


System Concept - Performance KPI definition

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Abstract	This documents defines the Performance KPIs and Performance Targets for a modular railway architecture and analyses the RAM Performance needed to reach overall Performance Targets
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1 Abbreviations


SPPRAMSS-11192 - The following abbreviations are used in this document and are not yet defined in...

The following abbreviations are used in this document and are not yet defined in SP-PRAMSS:

Abbreviation	Explanation
IM	Infrastructure Manager
RU	Railway Undertaking.
KPI	Key Performance Indicator (or Key Performance Index)
ERJU	Europe's Rail Joint Undertaking.
FBS	Functional Breakdown Structure
SP	System Pillar
SBS	System Breakdown Structure
MTTR	Mean Time To Repair. -> is deprecated: use  SPPRAMSS-4034 - MTTR see below.
RAM	Reliability, Availability, Maintainability.
OEE	Overall Equipment Effectiveness.
ISO	International Organization for Standardization.
OCORA	Open Common Operational Railway Architecture.

 Content to be approved]

SPPRAMSS-11191 - The following abbreviations are used in this document and are already defined in...

The following abbreviations are used in this document and are already defined in SP-PRAMSS:  Content to be approved]


PRAMS

Performance, reliability, availability, maintainability, safety

MTBF

mean operating time between failures


expectation of the duration of the operating time between failures

Note 1 to entry: Mean operating time between failures should only be applied to repairable items. For non-repairable items, see mean operating time to failure (192-05-11)  SPPRAMSS-4040 - [MTTF](#) .
[SOURCE: IEC 60050-192:2015, 192-05-13]

MRT

expectation of the (mean) repair time

[SOURCE: IEC 60050-192:2015, 192-07-21]


Note 1: MRT = fault localization time + fault correction time + function checkout time according  SPPRA MSS-3539 - [\[EN 61703: 2016\]](#)

MTTR

mean time to restoration - expectation of the time to restoration

deprecated: mean time to repair, mean time to recovery

Note 1 to entry: IEC 60050-191:1990 (now withdrawn; replaced by IEC 60050-192:2015) defined the term "mean time to recovery" as a synonym, but restoration and recovery are not synonyms.

Note 2 to entry: MTTR = MFDT + MAD + MLD + MTD + MRT according  SPPRAMSS-3539 - [\[EN 61703: 2016\]](#)

[SOURCE: IEC 60050-192, 192-07-23, modified: Note 2 to entry added.]

MDBF

Mean Distance Between Failures

[SOURCE: Wikipedia [Mean Distance Between Failure – Wikipedia](#)]

FMECA

failure modes, effects and criticality analysis

quantitative or qualitative method of analysis that involves failure modes and effects analysis together with a consideration of the probability of the failure mode occurrence and the severity of the effects

Note 1 to entry: The term "fault mode, effects and criticality analysis" in IEC 60050-191:1990 (now withdrawn; replaced by IEC 60050-192:2015) is deprecated, since a fault (192-04-01) is a state and cannot logically have a mode, whereas a failure mode (192-03-17) is a change of state.

[SOURCE: IEC 60050-192:2015, 192-11-06]


Note 2 to entry: FMEA is a systematic method of evaluating an item or process to identify the ways in which it might potentially fail, and the effects of the mode of failure upon the performance of the item or process and on the surrounding environment and personnel.

Failure modes may be prioritized according to their importance. The prioritization can be based on a ranking of the severity alone, or this can be combined with other measures of importance. When failure modes are prioritized, the process is referred to as failure modes, effects and criticality analysis (FMECA).

FTA

fault tree analysis

deductive analysis using fault trees

Note 1 to entry: See also fault tree (192-11-07  SPPRAMSS-4464 - [fault tree](#)).

[SOURCE: IEC 60050-192:2015, 192-11-08]

2 References

SPPRAMSS-11185 - The references used in this document and information for further insights are li...

The references used in this document and information for further insights are listed below: [🔒 Content to be approved]

[ISO 55000:2024]

Asset management — Vocabulary, overview and principles

[[Attachments], external reference - <https://www.iso.org/standard/83053.html> , 🔒 Content to be approved]

[EN 61703: 2016]

Mathematical expressions for reliability, availability, maintainability and maintenance support terms [[Attachments], [Hyperlinks], 🔒 Content to be approved]

[EN 50126-1:2017]

Railway Applications – The Specification and Demonstration of Reliability, Availability, Maintainability and Safety (RAMS) - Part 1: Generic RAMS Process [[Attachments], [Hyperlinks], 🌱 Open]

[ISO/IEC 25019:2023]

Systems and software engineering — Systems and software Quality Requirements and Evaluation (SQuaRE) — Quality-in-use model [[Attachments], external reference - <https://www.iso.org/standard/78177.html> , 🔒 Content to be approved]

[ISO/IEC 25010:2023]

Systems and software engineering — Systems and software Quality Requirements and Evaluation (SQuaRE) — Product quality model [[Attachments], external reference - <https://www.iso.org/standard/78176.html> , 🔒 Content to be approved]

[CLC/TS 50701:2023]


Railway applications - Cybersecurity [[Attachments], [Hyperlinks], 🔒 Content to be approved]

[ISO 45002-1:2018 or ISO 45002:2023]


Occupational health and safety management systems — General guidelines for the implementation of ISO 45001:2018 [[Attachments], external reference - <https://www.iso.org/standard/76619.html> , 🔒 Content to be approved]

[OCORA RAMSS Policy - 1.00]

[OCORA-TWS07-203_RAMSS_Policy.pdf , external reference - <https://github.com/OCORA->

[Public/Publications/blob/master/09_OCORA%20Release%20R4/OCORA-TWS07-203_RAMSS_Policy.pdf](#) ,  Content to be approved]



[FSR.EUI.EU Article:yyyy]

Article on improvement of the European Railway system [[Attachments], external reference - <https://fsr.eu.i.eu/define-measure-improve-performance-european-railway-system/> ,  Content to be approved]

[PRAMS System Concept]

 [System Concept - PRAMS](#) [[Attachments], [Hyperlinks],  Content to be approved]


[ERJU System Levels and System Pillar Tasks]

 [SPPRAMSS-3567 - System Levels and SP Tasks](#) [[Attachments], [Hyperlinks],  Content to be approved]

3 Introduction

SPPRAMSS-11180 - Introduction to performance

The term 'performance' gives the impression that multiple indicators of 'an element' within the Railway sector can be combined, compared and assessed against a target. However, the difficulty with this term is that interpretation of what 'performance' represents is dependent on a stakeholder's viewpoint, role and responsibility. This document intends to outline the definition and application of 'performance' in the Railway context. Initially the document is written to be used within the ERJU SP and IP context. Performance in a Railway context is "the ability of all technical and operational functions, in a specific operational context, to deliver a pre-defined and agreed level of service of the system and/or vehicle in operation".

