establish bidirectional traceability.

1. Ensure consistency and establish bidirectional traceability between the Mechanical System Requirements and the Upper System Requirements.
2. Ensure consistency and establish bidirectional traceability between the Mechanical System Requirements and the Upper System Architecture.
3. Ensure consistency and establish bidirectional traceability between the Mechanical Component Requirements and the Mechanical System Requirements.
4. Ensure consistency and establish bidirectional traceability between the Mechanical Component Requirements and the Mechanical System Architecture.

Note 9: Redundant traceability is not intended.

Note 10: Bidirectional traceability supports consistency, and facilitates impact analyses of change requests, and demonstration of verification coverage. Traceability alone, e.g., the existence of links, does not necessarily mean that the information is consistent with each other.

Note 11: In case of mechanic development only, the system requirements and system architecture refer to a given operating environment. In that case, consistency and bidirectional traceability can be ensured between stakeholder requirements and mechanic requirements.

MEE.1.BP6: Communicate agreed Mechanical Requirements and impact on the Operating Environment.
Communicate the agreed Mechanical System Requirements and Mechanical Component Requirements and results of the analysis of impact on the Operating Environment to all affected parties.

MEE.1 Mechanical Requirements Analysis	Outcome 1	Outcome 2	Outcome 3	Outcome 4	Outcome 5	Outcome 6	Outcome 7
Output Information Items							
17-ME05 Mechanical System Requirement	X	X					
17-ME06 Mechanical Component Requirement	X	X					
17-54 Requirement Attribute		X					
15-51 Analysis Results			X	X			
13-51 Consistency Evidence					X	X	
13-52 Communication Evidence							X
Base Practices							
BP1: Specify Mechanical Requirements	X						
BP2: Structure Mechanical Requirements		X					
BP3: Analyze Mechanical Requirements			X				
BP4: Analyze the impact on the Operating Environment				X			
BP5: Ensure consistency and establish bidirectional traceability					X	X	
BP6: Communicate agreed Mechanical Requirements and impact on the Operating Environment							X

4.1.2 MEE.2 Mechanical Architecture and Design

Process ID
MEE.2
Process name
Mechanical Architecture and Design
Process purpose
The purpose is to establish a Mechanical System Architecture and Mechanical Component Design, comprising static and dynamic aspects, consistent with the Mechanical System Requirements and

Mechanical Component Requirements, and to evaluate the Mechanical System Architecture and Mechanical Component Design against defined criteria.

Process outcomes

1) The Mechanical System Architecture and Mechanical Components are designed including static and dynamic aspects.
2) The Mechanical System Architecture and Mechanical Component Design are analyzed against defined criteria and special characteristics are identified.
3) Consistency and bidirectional traceability are established between the Mechanical System Architecture and Mechanical System Requirements.
4) Consistency and bidirectional traceability are established between the Mechanical Component Design and Mechanical System Architecture and/or Mechanical Component Requirements.
5) The Mechanical System Architecture and the Mechanical Component Design are agreed and communicated to all affected parties.

Base practices

MEE.2.BP1: Specify static aspects of the Mechanical System and Mechanical Component. Specify and document the

a) static structure of the elements of the Mechanical System, including their interfaces, and their relationships
b) static aspects of each Mechanical System Element

with respect to the functional and non-functional Mechanical System Requirements and Mechanical Component Requirements, including external interfaces. Document the rationale behind the Mechanical System Architecture and Mechanical Component Design decisions.

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 Architecture) that are described in the Mechanical Component Design.

Note 2: Examples of a design rationale can be implied by the reuse of a standard product kit, product platform, or product line, respectively, or by a make-or-buy decision, or found in an evolutionary way (e.g. set-based design).

Note 3: Model-based development (e.g. FEM, SysML) may facilitate the collaboration of the different engineering domains.

Note 4: Design for Manufacturing and Design for Assembly may be used to ensure manufacturability.

Note 5: Static aspects are determined by e.g., mechanical system structure.

Note 6: Non-functional requirements may include e.g. price per unit, maintenance, logistics, packaging, size, weight, manufacturability, environmental constraints, design guidelines, modelling guidelines, failure times.

MEE.2.BP2: Specify dynamic aspects of the Mechanical System and Mechanical Component. Specify and document the dynamic aspects of the Mechanical System and Mechanical Component with respect to the functional and non-functional Mechanical System Requirements, including the behavior of the Mechanical Elements and their interaction in the different modes.

Note 7: Dynamic aspects are determined by e.g., natural frequencies, stress, force, pressure, strain, temperature, NVH (Noise Vibration Harshness), operating modes (open, closed, in motion, misuse, emergency, etc.).

MEE.2.BP3: Analyze the Mechanical System Architecture and Mechanical Component Design.
Analyze the Mechanical System Architecture and Mechanical Component Design regarding relevant technical aspects and related to the Product Lifecycle to support project estimates. Identify and document Special Characteristics. Document the rationales for the architectural and design decisions.

Note 8: Analysis criteria shall be defined. Analysis criteria may include quality characteristics (cost, weight, packaging, modularity, maintainability, expandability, scalability, reliability, safety and usability) and results of make-buy-reuse analysis.

Note 9: Analysis of the Mechanical System Architecture and Mechanical Component Design supports project feasibility analysis (MAN.3 BP3) and project estimates (MAN.3.BP5).

Note 10: The analysis may include the suitability of pre-existing Mechanical Elements for the current application.

Note 11: Examples for Product Lifecycle Phases are production, maintenance & repair, decommissioning.

Note 12: Examples for technical aspects are manufacturability, suitability of pre-existing elements to be reused, or availability of elements.

Note 13: Examples of methods suitable for analyzing technical aspects are prototypes, simulations, qualitative analyses. The simulation methods could be FEM, FMEA, CFD.

Note 14: The identification of Special Characteristics is supported by e.g., simulation, risk analyses, sizing calculations.

Note 15: Design rationales can include arguments such as proven-in-use, a make-or-buy decision, or found in an evolutionary way.

MEE.2.BP4: Consider, determine, and document Design Constraints.
Determine and document Design Constraints for all Mechanical Elements and take them into account for creating the Mechanical System Architecture and Mechanical Component Design.

Note 16: Design constraints can be e.g., design guidelines, materials, manufacturing processes

MEE.2.BP5: Ensure consistency and establish bidirectional traceability.

1. Ensure consistency and establish bidirectional traceability between the Elements of the Mechanical System Architecture and Mechanical System Requirements.
2. Ensure consistency and establish bidirectional traceability between the Mechanical Component Design and the Mechanical System Architecture.
3. Ensure consistency and establish bidirectional traceability between the Mechanical Component Design and Mechanical Component Requirements.

Note 17: Redundancy should be avoided by establishing a combination of the approaches BP4.2 and BP4.3 that covers the project and the organizational needs.

Note 18: Bidirectional traceability supports consistency and facilitates impact analyses of change requests, and demonstration of verification coverage.

Note 18: Traceability alone, e.g., the existence of links, does not necessarily mean that the information is consistent with each other.

MEE.2.BP6: Communicate agreed Mechanical System Architecture and agreed Mechanical Component Design.
Communicate the agreed Mechanical System Architecture and the agreed Mechanical Component Design to all affected parties, including the Special Characteristics and updates to the Mechanical System Architecture and Mechanical Component Design.

