


PRAMS Plan - Part 1 Human and Organisational Factors

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Abstract	To establish a process for integrating the HOF into the train/wayside specifications and, in general, to provide guidance to railway companies managers and engineers regarding HOF principles and their practical application.
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Table 1 : Acronyms

Acronym	Description
ATO	 SPLI-763 - Automatic Train Operation
CBM	 SPPRAMSS-4079 - CBM
ERA	 SPLI-314 - European Union Agency for Railways
ERTMS	 SPLI-829 - EUROPEAN RAIL TRAFFIC MANAGEMENT SYSTEM
ETCS	 SPLI-312 - European Train Control System
FRMCS	 SPLI-865 - Future Railway Mobile Communication System
FTS	Functional Technical Specifications
HFA	Human Factors Assurance
HOFI	Human and Organisational Factors Integration
HOFIL	Human and Organisational Factors Issues Log
HMI	 SPLI-1311 - Human Machine Interface
HOF	Human and Organisational Factors
IM	 SPLI-582 - Infrastructure manager (IM)
IT	Information Technology
KPI	 SPLI-1533 - Key Performance Indicators
LCC	Life Cycle Costing
MMI	Man Machine Interface
PRAM(SS)	 SPLI-132 - Performance, reliability, availability, maintainability, safety and security
QHSE	Quality, Health, Safety and Environment
RAM	Reliability Availability Maintainability
RAMS	Reliability, Availability, Maintainability, Safety
RCM	Reliability
RU	 SPLI-339 - Railway Undertaking
SMS	 SPLI-346 - Safety Management System
TCMS	Train Control Management System

1 Scope and concept of Human and Organisational Factors (HOF)

1.1 Specific objective of the document

SPPRAMSS-10214 - Specific objective of the document

The main goal of this document is to establish a process for integrating the HOF into the train/wayside specifications, and, in general, to provide guidance to railway companies managers and engineers regarding HOF principles and their practical application.

Human and Organisational Factors (HOF) is a scientific discipline concerned with the understanding of interactions between humans and other elements of a system, and the profession that applies theory, principles, data, and other methods to design in order to optimize human well-being and overall system performance ([International Ergonomics Association](#)).

SPPRAMSS-11046 - Future updates of the document

In order to better frame both the context and the objective of this document, a collection of the standards and literature applicable to HOF has been made. These documents, collected in Annexes C and D, will constitute the input for the next version of this document.

1.2 Importance of taking Human and Organisational factors into account

SPPRAMSS-10225 - Importance of taking Human and Organisational factors into account

In integrating HOF, several benefits are expected for the new system:

- efficient and safe operation in the future, in terms of both production safety and health and safety at work;
- a resilient future system: capable of anticipating, preventing and positively managing deviations from nominal operating conditions;
- a capacity to adapt the system to variations in environmental constraints;
- satisfactory working conditions for production and maintenance teams;
- better anticipation and management of the skills required to use the system.

1.3 Human and Organisational Factors applicability

SPPRAMSS-10223 - Human and Organisational Factors applicability

Inclusion and analysis of HOF is important throughout the design, development, commissioning, operation, and decommissioning of a railway system. In fact, the HOF contribution can even precede the design phase and have an important impact, for example through analysis of Functional Technical Specifications (FTS) requirements, among others.

1.4 Human and Organisational Factors Integration (HOFI)

SPPRAMSS-10224 - Human and Organisational Factors Integration (HOFI)

The application of HOF knowledge and approaches within system design is via a process of Human and Organisational Factors Integration (HOFI), which can also be referred to as Human Factors Assurance (HFA). This process applies knowledge of human physical and mental strengths and limitations in order to ensure that the design is fit for purpose for the eventual end users. This is achieved via a human centred design process, where the needs of end users are identified from the start of the design and are incorporated and tested throughout the design.

1.5 Human and Organisational Factors Integration Objectives

SPPRAMSS-10222 - Introduction to objectives of HOFI

1. The human related issues should be identified through the implementation of the HOF, in particular those relevant to the safe and efficient operation of the railways, since the primary goal of HOF is to maximize effectiveness and efficiency by full consideration of the human contribution to the system performance.