The minimum level of performance is determined and influenced by technical and operational aspects on system, vehicle and operational level, such as but not limited to: reliability, availability, maintainability, safety, security, human factors, quality, mission profile, environmental impact and laws and regulations. This means that scope and boundaries (span of control) of performance need to be defined clearly. This also stresses why the inclusion of the principles of the RAM Policy to the ERJU activities for PRAMS, is of high importance. [ Content to be approved]

3.1.1 Why are KPI necessary in the System Pillar?

SPPRAMSS-11181 - Why are KPI necessary in the System Pillar?

Today, the EN 61703:2016 standard defines formulas for some PRAM KPIs (e.g. MTBF), but it does not include all PRAMS KPIs that are present in the different tenders of RUs/IMs. The non-harmonised KPIs lead to suppliers struggling to provide a product to different customers because of different KPI definitions. Each time, the supplier has to prove that the proposed KPIs used fit the customer's KPIs. Harmonising these KPIs will avoid misunderstandings and additional effort for suppliers (and their sub-suppliers) and RU/IM in PRAM requirements management.

This resulted in each RU/IM defining its own KPIs with proprietary formulas and values. These can be very different between customers and become a sensitive point when suppliers intend to respond to a tender.

Given the need to define a SERA (Single Europe Railways Area) and the liberalisation of the sector, it is necessary to harmonise indicators that measure performance in the same way. Let's say, for example, that a country or region in the EU wants to put commuter services out to tender and can require a minimum quality threshold using objective and harmonised criteria. The same would be true for IMs who, for example, would need to meet a minimum maintenance performance threshold in order to receive funding for asset upgrades.

This is best done through objective and harmonised indicators. [🗨️ Content to be approved]

3.1.2 How are KPI proposed?

SPPRAMSS-11231 - How are KPI proposed?

Recognising the difficulty of proposing valid parameters for so many countries with such different railway systems, a methodology for their definition will be proposed in each case. This methodology will also include some examples for better understanding.

Another of the most innovative aspects will be the definition of KPIs at four levels, which will be elaborated in Chapter 2 (Performance Architecture). In general we distinguish between:

- a) The highest level shall be used to measure the performance of the IM or RU at top management level. For example, the punctuality of passenger trains in a determined area.
- b) The intermediate level shall be used to measure the performance of railway operations for the day-to-day business management of the IM or RU. For example, the availability of the fleet of commuter trains in a region.
- c) The detailed level(s), typically one or two, shall be used to measure the performance of the entities responsible for the maintenance of railway assets (either rolling stock or infrastructure), taking into account the RAM criteria, such as technical requirements and process requirements (e.g. execution of maintenance). These KPIs shall be used as a basis by each SP domain down to the manufacturing. Depending on the required level of detail, this level can be divided in an asset level and subsystems level.

Note that highest level corresponds to 'level 1', intermediate level to 'level 2' and detailed level(s) to 'level 3' and 'level 4', as described in Chapter 2. [🔒 Content to be approved]

3.1.3 Performance as KPI is ambiguous

SPPRAMSS-11236 - Performance as KPI is ambiguous

The term 'performance' can be applied to physical objects, to processes, to structures and to networks in which physical objects and processes are combined. In industrial and manufacturing applications, the term is often related to effectiveness and efficiency of the output or the Overall Equipment Effectiveness (OEE). In maintenance applications, the term is often related to the Mean Time To Repair (MTTR) or Mean Down Time (MDT) and the necessary time to maintain the system. In Railways in general, the term is often related to operations, and in particular the amount of delays or cancellations of service (i.e. 'operational performance'), but can as well refer to life cycle costs (i.e. 'financial performance').

The main reason for different interpretation is that performance is considered as the ratio between a predetermined target value which sets expectations in comparison to what really has been achieved.

Note that performance can be expressed in both a quantitative and qualitative way, can comprise one or multiple indicators, has a different functional meaning at each hierarchical level, and is for that reason (!) subject to interpretation by different stakeholders, which makes a unified use of this term rather difficult – but not impossible. [🔒 Content to be approved]

3.1.4 Objective of this document

SPPRAMSS-11234 - Objective of this document

The application of the term 'performance' to the Railway sector, and in particular to ERJU projects has been outlined in this application guide. The goal of this guide is to help the reader:

- To understand the basic principles
- To recognize and distinguish between architectural levels of performance
- To know which standards and definitions are important
- To define performance indicators for any 'element' in the Railway sector
- To apply the principles to any System Pillar project or context, and
- To apply the principles to any Innovation Pillar projects at the correct phase

With this document, we hope the reader realizes and acknowledges the architectural levels of performance, the mutual relationship between factors affecting performance and the difference between agreed, actual and perceived performance of (any element of) a railway system. Also we would like to put emphasis on how the PRAMS team can help to include these principles to any SP or IM project. [🔒 Content to be approved]

4 Performance architecture

4.1 Performance levels

SPPRAMSS-11235 - Performance levels

As mentioned in the introduction and having the Systems Engineering principles (INCOSE) and Asset Management principles (ISO 55000:2014) in mind, a system or process can have multiple layers of integration. Think of systems, sub-systems and components having their own layer of integration and detailing in terms of engineering.

Generally, the highest echelon of a System Breakdown Structure (SBS) or Functional Breakdown Structure (FBS) defines the asset system or network, in which an asset or asset groups are integrated in a specific environment.