MEE.2 Mechanical Architecture and Design	Outcome 1	Outcome 2	Outcome 3	Outcome 4
Output Information Items				
04-ME01 Mechanical System Architecture	X			
04-ME02 Mechanical Component Design	X			
13-51 Consistency Evidence			X	
13-52 Communication Evidence				X
15-51 Analysis Results		X		
17-57 Special Characteristics		X		
Base Practices				
BP1: Specify static aspects of the Mechanical System and Mechanical Component.	X			
BP2: Specify dynamic aspects of the Mechanical System and Mechanical Component.	X			
BP3: Analyze the Mechanical System Architecture and Mechanical Component Design		X		
BP4: Consider, determine, and document Design Constraints	X			
BP5: Ensure consistency and establish bidirectional traceability			X	
BP6: Communicate agreed Mechanical System Architecture and Mechanical Component Design				X

4.1.3 MEE.3 Mechanical Component Sample Production

Process ID

MEE.3

Process name

Mechanical Component Sample Production

Process purpose

The purpose is to produce a Mechanical Component Sample that reflects properly the Mechanical Component Design and Mechanical Component Sample Production Specification.

Process outcomes

1) A Mechanical Component Sample Production Specification is developed, agreed on with and communicated to all affected parties.
2) Mechanical Component Samples are produced according to the Mechanical Component Sample Production Specification and Mechanical Component Design.
3) Consistency and bidirectional traceability are established between the Mechanical Component Sample Production Specification and Mechanical Component Design; and bidirectional traceability is established as chain between the Mechanical Component Sample, Production Data and Mechanical Component Sample Production Specification.
4) The Production Data are summarized to the Production Report, which is communicated to all affected parties.

Base practices

MEE.3.BP1: Develop Mechanical Component.
Develop a Specification for Sample Production of the Mechanical Components. The Mechanical Component Sample Production Specification shall be consistent with the Mechanical Component Design.

Note 1: The Mechanical Component Sample Production Specification may contain the definition of the production method(s), verification method(s) (control plan).

MEE.3.BP2: Agree on Mechanical Component Sample Production Specification.
Communicate the agreed Mechanical Component Sample Production Specification to all affected parties (e.g., engineering, sample shop, production).

Note 2: The communication of the Mechanical Component Sample Production Specification to suppliers is handled by ACQ.4 Supplier monitoring.

MEE3.BP3: Produce the Mechanical Component Samples.
Ensure and support the Sample Production of Mechanical Components according to the Mechanical Component Design and the Mechanical Component Sample Production Specification. Record Production Data according to the Mechanical Component Sample Production Specification.

Note 3: Production here means only sample phases (e.g., prototype building, pre-series production) and does not cover the process of industrialization.

MEE.3.BP4: Ensure consistency and establish bidirectional traceability.

1. Ensure consistency and establish bidirectional traceability between the Mechanical Component Sample Production Specification and the Mechanical Component Design.
2. Establish bidirectional traceability between the recorded Production Data and the Mechanical Component Sample Production Specification.
3. Establish bidirectional traceability between the produced Mechanical Component Samples and the recorded Production Data.

Note 4: Bidirectional traceability supports consistency, and facilitates impact analyses of change requests, and demonstration of verification coverage.

MEE.3.BP5: Summarize and communicate the Production Data.
Summarize the Production Data of the Mechanical Component Samples to the Production Report and communicate it to all affected parties.

Note 5: Production Data may contain:

- *Capability of chosen production method*
- *Manufacturability of the Mechanical Component Samples*
- *Improvement potentials for future releases*
- *Process Data and information*

Note 6: See SUP.9 for handling verification results that deviate from expected results.

Note 7: The communication of information mentioned above is handled by ACQ.4 Supplier monitoring in case of production at a supplier's site.

Affected parties could be:

- *Industrialization*
- *Series production*
- *Mechanical engineering*
- *Project Management*
- *Quality Assurance*

MEE.3 Mechanical Component Sample Production	Outcome 1	Outcome 2	Outcome 3	Outcome 4
Output Information Items				
19-ME01 Mechanical Component Sample Production Specification	X	X		
11-ME04 Mechanical Component		X		
13-51 Consistency Evidence			X	
15-ME01 Production Report				X
13-52 Communication Evidence				X
Base Practices				
BP1: Develop Mechanical Component Sample Production Specification	X			
BP2: Agree on Mechanical Component Sample Production Specification	X			
BP3: Produce the Mechanical Component Samples		X		
BP4: Ensure consistency and establish bidirectional traceability			X	
BP5: Summarize and communicate the Production Data				X

4.1.4 MEE.4 Mechanical Integration and Verification against Mechanical Architecture and Design

Process ID
MEE.4
Process name
Mechanical Integration and Verification against Mechanical Architecture and Design
Process purpose
The purpose is: 1. to verify the Mechanical Component against the Mechanical Component Design and 2. to ensure the integration of the Mechanical Elements into an integrated Mechanical System consistent with the Mechanical System Architecture and 3. to verify the integrated Mechanical System against the Mechanical System Architecture.
Process outcomes
1) Verification Measures are specified for Mechanical Component Design Verification based on the Mechanical Component Design. 2) Measures for Mechanical Component Design Verification are selected according to the Release Scope considering Regression Criteria. 3) The Mechanical Component Design is verified using the selected Verification Measures and the Verification Results are recorded. 4) The Mechanical Integration Sequence of the Mechanical Elements (Mechanical Component and/or Mechanical System) is specified consistent with the Mechanical System Architecture. 5) Verification Measures are specified for the Mechanical System Integration Verification based on the Mechanical System Architecture, including the interfaces and interactions between Mechanical Elements. 6) Mechanical Elements are integrated up to a complete integrated Mechanical System consistent with the Release Scope. 7) Measures for Mechanical System Integration Verification are selected according to the Release Scope considering Regression Criteria. 8) Integrated Mechanical Elements are verified using the selected Verification Measures and the Verification Results are recorded. 9) Consistency and bidirectional traceability are established between the Mechanical Component Design Verification Measures and Mechanical Component Design; and bidirectional traceability is established as chain between the Mechanical Component, Mechanical Component Design Verification Results and Mechanical Component Design Verification Measures. 10) Consistency and bidirectional traceability are established between Integration Steps and the Mechanical System Architecture; and consistency and bidirectional traceability are established between the Mechanical System Integration Verification Measures and Mechanical System Architecture; and bidirectional traceability is established as chain between the Mechanical System, Integration

Data and Integration Steps; and
bidirectional traceability is established as chain between the Mechanical System, Mechanical System Integration Verification Results and Mechanical System Integration Verification Measures.

11) Bidirectional traceability is established between the Mechanical Component and Mechanical System.
12) The Integration Data are summarized to the Integration Report, which is communicated to all affected parties; the Mechanical Component Design Verification Results and the Mechanical System Integration Verification Results are summarized and communicated to all affected parties.