1.5.1 Generic objectives of Human and Organisational Factors Integration (HOFI) activities

SPPRAMSS-10215 - Generic objectives of Human and Organisational Factors Integration (HOFI) activities

The generic objectives of HOFI activities are:

- Identify the influence on a particular project may have on human tasks and activities before starting development or construction
- Identify and understand the user population and their physical and cognitive needs
- Identify user requirements for the end product or system
- Develop a product or system that 'fits' the user population and the objectives of the organization (increasing user and customer acceptance of the system)
- Design out conditions that may cause harm to users
- Apply HOF knowledge and conduct HOF analysis to improve the working environment and fit the task to the user
- Assess the design and provide recommendations to minimise the likelihood of human error that may contribute to incidents and accidents
- Conduct training needs analysis and identify the user task technical and non-technical skill requirements
- Provide a HOF perspective on risk

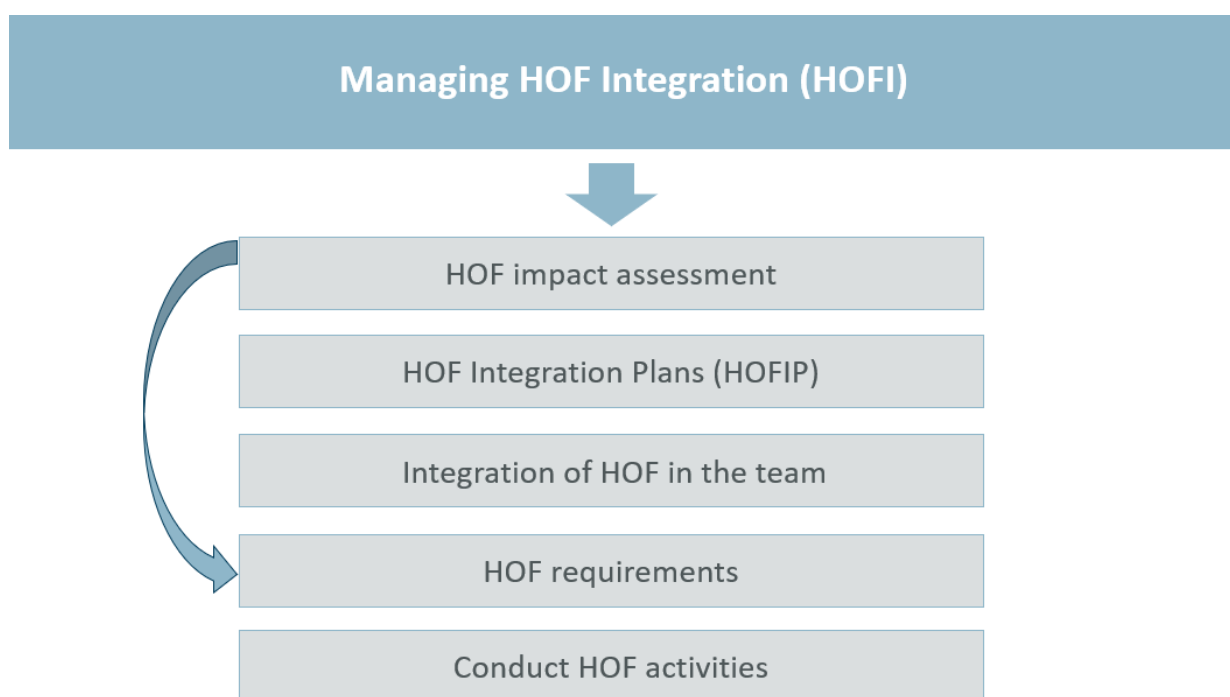


Figure 1 : Managing HOF Integration (HOFI)

This HOFI model is inspired by the process used at Irish Rail.

The model describes the key stages in managing HOF within a project or system design. The first step is the assess the potential impact of the proposed change on human tasks and activities (The HOF impact assessment). If a large enough impact is identified, a HOF integration plan should be drawn up which describes how HOF will be integrated with the technical design, development and validation activities, and HOF activities conducted during the design and validation phases to assess the design and provide recommendations to meet the HOF requirements.

2 Improved Human and Organisational Factors approach

SPPRAMSS-10226 - Introduction to improved HOF approach


Human and Organisational Factors are becoming an increasingly important part of the optimal functioning of a train, signalling system, maintenance depot (or any new system) in the transport system. Generally speaking, HOF are not yet sufficiently addressed and are often applied implicitly, sometimes insufficiently considered and can be limited to physical ergonomics.