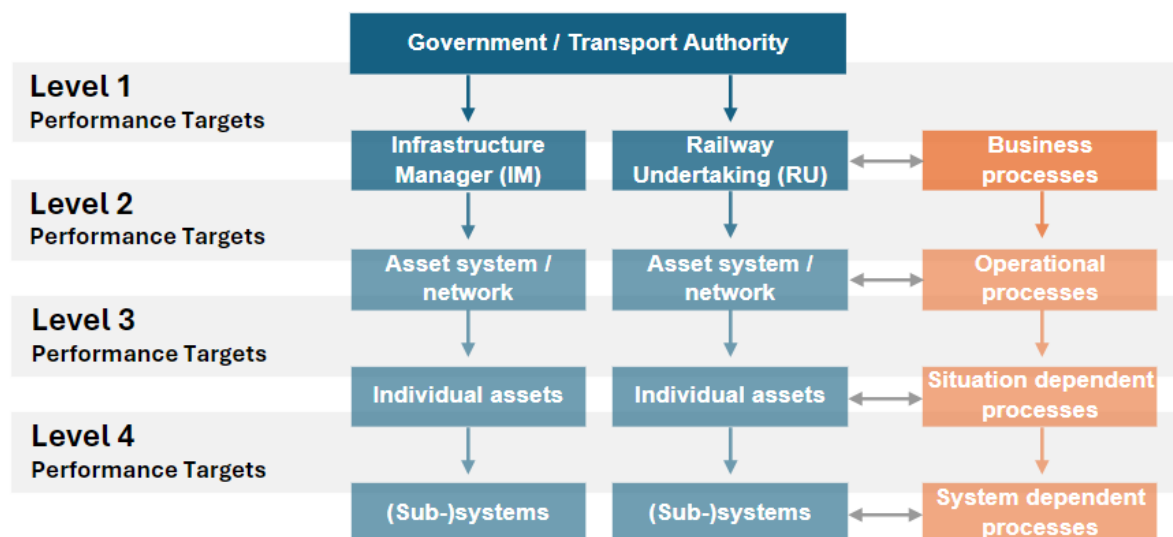
If we apply this theory to the Railway context, with respect to performance, we can define four architectural levels at which performance covers a specific area and has a specific meaning and objective:

- **Level 1:** the first level of performance covers the agreements between a public authority (such as a government, municipality or transport authority) and a concession holder (such as a Infrastructure Manager or Railway Undertaking). These agreements are generally covered within a concession or contract between both parties. Examples of indicators include but are not limited to punctuality, safety, capacity and customer satisfaction.
- **Level 2:** the second level of performance covers the targets for system of networks of assets (such as a fleet of trains, a group of infrastructure assets or a communication network providing a specific function). These systems or networks comprise multiple assets which might be different in type, form and function, but have been allocated in a dedicated system or network. For Asset Management (the Asset Manager) this level is important to manage performance, risks and costs.
- **Level 3:** the third level of performance covers the targets for individual assets (such as a infrastructure system, specific train or a distributed antenna system). Generally targets are applicable to all individual assets within an asset system or network, but can also be specific. For example in case a specific asset is critical to enable a function, or when redundancy is not present. For Reliability and Maintenance Engineering this level's performance targets enable to identify assets that are underperforming and starting root cause analyses to anomalies.
- **Level 4:** the fourth level of performance covers the targets for (sub-)systems within an asset (such as a switch motor, traction motor or a 5G antenna). For Reliability and Maintenance Engineering this level's performance targets enable to find solutions to improve system design to improve performance.

At all levels respectively business, operational, situation dependent and system dependent processes have an influence on the performance of the Railway system. It must be stressed that, however the breakdown is based on assets, the processes have a major influence. From experience in multiple major projects in recent years (up to 2023), the share of process related incidents versus technical related

incidents is up to 70% (!). Hence, requirements to related processes are key in managing performance at all levels.

This is represented graphically in the following figure:



Note that performance targets for asset systems / networks (level 2) can be apportioned to individual assets (level 3) and (sub-)systems of individual assets (level 4).

The four levels are necessary because they determine the level of performance of all assets. In this way, it is possible to disaggregate the level of performance down to the individual asset or 'subsystem' and determine, where appropriate, that poor performance is due to the failure of one of the component assets. Note also that staff is an (critical) 'asset' as well. The (sub-)systems below (level 4) can be interpreted as processes in place to create a safe and healthy work environment, enable staff to operate assets within their context, ensure Human Factors are incorporated into asset designs and ensure staff is satisfied and motivated in their work – ultimately to ensure that assets systems and/or networks (level 2) can comply to their performance targets. This 'asset' has its own performance targets, i.e. the targets for process efficiency, effectiveness, quality, etc. In other words, asset systems and networks have both a technical and process element to perform as required.

The application of performance agreements and targets to a responsible party is explained in the following table:

Level	Performance agreements/targets
Level 1	The performance agreements on this level applies to the Infrastructure Manager (IM), Railway Undertaking (RU) and their (related) business processes.

Level	Performance agreements/targets
Level 2	The Performance targets on this level applies to a business unit or management function responsible for an Asset system or Asset network and (related) operational processes.
Level 3	The Performance targets on this level applies to a management function responsible for individual Assets.
Level 4	The Performance targets on this level applies to a management function responsible for Asset designs and maintainability.

In Chapter 4 is explained how this architecture can be applied to the definition and management of performance at all levels.

[🔒 Content to be approved]


4.2 Performance stakeholders

SPPRAMSS-11232 - Performance stakeholders

Performance indicators serve two main purposes for any stakeholder. First, they allow to have precise knowledge of performance on a specific 'level' and, if necessary, put in place a corrective action plan. Secondly, they serve as information for accountability of performance to a higher ("hierarchical") level. The table below shows stakeholders which typically can be found at each defined 'level'. The examples show how performance indicators are being used for each stakeholder. Note that, although the list of stakeholders is long, it is not meant to be exhaustive.