Base practices

MEE.4.BP1: Specify Verification Measures for the Mechanical Component Design.
Specify Mechanical Component Design Verification Measures suitable to provide evidence for compliance of the Mechanical Component with the Mechanical Component Design. This includes:

a) techniques for the Verification Measures
b) pass/fail criteria for Verification Measures
c) a definition of Entry and Exit Criteria for the Verification Measures
d) necessary sequence of Verification Measures
e) the required Verification Infrastructure and Environment Setup

MEE.4.BP2: Select Verification measures for the Mechanical Component Design.
Document the selection of the Mechanical Component Design Verification Measures considering selection criteria including criteria for Regression Verification. The documented selection of Verification Measures shall have sufficient coverage according to the Release Scope.

Note 1: Examples for Selection Criteria can be prioritization of requirements, the need for Regression Verification due to e.g. changes to the Mechanical Component Design, the intended use of the delivered product release (test bench, test track, public road etc.).

MEE.4.BP3: Perform Mechanical Component Design Verification.
Perform Mechanical Component Design Verification using the selected Mechanical Component Design Verification Measures. Record the Mechanical Component Design Verification Results including pass/fail status and measured values with reference to the verified Mechanical Component.

Note 2: Capable Verification Environment as defined in the Component Design Verification Measures needs to be available for performing verification against Mechanical Component Design.

Note 3: See SUP.9 for handling verification results that deviate from expected results.

MEE.4.BP4: Define Integration Sequence Instruction and specify Mechanical System Integration Verification Measures.
Identify Mechanical Elements based on the Mechanical System Architecture.

Define the Integration Sequence Instruction including Integration Steps and Integration Verification Measures for the Mechanical System Integration.

The Integration Instruction shall be suitable to provide evidence for compliance of the integrated Mechanical System with the Mechanical System Architecture. This includes:

a) preconditions and techniques for the Verification Measures

b) pass/fail criteria for Verification Measures

c) a definition of Entry and Exit Criteria for Integration and the Verification Measures

d) necessary sequence of Verification Measures

e) the required Verification Infrastructure and Environment Setup

Note 4: Internal interfaces (between the mechanical elements) and external interfaces should be verified according to the Mechanical System Architecture and the specified Mechanical System Integration Verification Measures.

MEE.4.BP5: Select Mechanical System Integration Verification Measures.
Document the selection of Mechanical System Integration Verification Measures for each Integration Step considering selection criteria including criteria for Regression Verification. The documented selection of Verification Measures shall have sufficient coverage according to the Release Scope.

Note 5: Examples for Selection Criteria can be prioritization of requirements, the need for Regression Verification due to e.g., changes to the Mechanical System Architecture, or the intended use of the delivered product release.

MEE.4.BP6: Integrate Mechanical System Elements and perform Mechanical System Integration Verification.
Integrate the Mechanical Elements into an integrated Mechanical System according to the Release Scope based on the Integration Sequence Instruction.

Perform the selected Mechanical System Integration Verification Measures to verify the Mechanical Interfaces.

Record the Mechanical System Integration Verification Results including pass/fail status, integration data and the corresponding Verification Measure Data with reference to the Mechanical Elements.

Note 6: The Mechanical System Integration should be performed with verified Mechanical Elements. Otherwise, justification should be provided.

Note 7: Capable Verification Infrastructure and Environment Setup as defined in the Mechanical System Integration Verification Measures needs to be available for performing Mechanical System Integration and Mechanical System Integration Verification.

Note 8: See SUP.9 for handling verification results that deviate from expected results.

MEE.4.BP7: Ensure consistency and establish bidirectional traceability.

1. Ensure consistency and establish bidirectional traceability between the Mechanical Component Design Verification Measures and the Mechanical Component Design.

2. Establish bidirectional traceability between the Mechanical Component Design Verification Results and the Mechanical Component Design Verification Measures.
3. Establish bidirectional traceability between the verified Mechanical Components and the Mechanical Component Design Verification Results.
4. Ensure consistency and establish bidirectional traceability between the Integration Steps and the Mechanical System Architecture.
5. Establish bidirectional traceability between the Integration Data and the Integration Steps.
6. Establish bidirectional traceability between the integrated Mechanical System and the Integration Data.
7. Ensure consistency and establish bidirectional traceability between the Mechanical System Integration Verification Measures and the Mechanical System Architecture.
8. Establish bidirectional traceability between the Mechanical System Integration Verification Results and the Mechanical System Integration Verification Measures.
9. Establish bidirectional traceability between the verified integrated Mechanical System and the Mechanical System Integration Verification Results.
10. Establish bidirectional traceability between the Mechanical Components and integrated Mechanical System.

Note 9: Bidirectional traceability supports consistency, and facilitates impact analyses of change requests, and demonstration of verification coverage. Traceability alone, e.g. the existence of links, does not necessarily mean that the information is consistent with each other.

MEE.4.BP8: Summarize and communicate the Integration and Verification Results.
Summarize the Mechanical Component Design Verification Results.

Summarize the Integration Data into the Integration Report.

Summarize the Mechanical System Integration Verification Results.

Communicate them to all affected parties.

Note 10: Providing all necessary information from the verification measure execution in a summary enables other parties to judge the consequences.

MEE.4 Mechanical Integration and Verification against Mechanical Architecture and Design	Outcome 1	Outcome 2	Outcome 3	Outcome 4	Outcome 5	Outcome 6	Outcome 7	Outcome 8	Outcome 9	Outcome 10	Outcome 11	Outcome 12
Output Information Items												
08-60 Verification Measure	X				X							
08-58 Verification Measure Selection Set		X					X					
15-52 Verification Results			X					X				
03-50 Verification Measure Data								X				
06-50 Integration Sequence Instruction				X								
11-ME03 Mechanical System						X						
13-51 Consistency Evidence									X	X	X	
15-ME02 Integration Report												X
13-52 Communication Evidence												X
Base Practices												
BP1: Specify Mechanical Component design verification measures	X											
BP2: Select Mechanical Component design verification measures		X										
BP3: Perform Mechanical Component design verification			X									
BP4: Define Integration Sequence Instruction and specify Mechanical System Integration Verification Measures				X	X							
BP5: Select Mechanical System Integration verification measures							X					
BP6: Integrate Mechanical System elements and perform Mechanical System integration verification						X		X				
BP7: Ensure consistency and establish bidirectional traceability									X	X		
BP8: Summarize and communicate the Integration and verification results											X	X

4.1.5 MEE.5 Verification against Mechanical Requirements

Process ID
MEE.5
Process name
Verification against Mechanical Requirements
Process purpose
The purpose is to ensure that the Mechanical Components and the integrated Mechanical System are verified to provide evidence for compliance with the Mechanical System Requirements and Mechanical Component Requirements.
Process outcomes
1) Verification Measures are specified for the Mechanical System Verification and Mechanical Component Verification based on the Mechanical System Requirements and Mechanical Component Requirements. 2) Verification Measures are selected according to the Release Scope considering Regression Criteria, including criteria for Regression Verification. 3) The Mechanical System and Mechanical Components are verified using the selected Verification Measures and the Verification Results are recorded. 4) Consistency and bidirectional traceability are established between the Mechanical Component Requirements Verification Measures and Mechanical Component Requirements; and bidirectional traceability is established as chain between Mechanical Component, Mechanical Component Requirements Verification Results and Mechanical Component Requirements Verification Measures. 5) Consistency and bidirectional traceability are established between the Mechanical System Requirements Verification Measures and Mechanical System Requirements; and bidirectional traceability is established as chain between the Mechanical System, Mechanical System Requirements Verification Results and Mechanical System Requirements Verification Measures. 6) Mechanical System Verification Results and Mechanical Component Verification Results are summarized and communicated to all affected parties.