Operators (IMs and RUs) will benefit from ensuring that HOFs are explicitly included in the procurement process and in the implementation of changes to any new systems within the organisation. At present, HOFs are mainly related to health and safety at work, and less to system performance but deep consideration of HOF has performance benefits as well as safety. The aim of this document is to establish a closer and more systematic link between the HOF knowledge of the industry and practice in the transport sector, which is not limited to modelling and designing trains, but to all relevant system changes in the rail industry, based on the V-cycle used in system engineering.

2.1 Current V-cycle model used in the EN 50126-1

SPPRAMSS-10228 - Current V-cycle model used in the EN 50126-1

A correct management of all potential hazards requires a comprehensive vision that takes into account both techniques and tools for carrying out the risk assessment activities depicted in EN 50126/50129 and the CSM-RA process (in order to ensure that all foreseeable HOF hazards, for example rolling stock driver interfaces and railway system, are identified and adequately controlled).

In this document, we have chosen to take as a reference the classic V-cycle model, as described in standard  SPPRAMSS-349 - [\[EN 50126-1:2017\]](#) .

EN 50126-1:2017 (E)

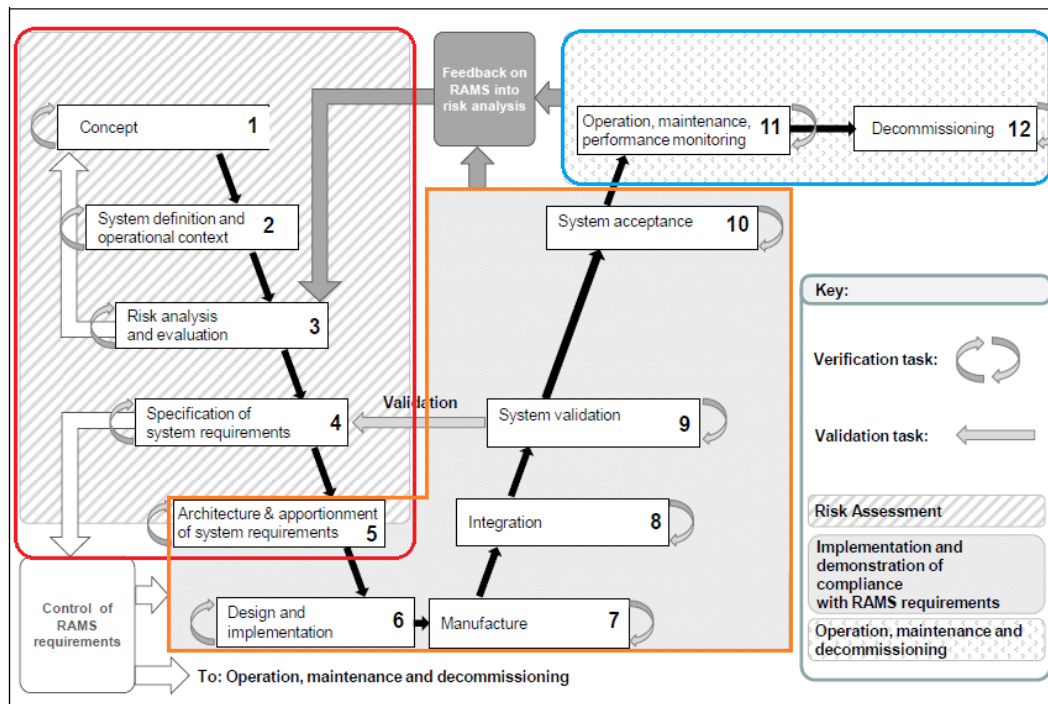


Figure 2 : The V-cycle representation

The 'classic' representation of the V-cycle in  SPPRAMSS-349 - [\[EN 50126-1:2017\]](#) composed of 12 phases

can be divided in three major blocks (see the figure 2):

- Risk Assessment and requirement development (i.e., '*Tender*' block, marked in red in figure 2), including phases from 1 to 5.
- Implementation and demonstration of compliance with RAMS requirements (i.e. '*Design and Commissioning*' block, marked in orange in figure 2), including phases from 5 to 10. Phases 8, 9 and 10 can be seen as an integration subphase.
- Operation, maintenance and decommissioning (i.e. '*Operation*' block, marked in blue in figure2), including phases 11 and 12.

For all the 12 phases of the V-cycle, HOF plays an important role in achieving the desired safety and performance. This document proposes to use the stages that logically follow each other during the V-cycle (EN 50126), which is traditionally used as a reference to develop a new system whether they are safety equipment, new trains or any new system to set up within a railway organisation.