Level	Users	Example
Level 1	Executive Committee of the Infrastructure Manager (IM) or Railway Undertaking (RU)	<i>Performance indicators need to be generic, providing a macro view of performance. For example: the punctuality of trains within a concession, the availability of infrastructure, the customer satisfaction of services provided, etc. They must be easy to understand so that they can be used as a means of communicating with customers or transport authorities.</i>
Level 2	Business Unit Manager	<i>Performance indicators are specific for the business unit's responsibility, whilst taking into account indirect effects to other business units (such as business units for Asset Management, Maintenance and Operations). For example, number of trains cancelled, the availability of trains or infrastructure (for operations), the number of incidents affecting the infrastructure, etc.</i>

Level	Users	Example
Level 2	Local Operational Manager	<i>Performance indicators are specific for the operation manager's responsibility, such as region, department, etc. For example, the number of train cancelled and punctuality of trains within a specific area of use, the availability of rolling stock or infrastructure elements within a specific area or of one or more specific type(s).</i>
Level 2	Safety Manager	<i>Performance indicators are related to Safety and for the safety manager's responsibility. For example, the number of incidents having a safety impact or could have a safety impact (but is avoided), the number of safety incidents or near misses in maintenance, etc.</i>
Level 2/3	Asset Manager	<i>Performance indicators are related to RAM, Life Cycle Costs and (related) risks. For example, the reliability of (a specific type of) rolling stock or (a specific type of) infrastructure element, the operational expenditures of maintenance, the capital expenditures of changes to rolling stock and/or infrastructure, etc.</i>
Level 2/3	Supplier	<i>Performance indicators are related to contractually agreed values for rolling stock, infrastructure or other systems. For example, mean distance between service affecting failures (MDBSF) of rolling stock, availability of infrastructure within a certain period, the uptime of systems delivered, etc.</i>
Level 3/4	Reliability / Maintenance Engineering	<i>Performance indicators are related to RAM of specific systems (i.e. at detailed level). For example, the failure rate of a compressor, the availability of traction system, the reliability of switches, the uptime of power supply, etc.</i>
Level 4	Technical Expert	<i>Performance indicators are related to RAM and Life Cycle Costs of technical systems (i.e. system design). For example, the FIT-rates of components, the reliability of systems with and without redundancy design, the operational costs of components used, the capital and operational costs related to complexity of design, etc.</i>

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5 Performance definition(s)

This Chapter describes the definitions of performance, the indicators that drive performance and the structure in which indicators can be categorized.

5.1 Performance definition

SPPRAMSS-11233 - Performance definition


The Asset Management standard describes 'Performance' in a very compact way as **"measurable result"** (ISO 55000:2014), with the following notes to it:

- Performance can relate either to quantitative or qualitative findings
- Performance can relate to the management of activities, processes, products, systems or organizations, and
- For the purposes of asset management, performance can relate to assets in their ability to fulfil requirements or objectives.

When taking this definition as a basis and translating it to application in the Railway sector in general, the definition can be made specific and will read: **"the ability of all technical, operational and maintenance functions, in a specific operational context, to deliver a pre-defined and agreed level of service"**

Next to this definition, the following notes are applicable:

- It has a functional different meaning at each aggregation level
- It represents a specific context (e.g. the resulting effect on punctuality and cancellations of service)
- The minimum level is determined and influenced by system conditions, operating conditions and maintenance conditions
- It is based on a specific scope and boundary
- It comprises multiple indicators
- It comprises quantitative and qualitative information
- It is influenced by external factors which can partially or cannot be influenced

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5.2 Railway Performance

SPPRAMSS-11237 - Railway Performance

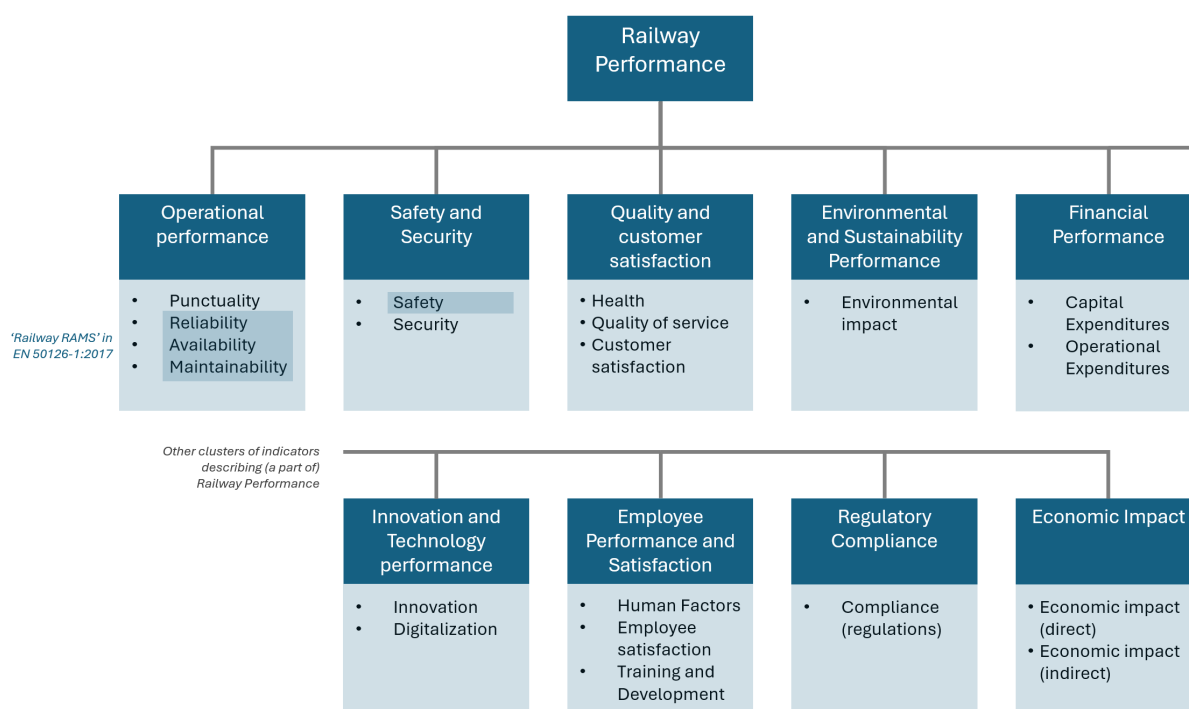
As described in the former section, Railway Performance can be described in many ways, depending in the scope and/or responsibility of a specific entity to which responsibility for this performance is addressed. This entity could be a Railway Undertaker, Infrastructure Manager or other stakeholder.