Base practices
MEE.5.BP1: Specify Verification Measures for Mechanical Components and integrated Mechanical System. Specify Verification Measures for Mechanical Components and integrated Mechanical System suitable to provide evidence for compliance with the with the functional and non-functional information Mechanical System Requirements and with the functional and non-functional information Mechanical Component Requirements, including: a) techniques for the Verification Measures b) pass/fail criteria for Verification Measures c) a definition of entry and exit criteria for the Verification Measures

d) necessary sequence of Verification Measures

e) the required Verification Infrastructure and Environment Setup

Note 1: The Verification Measures may cover aspects such as thermal, environmental, robustness/lifetime, etc.

MEE.5.BP2: Select Verification Measures for Mechanical Components and integrated Mechanical System.
Select Mechanical Component Requirements Verification Measures as well as Mechanical System Requirements Verification Measures. Document the selection of the Verification Measures considering Selection Criteria including criteria for Regression Verification. The documented selection of Verification Measures shall have sufficient coverage according to the Release Scope.

Note 2: Examples for Selection Criteria can be prioritization of requirements, the need for regression due to e.g. changes to the Mechanical Component Requirements or the Mechanical System Requirements, the intended use of the delivered product release (test bench, test track, public road etc.)

MEE.5.BP3: Verify the Mechanical Components and integrated Mechanical System.
Perform the verification of the Mechanical Components and the integrated Mechanical System using the selected Verification Measures. Record the Verification Results including pass/fail status and corresponding Verification Measure Data.

Note 3: Capable verification environment as defined needs to be available for performing verification of mechanical component and integrated mechanical system.

Note 4: Mechanical Elements can be physical or virtual.

Note 5: See SUP.9 for handling verification results that deviate from expected results.

MEE.5.BP4: Ensure consistency and establish bidirectional traceability.

1. Ensure consistency and establish bidirectional traceability between the Mechanical System Requirements Verification Measures and the Mechanical System Requirements.
2. Establish bidirectional traceability between the Mechanical System Requirements Verification Results and the Mechanical System Requirements Verification Measures.
3. Establish bidirectional traceability between the integrated Mechanical System and the Mechanical System Requirements Verification Results.
4. Ensure consistency and establish bidirectional traceability between the Mechanical Component Requirements Verification Measures and the Mechanical Components Requirements.
5. Establish bidirectional traceability between the Mechanical Component Requirements Verification Results and the Mechanical Component Requirements Verification Measures.
6. Establish bidirectional traceability between the Mechanical Components and the Mechanical Component Requirements Verification Results.

Note 6: Bidirectional traceability supports consistency, and facilitates impact analyses of change requests, and demonstration of verification coverage. Traceability alone, e.g. the existence of links, does not necessarily mean that the information is consistent with each other.

MEE.5.BP5: Summarize and communicate the Verification Results.
Summarize the Mechanical Component Requirements Verification Results and the Mechanical System Requirements Verification Results and communicate them to all affected parties.

Note 7: Providing all necessary information from the verification measure execution in a summary enables other parties to judge the consequences.

MEE.5 Verification against Mechanical Requirements	Outcome 1	Outcome 2	Outcome 3	Outcome 4	Outcome 5	Outcome 6
Output Information Items						
08-60 Verification Measure	X					
03-50 Verification Measure Data			x			
08-58 Verification Measure Selection Set		X				
15-52 Verification Results			X			
13-51 Consistency Evidence				X	X	
13-52 Communication Evidence						X
Base Practices						
BP1: Specify Verification Measures for Mechanical Components and integrated Mechanical System	X					
BP2: Select Verification Measures for Mechanical Components and integrated Mechanical System		X				
BP3: Perform verification of the Mechanical Components and integrated Mechanical System			X			
BP4: Ensure consistency and establish bidirectional traceability				X	X	
BP5: Summarize and communicate the Verification Results						X

5 Process capability level and process attributes

The entire Capability Dimension of Automotive SPICE® Version 4.0, Chapter 5, applies. The Capability level and Process Attribute definitions in Automotive SPICE® are the ones defined in ISO/IEC 33020.

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 33004:2015. The process assessment model can be used in the performance of assessments that meet the requirements of ISO/IEC 33002:2015.

This clause serves as the statement of conformance of the process assessment and process reference models to the requirements defined in ISO/IEC 33004:2015.

[ISO/IEC 33004:2015, 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 33004:2015.

A2. Conformance to the requirements for process reference models

A2.1 Clause 5.3, "Requirements for process reference models"

The following information is provided in Chapter 1 and Chapter 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 33004:2015 clause 5.4 is provided in Chapter 4 of this document.

[ISO/IEC 33004:2015, 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 33004:2015, 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 33004:2015, 5.3.3]

A2.2 Clause 5.4, "Process descriptions"

These requirements are met by the process descriptions in Chapter 4 of this document.

[ISO/IEC 33004:2015, 5.4]

A3. Conformance to the requirements for process assessment models

A3.1 Clause 6.1, "Introduction"

The purpose of this process assessment model is to support assessment of process capability within the automotive domain using the defined process measurement framework.

[ISO/IEC 33004:2015, 6.1]

A3.2 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 33004:2015, clause 5 as described in Annex A2.

The process capability scope of this process assessment model is defined in the process measurement framework, which defines a process measurement framework for process capability satisfying the requirements of ISO/IEC 33003:2015.

[ISO/IEC 33004:2015, 6.2]

A3.3 Clause 6.3, "Requirements for process assessment models"

The SPICE for Mechanical Engineering process assessment model is related to process capability.

[ISO/IEC 33004:2015, 6.3.1]

This process assessment model incorporates the process measurement framework, which satisfies the requirements of ISO/IEC 33003:2015.

[ISO/IEC 33004:2015, 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 defined Measurement Framework.

[ISO/IEC 33004:2015, 6.3.3]

The processes included in this process assessment model are identical to those specified in the Process Reference Model

[ISO/IEC 33004:2015, 6.3.4]

For all processes in this process assessment model all levels defined in the process measurement framework are addressed.

[ISO/IEC 33004:2015, 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 33004:2015, 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.

[ISO/IEC 33004:2015, 6.3.5 e]

A3.4 Clause 6.3.1, "Assessment indicators"

NOTE: Due to an error in numbering in the published version of ISO/IEC 33004:2015 the following reference numbers are redundant to those stated above. To refer to the correct clauses from ISO/IEC 33004:2015, 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 33004:2015, 6.3.1 a, "Assessment indicators"]

- Generic practices and Generic resources

[ISO/IEC 33004:2015, 6.3.1 b, "Assessment indicators"]

A3.5 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 the tables for each process 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 the tables for each process attribute in Chapter 5.