This structure is used to describe the actions to be taken at each stage of the cycle to ensure that HOF is considered at the right time.

HOF should be integrated throughout the V-cycle, i.e. in all the three major blocks. This is why we are suggesting a new approach to the “implementing any new system within the organisation”, with HOFs being considered at the same level as the technical elements.

2.2 Human and Organisational Factors Integration in organisational change management

SPPRAMSS-10216 - Human and Organisational Factors Integration in organisational change management

Railway organisations must have a standard process for implementing new systems, new trains, new safety equipment or major modifications (i.e. a change management process). We propose that HOF can be integrated in the change management process by following the steps below. For each phase of the standard process the link to and the consideration of HOFs is mentioned.

Figure 3 below describes the process of integrating HOF throughout the V-cycle alongside the technical elements.

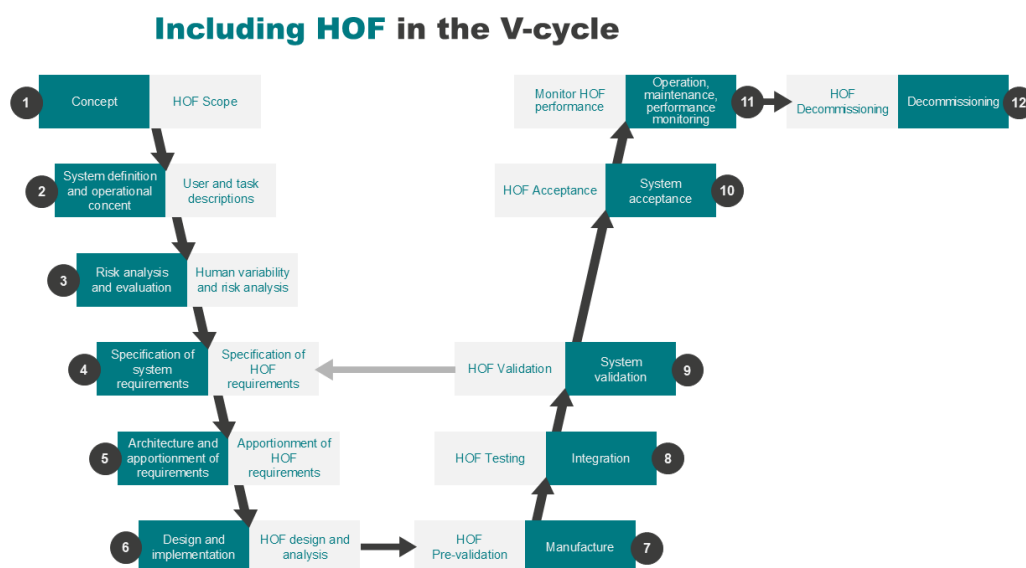


Figure 3 : HOF steps of the V-cycle

The HOF steps are:

1. **HOF Scope** (Concept) – at this stage, the HOF Scope for the project should be set, considering the possible impact of the change on the end users.
2. **User and task descriptions** (System definition and operational context) – at this stage, all end users of the system should be described in detail and a high level description of their main goals and tasks provided. The major interfaces between the end users and technical system elements should be identified. The HOF Assurance Plan should be produced at this stage.
3. **Human variability and risk analysis** (Risk analysis and evaluation) – at this stage, HOF should be integrated with the overall risk assessment process to represent HOF hazards. Specific HOF risk assessments may be carried out into potential human performance risks. The HOF Issues Log (HOFIL) should be started at or before this stage.
4. **Specification of HOF requirements** (Specification of system requirements) – at this stage, HOF requirements on the end system should be developed and documented, including criteria for acceptance and means of compliance.
5. **Apportionment of HOF requirements** (Architecture and apportionment of system requirements) – at this stage, the HOF requirements should be apportioned to the relevant sub-systems. The HOF Assurance Plan should be updated.
6. **HOF Design and Analysis** (Design and implementation) – at this stage, specific HOF assessments may be conducted to support the design process and provide evidence for closure of HOF issues. Human centred design is best suited to an iterative design process where evolving designs can be tested with end users at different stages of design maturity and feedback used to improve the design. Wherever possible, this should be facilitated.
7. **HOF Pre-validation** (Manufacture) – at this stage, the HOF focus is on preparing for validation of the final product. There may also be some HOF issues to be addressed relating to preparing for operations and maintenance.
8. **HOF Testing** (Integration) – at this stage, the integration of the human component (end users) should be tested with the technical components they are required to interact with.
9. **HOF Validation** (System validation) – at this stage, the HOF requirements are validated against the final product and the HOFI Report is produced documenting the HOF activities undertaken throughout the project, and their results. The acceptability of the design is finalised against the HOF requirements and with end users, and issues on the HOFIL should be closed out.
10. **HOF acceptance** (System acceptance) – at this stage, the HOFI Report is reviewed and accepted by a reviewer with suitable HOF expertise.
11. **Monitor HOF performance** (Operation, maintenance and performance monitoring) – post-commissioning reviews are performed with end users to close out any outstanding issues on the HOFIL and to identify any additional issues that may need to be resolved. In-service reviews may be carried out through the lifetime of the system to identify and resolve any operational or maintenance HOF issues.
12. **HOF Decommissioning** – the HOF impact of planned decommissioning activities is assessed and a HOF plan put in place to manage any expected issues.