The figure below shows a possible categorization of how Railway Performance can be broken down into smaller (measurable) performance indicators.

We distinguish the following categories:

- Operational Performance
- Safety and Security
- Quality and customer satisfaction
- Environmental and Sustainability performance
- Financial performance
- Innovation and Technology performance
- Employee performance and satisfaction
- Regulatory compliance
- Economic impact

The clusters 'Environmental and Sustainability Performance', 'Innovation and Technology performance' and 'Economic impact' are (currently) not taken into account in this application guideline. Which doesn't mean they do not have to be taken into account in general. The highlighted indicators are part of the EN50126-1:2017 standard on Railway RAMS.



[🔒 Content to be approved]

5.3 Indicators

SPPRAMSS-11238 - indicators

- **Indicators, PI and KPI**

An indicator is a measurable source or subset of data or information which gives insight in quality of 'an element' in its environment. Depending on the importance to a Railway Undertaking or Infrastructure Manager one or more indicators can be defined as a 'performance indicator' (PI). When one or more indicators are critical to success, they are defined as a 'key performance indicator' (KPI).

- **Railway Performance Indicators**

There are several indicators that can be used to define the level of performance of 'an element' in the railway industry. Typically, many of these factors are generic (i.e. not specifically or unique for the Railway sector) and used in risk management as well. Specifically, in risk matrices to evaluate the severity of an event and the resulting risk. This also implies that indicators can have a threshold value above which the quality is (perceived as) reduced or not accepted.


The indicators to describe performance within the Railway sector are: punctuality, reliability, availability, maintainability, safety, security, quality, health, environmental impact, life cycle costs (capital and operational expenditures), innovation, digitalization, human factors, employee satisfaction, training and development, compliance (laws and regulations) and economic impact.

- **Mutual relationships**

In EN 50126-1: 2017 is explained how many of these indicators mutually influence each other, where one should take into account that this figure might be different in a specific context. Which means that in some applications indicators have less influence or are even absent.

In the RAM Policy of OCORA ([OCORA-TWS07-050_RAM_Strategy](#)) is defined how different indicators could be combined as a guideline on how to take mutual relationships in mind.

Note that, when combining indicators (as with 'performance') also thresholds for each of the indicators involved are being combined. It is important to think about mutual relations and dependencies between indicators when at least one of the combined indicators is passing a predefined threshold. Please also refer to Section 4.4.2.

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5.3.1 RAMSS indicators

SPPRAMSS-11242 - RAMSS indicators

The RAMSS indicators include, in random order:

- **Reliability:** Reliability is an important factor in the railway industry, as 'an element' that is prone to failure can disrupt operations and cause delays. Reliability is defined as the 'ability to perform as required, without failure, for a given time interval, under given conditions' [EN50126-1:2017]. Reliability can be measured in terms of failure rate per operational hour (or mileage driven), mean time between failures (MTBF), mean time or distance between failures (MTBF/MDBF), mean time between service affecting failures (MTBSF), etc.
- **Availability:** The availability of 'an element' is a second important factor in the railway industry, as elements that are frequently out of service can disrupt operations. Availability is defined as the 'ability of an item to be in a state to perform a required function under given conditions at a given instant of time or over a given time interval, assuming that the required external resources are provided' [EN50126-1:2017]. Availability can be measured in terms of mean downtime, available 'assets' at a certain period of moment in time, etc.
- **Maintainability:** The maintainability of 'an element' is a third important consideration, as it can affect the cost and efficiency of maintaining the element over time. Elements that are easy to maintain are typically more cost-effective and have lower downtime. Maintainability is defined as the 'ability to be retained in, or restored to, a state to perform as required, under given conditions of use and maintenance' [EN50126-1:2017]. Maintainability can be measured in terms of throughput time of maintenance activities, such as Mean Time To Restore/Repair (MTTR), Mean Down Time (MDT), etc.
- **Safety:** The safety of 'an element' is a fourth important consideration in the railway industry, as tools that fail or malfunction can have serious consequences on people and environment. Safety is defined as 'freedom from unacceptable risk' [EN50126-1:2017]. The level of safety of 'an element' can be evaluated based on its design, construction, and maintenance procedures, as well as its track record of performance.
- **Security:** The security of 'an element' is a fifth important consideration in the railway industry, as elements that are vulnerable to cyber threats can pose risks to the safety and reliability of rail operations. Security is defined as a 'set of activities and measures taken with the objective to identify, protect against, detect, respond to, and recover from unauthorized access or cyberattack

which could lead to an accident, an unsafe situation, or railway application performance degradation' [TS50701:2023]. The level of security of 'an element' can be evaluated based on the activities and measures in place to protect it against (cyber)security threats and the track record of performance in this regard.

Overall, the level of performance of 'an element' in the Railway sector can be evaluated based on a combination of these RAMSS factors and other indicators (see Section 3.3.2) that may be specific to the element itself or the needs of the organization. [🔒 Content to be approved]

5.3.2 Other indicators

SPPRAMSS-11240 - Other indicators

In addition to the PRAMSS factors, other factors might also be used to define the level of performance of 'an element'.

- **Punctuality:** Punctuality of 'an element' is probably the most profound indicator in the railway industry, as it is directly related to and perceived by users (passengers) of the Railway system. Punctuality is defined as the 'difference between the actual time of arrival and the scheduled time of arrival' [EN15140:2006] or lateness experienced at each recorded station stop. Punctuality can be measured in terms of percentage of arrivals at scheduled time within a certain bandwidth (i.e. 0-3 minutes, >3-10 minutes and >10 minutes delay). In [EN50126-1:2017] this categorization is referred to as 'RAM severity' and comprise minor, major and significant.
- **Quality:** The quality of 'an element' relates to the criteria and perception of 'quality' perceived by stakeholders. These criteria are typically different per phase of the life cycle (i.e. production phase versus operational phase). Quality is defined as 'the extent to which ... ['an element'] ... satisfies or exceeds stakeholders needs to achieve specified beneficial goals or outcomes' [ISO25019:2023]. Quality can be measured using the 'Quality-in-use' model of [ISO25010:2011] comprising 'effectiveness', 'efficiency', 'satisfaction', 'freedom from risk' and 'content coverage' indicators.
- **Health:** The health of 'an element' can be related to a technical or operational condition (the health of an element) or occupational health of stakeholders. Occupational health is defined as the 'adverse effect on the physical or mental condition of a person arisen from exposure to a workplace health risk, including where exposure aggravates a pre-existing condition or the pre-existing condition affects the worker's ability to perform the task [ISO45002-1:2018].
- **Environmental impact:** The environmental impact of 'an element' can be measured in terms of exposure of harmful or polluting substances of the 'element' to the environment, due to operations and maintenance or disposal and replacement. Environmental impact can be measured by

comparing actual versus target or threshold emissions per substance.