[ISO/IEC 33004:2015, 6.3.2, "Mapping process assessment models"]

A3.6 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. Consequently, 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 33004:2015, 6.3.3, "Expression of assessment results"]

A4. Conformance to the requirements for measurement frameworks

The measurement framework defined in Automotive SPICE® 4.0, also used for SPICE for Mechanical Engineering, is an adaption of the measurement framework defined in ISO/IEC 33020:2019. The following modifications have been performed:

- Renaming of the Process attribute titles.
- Changes in the generic practices.
- Assignments of indicators to process attribute achievements.

Conceptualization, Construct definition and Operationalization relevant for conformity to ISO/IEC 33003:2015 has been adopted from ISO/IEC 33020:2019.

The conformity of the Automotive SPICE® Measurement Framework is thereby confirmed based on the existing conformance statement of 33020:2019.

Annex B – Information Items Characteristics

Information item 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 information item, 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.

Information items are defined using the schema in Table 9. Information items and their characteristics should be taken as a starting point for evaluating whether Information items are contributing to the intended purpose of the process in a given context, and not as a checklist of what every organization must have.

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

Table 9 – A.1 Structure of Information Items Characteristics tables

The generic Information Items (ID nn-xx) are taken from Automotive SPICE® 4.0 Annex B; in case of different formulation the definition in Automotive SPICE® 4.0 is binding.

The SPICE for Mechanical Engineering specific Information Items are marked with ID nn-**ME**xx.

ID	Name	Characteristics
04-00	Design	• Describes the overall product/system structure • Identifies the required product/system elements • Identifies the relationship between the elements • Consideration is given to: - any required performance characteristics - any required interfaces - any required security characteristics
04-ME01	Mechanical System Architecture	• Describes the overall mechanical structure e.g., block diagram, P-diagram/boundary diagram (Interface control document), system structure, 3D-models • 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 aspects of the mechanical system • Consideration is given to: - any required mechanical performance characteristics - any required mechanical interfaces - any required critical characteristics • Bill of Material
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)
06-50	Integration Sequence Instruction	• Identification of required physical elements (e.g., hardware, mechanical, wiring elements), and software executables and application parameters (being a technical implementation solution for configurability-oriented requirements) • necessary sequence or ordering of integration • preconditions for starting system integration
08-58	Verification Measure Selection Set	• include criteria for re-verification in the case of changes (regression). • Identification of verification measures, also for regression testing

ID	Name	Characteristics
08-60	Verification Measure	• A verification measure can be a test case, a measurement, a calculation, a simulation, a review, an optical inspection, or an analysis • The specification of a verification measure includes - pass/fail criteria for verification measures (test completion and ending criteria) - a definition of entry and exit criteria for the verification measures, and abort and re-start criteria • Techniques (e.g. black-box and/or white-box-testing, equivalence classes and boundary values, fault injection for Functional Safety, penetration testing for Cybersecurity, back-to- back testing for model-based development, ICT) • Necessary Verification environment & infrastructure • Necessary sequence or ordering
11-00	Product	• Is a result/deliverable of the execution of a process, includes services, systems (software and hardware) and processed materials • Has elements that satisfy one or more aspects of a process purpose • May be represented on various media (tangible and intangible)
11-ME03	Mechanical System	• Mechanical System is an integration of at least two mechanical elements (e.g. Mechanical Component, Mechanical System).
11-ME04	Mechanical Component	• Mechanical Components are the lowest level of mechanical elements of the architecture.
13-00	Record	• Work product stating results achieved or provides evidence of activities performed in a process • An item that is part of a set of identifiable and retrievable data

ID	Name	Characteristics
13-51	Consistency Evidence	• Demonstrates bidirectional traceability between artifacts or information in artifacts, throughout all phases of the life cycle, by e.g. - tool links - hyperlinks - editorial references - naming conventions • Evidence that the content of the referenced or mapped information coheres semantically along the traceability chain, e.g. by - performing pair working or group work - performing by peers, e.g. spot checks - maintaining revision histories in documents - providing change commenting (via e.g. meta-information) of database or repository entries *Note: This evidence can be accompanied by e.g. Definition of Done (DoD) approaches.*
13-52	Communication Evidence	• All forms of interpersonal communication such as - e-mails, also automatically generated ones - tool-supported workflows - meeting, verbally or via meeting minutes (e.g.: daily standups) - podcast - blog - videos - forum - live chat - wikis - photo protocol
15-00	Report	• A work product describing a situation that: - includes results and status - identifies applicable/associated information - identifies considerations/constraints - provides evidence/verification
15-ME01	Production Report	• Identification of produced items (e.g. drawing, BOM, serial number, batch number, lot number) • Records related to: - Findings and observations - production data - deviations (e.g. from the assembly plan, control plan, mechanical component production specification)

<table>
<tr><th>ID</th><th>Name</th><th>Characteristics</th></tr>
<tr><td>15-ME02</td><td>Integration Report</td><td>Identification of the used BOM
Identification of assembled elements (e.g. serial number, batch number, lot number)
Assembly related:
- Findings and observations
- Integration data
- deviations from the integration specification</td></tr>
<tr><td>15-51</td><td>Analysis Results</td><td>Identification of the object under analysis.
The analysis criteria used, e.g.
selection criteria or prioritization scheme used
decision criteria
quality criteria
The analysis results, e.g.
what was decided/selected
reason for the selection
assumptions made
potential negative impact
Aspects of the analysis may include
correctness
understandability
verifiability
feasibility
validity</td></tr>
<tr><td>15-52</td><td>Verification Results</td><td>Verification data and logs
Verification measure passed
Verification measure not passed
Verification measure not executed
information about the test execution (date, tester name etc.)
Abstraction or summary of verification results</td></tr>
</table>

ID	Name	Characteristics

17-00	Requirement	• An expectation of functions and capabilities (e.g. non-functional requirements), or one of its interfaces
		  - from a black-box perspective
		  - that is verifiable, does not imply a design or implementation decision, is unambiguous, and does not introduce contradictions to other requirements.
		• A requirements statement that implies, or represents, a design or implementation decision is called “Design Constraint”.
		• Examples for requirements aspects at the system level are thermal characteristics such as
		  - heat dissipation
		  - dimensions
		  - weight
		  - materials
		• Examples of aspects related to requirements about system interfaces are
		  - connectors
		  - cables
		  - housing
		• Examples for requirements at the hardware level are
		  - lifetime and mission profile, lifetime robustness
		  - maximum price
		  - storage and transportation requirements
		  - functional behavior of analog or digital circuits and logic
		  - quiescent current, voltage impulse responsiveness to crank, start-stop, drop-out, load dump
		  - temperature, maximum hardware heat dissipation
		  - power consumption depending on the operating state such as sleep-mode, start-up, reset conditions
		  - frequencies, modulation, signal delays, filters, control loops
		  - power-up and power-down sequences, accuracy and precision of signal acquisition or signal processing time
		  - computing resources such as memory space and CPU clock tolerances
		  - maximum abrasive wear and shearing forces for e.g. pins or soldering joints
		  - requirements resulting from lessons learned
		  - safety related requirements derived from the technical safety concept

ID	Name	Characteristics
17-ME05	Mechanical System Requirement	Requirements that are specific for the mechanical part of the mechatronic system, derived from the Upper (Mechanical) System Requirements and the Upper (Mechanical) System Architecture. Examples for mechanical system requirements are - Functional requirements - Fatigue life - Material properties - Environmental Requirements (e.g. REACH) - Weight - Noise Vibration Harshness (NVH) - Bauraum
17-ME06	Mechanical Component Requirement	Requirements that are specific for the mechanical components of the mechanical system, derived from the Upper (Mechanical) System Requirements and Upper (Mechanical) Architecture. Examples for mechanical component requirements are - Fatigue life - Material properties - Environmental Requirements (e.g. REACH) - Weight - Supplier - Color
17-54	Requirement Attribute	• Meta-attributes that support structuring and definition of release scopes of requirements • Can be realized by means of tools *Note: usage of requirements attributes may further support analysis of requirements*
17-57	Special Characteristics	• Special Characteristics in terms of relevant standards such as IATF 16949, VDA 6.x Guidelines, ISO 26262. • Special Characteristics according to IATF 16949:2016, are product characteristics or production process parameters that may have an impact on safety or compliance with official regulations, the fit, the function, the performance or further processing of the product. • Special characteristics shall be verifiable according to VDA vol. 1 • *Note: A typical method for identifying and rate special characteristics is an FMEA.*

ID	Name	Characteristics
19-ME01	Mechanical Component Production Specification	• 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 Mechanical Component Production Specification may include: - process design - locations - vertical range of manufacture - manufacturing equipment - structure and logistics of manufacturing - suppliers - staff structure - reference to release scope - reference to verification measures

Table 10 – A.2 Information item characteristics

Annex C – Terminology

Table 11 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.

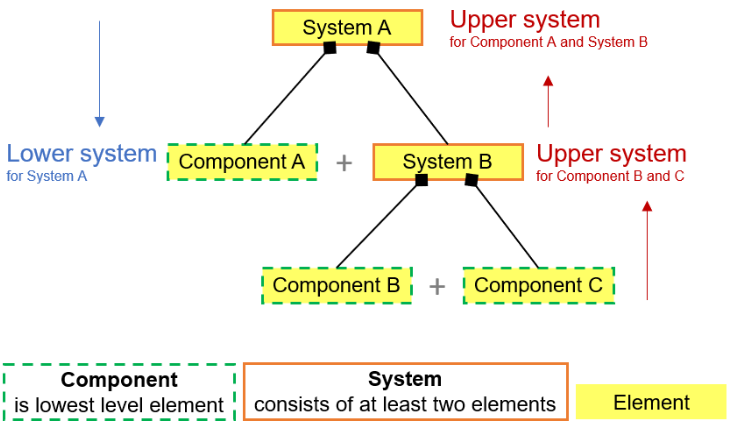
Term	Origin	Description
Activity	Automotive SPICE® V4.0	Execution of a task by a stakeholder or an involved party.
Application parameter	Automotive SPICE® V4.0	An application parameter is a software variable containing data that can be changed at the system or software levels; they influence the system or software behavior and properties. The notion of application parameter is expressed in two ways: • The specification (including variable names, the domain value range, technical data types, default values, physical unit (if applicable), the corresponding memory maps, respectively). • The actual quantitative data value it receives by means of data application. Application parameters are not requirements. They are a technical implementation solution for configurability-oriented requirements.
Approval	Automotive SPICE® V4.0	Written statement that a deliverable is fit for its intended use, and compliant with defined criteria.
Assembly instruction	SPICE for Mechanical Engineering V2.0	Is based on the architecture and contains a description of the steps how the mechanical elements shall be assembled/integrated to a mechanical system considering the release scope. 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
Baseline	Automotive SPICE® V4.0	A defined and coherent set of read-only information, serving as an input information for affected parties.
Bill of Materials	SPICE for Mechanical Engineering V2.0	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 Verification Environment	SPICE for Mechanical Engineering V2.0	Documented, qualified (e.g., gauge repeatability and reproducibility [R&R]) and released test infrastructure.

Component	SPICE for Mechanical Engineering V2.0	Components (physical or virtual) are the lowest level elements of the mechanical architecture for which the component design is further defined.
Consistency	Automotive SPICE® 3.1	Consistency addresses content and semantics and ensures that Information items are not in contradiction to each other. Consistency is supported by bidirectional traceability. See also chapter D.3.
Control plan	IATF16949 Appendix A	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	SPICE for Mechanical Engineering V2.0	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 ♦ Elements test coverage: degree of tested elements versus all created elements ♦ Verification coverage for critical characteristics: ratio of tested or verified (e.g. production process capability – cpk) critical characteristics based on control plan
Deliverable	PMBOK® Guide – Fourth Edition	Any unique and verifiable product, result, or capability to perform a service that must be produced to complete a process, phase, or project. Often used more narrowly in reference to an external deliverable, which is a deliverable that is subject to approval by the project sponsor or customer.
Design constraints	SPICE for Mechanical Engineering V2.0	Limits which must be considered when designing elements. Limit the number of design variants. Examples: packaging, costs
Dynamic aspects	SPICE for Mechanical Engineering V2.0	Time dependent physical aspects of system/components, e.g. thermal aspects, deformation, motion, vibration, fluid mechanics.

Integration strategy	SPICE for Mechanical Engineering V2.0	Defines the order of assembly steps of items based on the re-lease scope.
(Mechani-cal) Element	SPICE for Mechanical Engineering V2.0	The term Element is a collective term for virtual or physical objects on architecture, design, and verification level on the left and right side of the "V-Model". An architecture specifies the elements of the system. Elements are hierarchically de-composed into smaller elements down to the components which are at the lowest level of the architecture.
Functional requirement	ISO/IEC/IEEE 24765	A statement that identifies what a product or process must accomplish to produce required behavior and/or results.
Integration Verification	SPICE for Mechanical Engineering V2.0	The emphasis of integration verification is on the interfaces and interactions between the different elements.
Interaction	SPICE for Mechanical Engineering V2.0	Interaction occurs between elements of the respective sys-tem or between elements of the respective system and the Operating Environment.
Measure	Automotive SPICE® V4.0	An activity to achieve a certain intent.
Measure-ment	Oxford Dictionary	"The activity to find the size, quantity or degree of some-thing".
Model-based devel-opment	SPICE for Mechanical Engineering V2.0	Development which is based on models (e.g., analytical, nu-merical) that represent the reality of the respective elements in a sufficient way and that are used for sizing, design, simula-tion, optimization, and validation. *Note: Simulation results should be verified by tests of physical elements.*
Operating Environ-ment	SPICE for Mechanical Engineering V2.0	Operating Environment is the context in which the considered system works.
Plan	Automotive SPICE V3.1 (WP ID 08-00)	As appropriate to the application and purpose: ♦ Identifies what objectives or goals there are to be sat-isfied ♦ Establishes the options and approach for satisfying the objectives, or goals ♦ Identification of the plan owner ♦ Includes: o the objective and scope of what is to be ac-complished o assumptions made o constraints o risks o tasks to be accomplished o schedules, milestones and target dates o critical dependencies o maintenance disposition for the plan ♦ Method/approach to accomplish plan