- **Capital expenditures:** The cost of 'an element' can be measured in terms of the total cost to create or acquire, operate and maintain and/or dispose or replace the 'element', over a certain period. Capital expenditures can be defined as 'expenditures on acquisitions of, or improvements to, ['elements'] [TS55010:2024]. These expenditures are thus related to investments and one-off costs during the lifecycle, for example upgrades or (unplanned) renewal of systems. Capital expenditures can be measured by comparing actual investments versus predicted budget.
- **Operational expenditures:** The cost of 'an element' can be measured in terms of the total cost to create or acquire, operate and maintain and/or dispose or replace the 'element', over a certain period. Operational expenditures can be defined as 'recurrent or specific non-capital expenditures required to provide a service or product' [TS55010:2024]. These expenditures are thus related to recurring costs during the lifecycle, for example maintenance. Operational expenditures can be measured by comparing actual recurring costs versus predicted budget.
- **Innovation:** The level of innovation of 'an element' can be measured in qualitative way, by the degree of adaptation of new technologies or innovations which are adopted in the current situation or in the roadmap for futures upgrades or renewals.
- **Digitalisation:** The level of digitalisation of 'an element' can be measured in qualitative way, by the degree of producing or using data of the 'element' (or use of data from its surroundings) to gather improved insight in the health or status of the 'element' and/or to support decisions based on a (near) real-time insights.
- **Human Factors:** Human Factors is a discipline dealing with the interaction between humans and 'an element' having a positive or negative influence on the 'element'. The degree to which Human Factors are incorporated in a design or process can be described qualitatively or measured by using the 'Quality-in-use' model of [ISO25010:2011], see indicator 'Quality'.
- **Employee Satisfaction:** The level of employee satisfaction can be measured in a qualitative way, and also has a relationship with the degree to which Human Factors are considered.
- **Training and Development:** The level of training and development can be measured in a qualitative way, and indicates the degree to which training and development of staff, hence knowledge and experience with the 'element' or related process(es), positively or negatively

influences the 'element'.

- **Compliance (laws and regulations):** The level of compliance can be measured in a qualitative way, and indicates to which laws and regulations the 'element' complies to.
- **Economic Impact:** The economic impact can be measured in terms of contribution of the Railway 'element' to the local community and its economics. Economic impact can be measured in various ways, such as employment, added value, benefits for local communities, etc., and can have both a direct and indirect effect.

Overall, these other indicators are additional types of metrics that could be used to evaluate the performance of 'an element' in the Railway sector. The metrics that are used will depend on the element itself, its specific context and the needs and requirements of the organization. [🔒 Content to be approved]

6 Performance application(s)

In this Chapter the application of performance to the Railway context is outlined. Subsequently the following topics will be addressed: incorporation of performance viewpoints, how to manage expectations, application of the performance architecture and examples of performance indicators.

6.1 User's perspective

SPPRAMSS-11241 - User's perspective

When talking about performance there is a distinction between agreed, actual and perceived performance. We introduce this topic as the 'performance viewpoints triangle'.

The following elements of this triangle are defined:

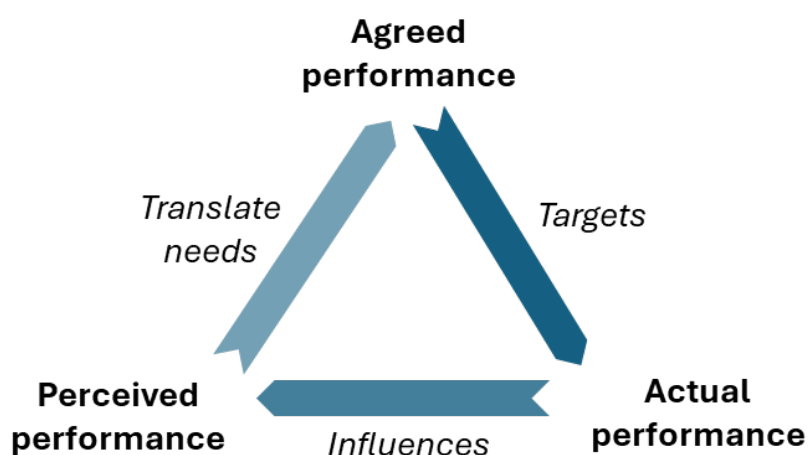
- The '**agreed performance**' is a predefined and agreed target to which a system or process needs to comply with and is generally agreed upon between two parties. For example, a public authority and a concession holder, or a supplier and an operator, or an infrastructure manager and operator, etc. The agreed performance comprises one or multiple indicators, and is included in a concession agreement, purchase agreement, service level agreement, or any other form a contract between two parties. The agreed performance can also serve as reference (target) when a validation is required.
- The '**actual performance**' is the current or actual level that a system or process is able to achieve or fulfill. Note that actual performance is time dependent, can vary over time and is being influenced by internal and external factors. Validation is a principle used to measure actual performance. For example at a certain point in time, over a certain period of time, at certain batch or over a certain number of output. In this way the actual performance can be compared to the agreed performance and the level of fulfillment according to an agreement or contract can be

evaluated.

- The '**perceived performance**' is, as the term already reads, the level of satisfaction of a stakeholder using the system or process. Stakeholders can be divided in internal stakeholders (e.g. project manager, company division, operator, etc.) and external stakeholders (e.g. public authority, interest group, passenger, etc.). The difficulty with perceived performance is that it is highly subjective, might have nothing to do with agreed and actual targets, can be influenced by external factors, but influences a company or industry's image significantly.