		♦ Identifies: o task ownership, including tasks performed by other parties (e.g. supplier, customer) o quality criteria o required work products ♦ Includes resources to accomplish plan objectives: o time o staff (key roles and authorities e.g. sponsor) o materials/equipment o budget ♦ Includes contingency plan for non-completed tasks ♦ Plan is approved
Production	SPICE for Mechanical Engineering V2.0	Production is defined as component manufacturing or system assembly or the combination of both.
Production relevant require-ments and data	SPICE for Mechanical Engineering V2.0	Identifies requirements and data related to production, like: ♦ process parameters ♦ guidelines ♦ maintenance requirements ♦ required technologies
Mechanical Component Sample Pro-duction Specification	SPICE for Mechanical Engineering V2.0	Mechanical Component Sample Production Specification in-cludes, e.g.: ♦ process design ♦ vertical range of manufacture ♦ manufacturing equipment ♦ structure and logistics of manufacturing ♦ make or buy decision ♦ production process parameters (e.g. pressure, rates, calibration data)
Regression verification	Automotive SPICE® V4.0	Selective re-verification of elements to verify that modifica-tions have not caused unintended effects
Release	Automotive SPICE® V4.0	A physical product delivered to a customer, including a de-fined set of functionalities and properties.
Special Characteris-tics	SPICE for Mechanical Engineering V2.0	Special Characteristics are e.g.: ♦ Significant characteristics having high impact on de-signed 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 character-istics is an FMEA.* Further details can be found in ♦ IATF 16949:2016 ♦ 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.
Stakeholder requirements	Automotive SPICE® V4.0	Any type of requirement for the stakeholders in the given context, e.g., customer requirement, supplier internal requirements (product-specific, platform etc.), legal requirements, regulatory requirements, statutory requirements, industry sector requirements, international standards, codes of practice etc. …
Static behavior	SPICE for Mechanical Engineering V2.0	Time independent physical aspects of elements over required lifetime, e.g., transmission ratio, weight, mass, geometry.
Strategy	Automotive SPICE® V3.1 (WP ID 19-00)	♦ 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
System Element	Automotive SPICE® V4.0	System elements can be: ♦ Logical and structural objects at the architectural and design level. System elements can be further decomposed into more fine-grained system elements of the architecture or design across appropriate hierarchical levels. ♦ Physical representations of these objects, or a combination, e.g., peripherals, sensors, actuators, mechanical parts, software executables.
Task	Automotive SPICE® V4.0	A definition, but not the execution, of a coherent and set of atomic actions.
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.
Traceability	Automotive SPICE® V3.1	Traceability refers to the existence of references or links between Information items. Traceability supports coverage analysis, impact analysis, requirements implementation status tracking etc. See also chapter D.3.

Upper system	SPICE for Mechanical Engineering V2.0	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. 
Validation measure	Automotive SPICE® V4.0	Validation measure can be: ♦ Operational use case testing under real-life conditions ♦ Highly accelerated life testing (HALT) ♦ Simulations under real-life conditions ♦ End user trials ♦ Panel or blind tests ♦ Expert panels
Verification	Automotive SPICE® V4.0	Verification is confirmation through the provision of objective evidence that an element fulfils the specified requirements.
Verification criteria	SPICE for Mechanical Engineering V2.0	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 measure	Automotive SPICE® V4.0	Verification measure can be: ♦ Test cases ♦ Measurements ♦ Calculations ♦ Simulations ♦ Reviews ♦ Analyses *Note: In particular domains certain verification measures may not be applicable, e.g., software units generally cannot be verified by means of calculations or analyses.*

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

Table 11 – B.1 Terminology

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 Mechanical Engineering V-Model as plug-in to Automotive SPICE®

SPICE for Mechanical Engineering uses the same concept as Automotive SPICE® for the software processes.

- MEE.1 and MEE.5 are comparative to the SWE.1 and SWE.6 (Requirements analysis and verification against requirements). MEE.2 and MEE.4 are comparative to the SWE.2 and SWE.5 (Architectural Design and verification against architecture).
- SPICE for Mechanical Engineering splits SWE.3 Software Detailed Design and Unit Construction into two processes: *MEE.2 Mechanical Architecture and Design* and *MEE.3 Mechanical Component Sample Production*.
- This separates the engineering activities, described in MEE.2, from the physical production of the mechanical components in MEE.3, to reflect the common proceeding in business.
- The verification of the outcomes generated through the MEE.3 process (the mechanical components), is performed in MEE.4. This verification is against the Mechanical Design defined in MEE.2 (see Figure 6).
- The scope of SPICE for Mechanical Engineering and particularly MEE.3 is not the **serial** production of the components, but the support of the sample production.

This concept can be used iterative on each decomposition level.

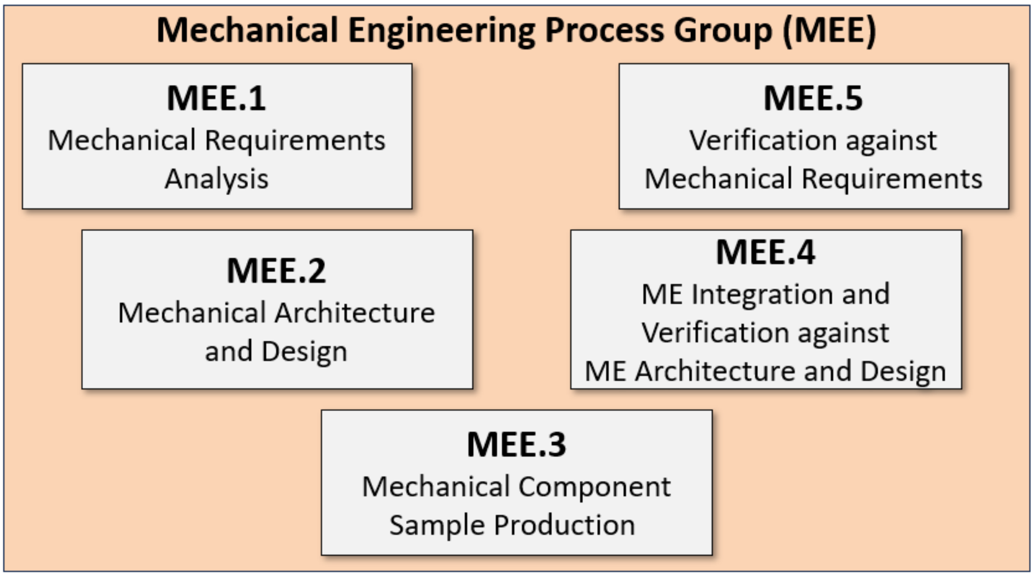


Figure 6 – C.1.1 Mechanical Engineering "V"-Model

D.2 Terms "Element", "Component" and "Sample"

The definition of element, component and sample can be seen in the following picture:

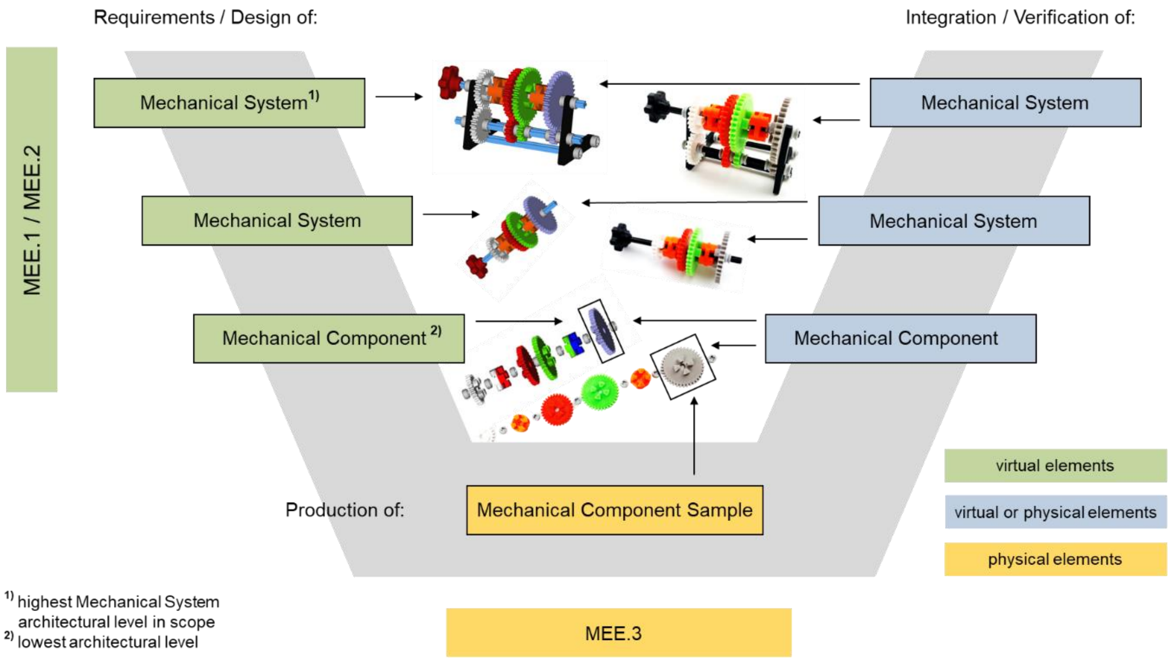


Figure 7 – C.2.1 The terms "element", "component" and "sample"

The term **"Element"** is a collective term for virtual or physical objects on architecture, design, and verification level on the left and right side of the "V-Model". 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" (physical or virtual) are the lowest level elements of the mechanical architecture for which the component design is further defined.

Outcome of the Mechanical Component sample production process are the produced component samples before Start of Production. Therefore, the term **"Sample"** is the physical expression of the virtual component.

D.3 Traceability and Consistency

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

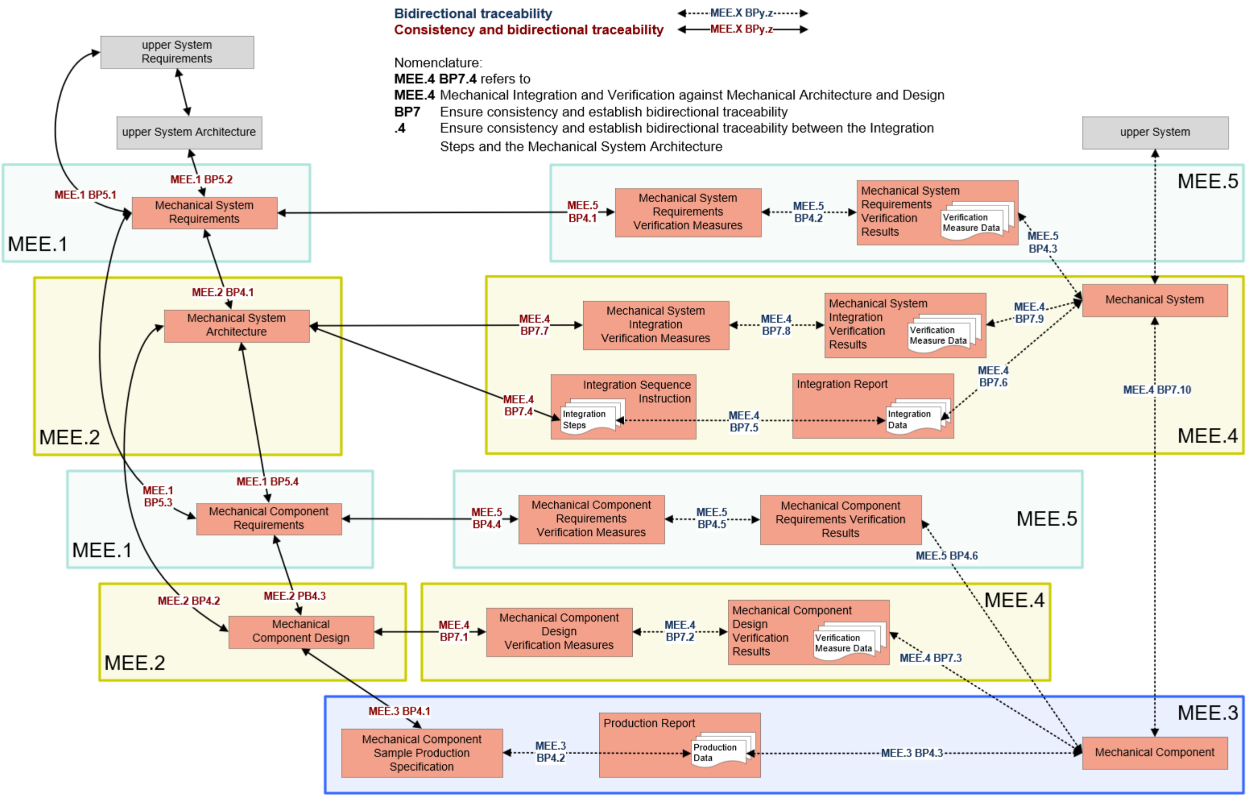


Figure 8 – C.3.1 Traceability and consistency

Annex E Reference standards

Annex D provides a list of reference standards and guidelines that support implementation of the SPICE for Mechanical Engineering PRM/PAM.

Automotive SPICE® 4.0	Automotive SPICE® Process Assessment / Reference Model
IATF 16949:2016	Requirements of a quality management system for organizations in the automotive industry
VDA	German Association of the Automotive Industry
VDA 6.x	Quality standards of VDA
ISO/IEC 33001:2015	Information technology -- Process assessment – Concepts and terminology
ISO/IEC 33002:2015	Information technology -- Process assessment – Requirements for performing process assessment
ISO/IEC 33003:2015	Information technology -- Process assessment – Requirements for process measurement frameworks
ISO/IEC 33004:2019	Information technology -- Process assessment – Requirements for process reference, process assessment and maturity models
ISO/IEC 33020:2019	Information technology -- Process assessment – Process measurement framework for assessment of process capability
ISO/IEC/IEEE 24765:2017	Systems and software engineering -- Vocabulary
ISO/IEC IEEE 29148:2018	Systems and software engineering
INCOSE Guide for Writing Requirements	https://www.incose.org/
PAS 1883:2020	Operational design domain (ODD) taxonomy for an automated driving system (ADS)
ISO 26262:2018	Road vehicles – Functional safety, Second Edition 2018-12

Table D.1 Reference standards