The challenge is to find the right balance between this 'triangle' of performance viewpoints in Railway applications. This starts with defining performance levels which both suit and satisfy the expectations of different stakeholders or user groups, and are reasonable and realistic to achieve in a real-world environment. The latter means that a system or process' operational context needs to be understood to a high degree, so that a system or process is capable of achieving the required performance when used and operated correctly.

The perceived performance can also be influenced by implementing effective 'stakeholder management' processes within an organization.



[🔒 Content to be approved]

6.2 How to manage expectations

SPPRAMSS-11239 - How to manage expectations

As mentioned in the former section, performance comprises one or multiple indicators to define what is 'expected' from a technical or operational function. This means that expectations and requirements from internal and external stakeholders should be clear and unambiguous, and then translated into a set of indicators together defining the 'performance' of a technical or operational function.

When communicating about 'performance', 'performance levels', 'performance targets' it should be combined with explanation about which indicators drive this 'performance' and how it has been derived and agreed upon. If not communicated directly, it should be clear for anyone where this information and substantiation can be found.

Stakeholder management is the discipline to define first and second order stakeholders, engage with

them to really understand their needs, translate these needs into effective measures (such a requirements, but also to set, steer and influence expectations), carefully implement these measures, measure their effectiveness and improve where necessary.

Note that communicating (written, vocal, etc.) about performance without giving the context, unintentionally creates the basis for setting own expectations by any stakeholder, leading to potential dissatisfaction (i.e. a difference between 'actual performance' and 'perceived performance'). [🔒 Content to be approved]

6.3 How to approach Performance

6.3.1 System breakdown approach

SPPRAMSS-11247 - System breakdown approach

In Chapter 2 was explained that a System Breakdown Structure (SBS) or Functional Breakdown Structure (FBS) helps to define the mutual relationships of elements that define and influence performance, including architecture in which performance needs to be defined.

A top-down approach works best in most of the cases. This means that deriving requirements from a concession agreement or contract towards what is expected from assets systems and networks is the preferred approach. Subsequently, from this level further requirements can be derived towards individual assets and (sub-)systems of which the asset is composed.

In any case, it is of the most importance that direct and indirect aspects influencing performance targets are taken into account. Meaning that aspects influencing performance, but are not part of the requirements at a parent level, shall be part of the calculations/assessment as they cannot be ignored.

Please refer to the PRAMS System Concept (📄 [System Concept - PRAMS](#)) in which is explained how various indicators have a mutual relationship and need to be assessed and defined as a whole. For example, technical Reliability-requirements, Maintainability-requirements, Safety-requirements, Security-requirements which all influence an asset's availability. [🔒 Content to be approved]


6.3.2 System breakdown approach in SP

SPPRAMSS-11245 - System breakdown approach in SP

The approach of System Breakdown Structure (SBS) is also applied to the context of the System Pillar, see 📄 [SPPRAMSS-3567 - System Levels and SP Tasks](#). A comparison between the levels in this application guide and the structure of the SP context is as follows:

- Task 0 (Public Transport System) refers to the highest level, which is described as 'level 1' in Chapter 2.
- Task 1 (The Railway System) refers to a layer between the highest level 'level 1' and intermediate 'level 2' in Chapter 2. The reason for this is that CCS in the SP context defined on a "Railway System" level (which is at 'level 1'). There is no distinction on the same level between CCS-part of the Infrastructure Manager and Railway Undertaking (with is done at 'level 2'). From a architecture point of view this is logical, however, from a KPI point of view a split of responsibility at higher level is more logical.

- Task 2 (CCS Architecture and CCS System) refers to the intermediate level and detailed levels below, which are described as 'level 2', 'level 3' and 'level 4' in Chapter 2. Within this task 2 a breakdown of smaller elements is made, and an architecture is designed, which forms a series of layers, exactly as done at the 'levels' in Chapter 2. The precise layers and their context is part of the Architecture design choices in the respective team.


 Content to be approved]

6.3.3 Examples

SPPRAMSS-11246 - Examples related to "performance"

Some examples to clarify this application:

- An asset system or network (level 2) needs to contribute to achieve the performance agreements as agreed between a public authority and a concession holder (level 1). The requirements (performance targets) for an asset system or network can be derived from the parent level. This principle is applied when a complete asset system or network needs to be replaced, renewed or upgraded.
- An individual asset (level 3) needs to contribute to achieve the performance targets as defined by the asset owner or asset manager for the asset system or network (level 2) which the individual assets belongs to. The requirements (performance targets) for an individual asset can be derived from the parent level. This principle is applied when an individual or group of assets within an asset system or network needs to be replaced, renewed or upgraded.
- A (sub-)system (level 4) needs to contribute to achieve the performance targets as defined by the asset owner or asset manager for the individual asset (level 3) or asset system or network (level 2) which the (sub-)system belongs to. The requirements (performance targets) for an individual (sub-)system can be derived from the parent level. This principle is applied when a specific (sub-)system within an asset needs to be replaced, renewed or upgraded.

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6.4 Definition of indicators

The definition of indicators, target values and requirements is very specific to the level, scope, boundary conditions and application for which these need to be developed. In this section we describe which input sources, analytics and monitoring methodologies can be used.

6.4.1 Definition of indicators per level

SPPRAMSS-11243 - Definition of indicators per level

- **Level 1**

Level 1 indicators provide a macro view of performance. These indicators are generally already provided by and agreed with a government or transport authority for a specific period of management and/or operations (i.e. 'license to operate'). Sources include: concession requirements, concession contracts and agreements, executive management dash-boarding and accountability reports, (public) company yearly

reports on operational and financial performance, stakeholder group whitepapers and proposals, etc.

- **Level 2**

Level 2 indicators provide an intermediate level of performance. These indicators are very dependent on the organizational structure. For example, in ERJU hierarchy this level comprises CCS as a whole, there at company level CCS systems or allocation might be categorized into system-groups or a network of systems which are managed as a whole. Particularly this difference requires a deep understanding of future applications and apportionment of responsibilities (such as for target values of performance).

Sources include: business unit agreements, operations or department specific agreements, subject specific agreements (such as Safety levels), top management dash-boarding and accountability reports, substantiation of achieved performance within (public) company yearly reports, etc.

- **Level 3**

Level 3 indicators provide a detailed level of performance. These indicators are specific to individual assets (e.g. systems), their performance and contribution to higher level performances. For example, in ERJU hierarchy this level comprises innovation and development projects or specific new systems or innovations, specific applications and architecture choices. Depending on the scope of work and boundary conditions, information and data of similar systems, applications, processes etc. can be derived and translated into future situations. Sources include: management reports, reliability analyses, maintenance analyses, computerized maintenance management systems (CMMS), enterprise resource planning (ERP) systems, system specific dashboards and accountability reports, etc.

- **Level 4**

Level 4 indicators provide a further detailed level of performance with respect to level 3. These indicators are specific to system design, process design and their contribution to the overall asset (e.g. system) performance. For example, in ERJU hierarchy this level comprises detailed design choices in an architecture, selection of sub-systems and components to achieve a certain functionality, requirements on modularity, interchangeability, testability, accessibility, standardization, etc. Sources include: reliability analyses, Fault Tree Analysis (FTA), Reliability Block Diagram (RBD), Failure Modes, Effect and Critically Analysis (FMECA), design studies (morphological methods, multi-criteria decision methods, etc.), etc. [🔒
Content to be approved]

6.4.2 Boundary conditions to definition of indicators

SPPRAMSS-11244 - Boundary conditions to definition of indicators

It is important to realize that indicators can be in contradiction with each other. For this reason the dependencies and relationships between indicators should be carefully taken into account when defining indicators for any application. Allow us to give some examples:

- The indicators for Reliability, Availability and Maintainability have a mutual relationship, meaning that two of these indicators drive the third indicator. When defining target values or requirements for all these three indicators, one should calculate that compliance to all three indicators is still possible.
- The indicators Reliability, Availability, Safety and Security (and even more) have a mutual relationship. Requirements on Reliability, Safety and Security automatically influence and determine the Availability (of an asset or even asset system or network). Meaning that applying Safety and Security functions without taking the technical Reliability in mind, it might result in an asset not complying to operational preconditions anymore when (due to added functions) Availability is heavily impacted and no redundancy or (acceptable) degraded mode in use is implemented.
- The indicators at each level (please refer to Section 2.1 Performance Levels) have a strong mutual relationship as from top-down perspective the level 1 'Performance agreements' sets the requirements on Level 2, 3 and 4 below (which are basically boundaries). The other way around, the achieved or achievable 'Performance Targets' at level 3 and level 4 drive the higher level's Performance Targets directly. As business, operational and situation dependent processes (for example the handling of failures or unexpected situations by users/operators) have a major impact on the Performance Targets, these have been included in the figure in Section 2.1 as well.

More information on these contradictions and how to cope with them are included in the RAM Policy of OCORA ([OCORA-TWS07-050_RAM_Strategy](#)). [🔒 Content to be approved]

6.5 Harmonized method

SPPRAMSS-11248 - Harmonized method

Defining the performance of an element in the railway industry (such as assets and systems) in a universal and harmonized manner can be challenging, as the specific factors that are important may vary depending on the element and the needs of the organization. However, some general principles that could be followed to create a universal and harmonized method for evaluating the performance at each level in the railway industry include:

1. **Use standardized metrics:** To make comparisons between different levels and organizations, it may be helpful to use standardized metrics that are widely accepted in the industry. This could include metrics such as reliability, maintainability, and security, as well as any other factors that are specific to the level or the needs of the organization.
2. **Consider the needs of the organization:** It is important to consider the specific needs and goals of the organization when evaluating the performance of a specific level. This could include factors such as cost, compatibility with other systems, and ease of use, as well as any other factors that are specific to the organization.
3. **Use a consistent evaluation process:** To ensure that evaluations are consistent and fair, it may be helpful to use a standardized evaluation process that is followed consistently across different elements and organizations. This could include using the same set of metrics and procedures for evaluating the performance at each level.
4. **Use a multi-faceted approach:** To get a comprehensive understanding of the performance at each level, it may be helpful to use a multi-faceted approach that considers a range of different factors. This could include both quantitative measures, such as performance data and metrics, as well as qualitative measures, such as user feedback and observations.

Overall, developing a universal and harmonized method for evaluating the performance at each level (such as level 3 for assets and systems) in the railway industry will likely involve a combination of standardized metrics and procedures, as well as a consideration of the specific needs and goals of the organization. [🔒 Content to be approved]

7 Support

SPPRAMSS-11249 - Support

The PRAMSS team within the System Pillar offers support to other SP/IP projects, specifically to understand and develop activities related to Performance (requirements) within their projects. The team has sufficient and proven knowledge from operators and industry to gather, share and develop future specifications for Performance and KPI's and support with those activities in any stage of a SP/IP project.

This support is aimed at working collaboratively with any SP or IP project to:

- Apply the principles of performance to a System Pillar working group or project
- Apply the principals of performance to an Innovation Pillar project
- Define the correct set of KPI's for a specific level, application or project
- Define practical and realistic target values for selected KPI's
- Define requirements and practices to cope with performance and KPI's (at each level) during the various project phases, and

- Define performance requirements for specific applications (e.g. the integration or application of assets, systems or components for a specific area of use)

Currently for Remit 2.4 ([EU-RAIL SC 2.4](#)), i.e. working activities in 2024-2025, no direct collaborations or support is foreseen. [🔒 Content to be approved]

8 Annex: KPI examples for IM, RU and ETCS

Based on project experience, practical insights, knowledge and experience a set of KPI examples have been drafted for Infrastructure Managers (IM), Railway Undertakings (RU) and examples are included for ETCS track-side and on-board equipment.

From this already quite comprehensive list, it is important to stress that selection of the correct KPI's for a specific level or application, and definition of correct values is an activity where the PRAMS team can support. Please refer to Chapter 5 (Support).

8.1 KPI for Infrastructure Managers (IM)

 [PERFORMANCE_DEF_PRAMSS_IM](#)

8.2 KPI for Railway Undertakings (RU)

 [PERFORMANCE_DEF_PRAMSS_RU](#)

8.3 Example of KPI application: ETCS track-side and on-board equipment

 [PERFORMANCE KPI EXAMPLE](#)