Table 2 below describes the HOF tasks for each of the 12 HOF steps, aligned with the General Tasks from figure 2 of EN 50126-1.


Table 2 : HOF tasks for lifecycle steps 1-12

Phase #	Phase name	HOF Steps	General tasks	HOF tasks
1	Concept	HOF Scope	<ul style="list-style-type: none"> - Investigate scope, context, and purpose of system - Investigate the environment of the system 	<ul style="list-style-type: none"> - Investigate the HOF impact of the system - Investigate HOF issues on similar systems - Identify relevant HOF standards - Define the HOF scope for the project
2	System definition and operational context	User and task descriptions	<ul style="list-style-type: none"> - Define the system and its mission profile - Define the system boundary - Define the scope of operational requirements - Establish the organisation 	<ul style="list-style-type: none"> - Define the end users - Define the high-level tasks of end users - Identify end users interfaces with technical components/sub-systems - Establish the HOFI Plan
3	Risk analysis and evaluation	Human variability and risk analysis	<ul style="list-style-type: none"> - Identification and classification of risks (hazards) - Assessment of risks 	<ul style="list-style-type: none"> - Input to risk analysis - Conduct any necessary human performance analyses - Establish HOF issues Log (HOFIL)
4	Specification of system requirements	Specification of HOF requirements	Specify system requirements	<ul style="list-style-type: none"> - Establish HOF requirements specification - Update HOFIL - Update HOFI Plan - Establish HOF requirements validation plan
5	Architecture and apportionment of system requirements	Apportionment of HOF requirements	<ul style="list-style-type: none"> - Define the system architecture - Identify the requirements for integration of pre-existing subsystems/components - Define acceptance criteria and processes for subsystems/components 	<ul style="list-style-type: none"> - Allocate HOF requirements to sub-systems - Update HOFIL - Update HOFI Plan - Update of HOF requirements validation plan
6.	Design and implementation	HOF design and analysis	<ul style="list-style-type: none"> - Design subsystems/components - Prepare operation and maintenance procedures - Define training measures for operation and maintenance - Define and establish manufacturing process for producing subsystems and components - Define and establish system integration process - Prepare installation and commissioning procedures 	<ul style="list-style-type: none"> - Conduct iterative HOF assessments on the emerging design - Conduct user testing where possible - Provide feedback and recommendations on design improvements - Conduct HOF assessments on operation and maintenance procedures - Identify HOF training needs - Update the HOFIL
7	Manufacture	HOF pre-validation	Implement and operate manufacturing process	<ul style="list-style-type: none"> - Prepare HOF requirements validation plan - Update the HOFIL
8	Integration	HOF testing	<ul style="list-style-type: none"> - Integrate subsystems and components - Demonstrate system functionality - Test and analyse system - Arrange system support arrangements 	<ul style="list-style-type: none"> - Conduct end user testing on the final product - Update the HOFIL

Phase #	Phase name	HOF Steps	General tasks	HOF tasks
9	System Validation	HOF validation	<ul style="list-style-type: none"> - Establish validation report - Establish process for the acquisition and evaluation of operational and maintenance data 	<ul style="list-style-type: none"> - Collect evidence that HOF requirements have been met - Collect evidence that HOF issues have been closed - Documents results of all HOF activities - Produce HOFI report
10	System acceptance	HOF Acceptance	<ul style="list-style-type: none"> - Record an acceptance record - Verify the acceptance record 	<ul style="list-style-type: none"> - Review of HOF validation activities and record of acceptance
11	Operation, maintenance and performance monitoring	Monitor HOF performance	<ul style="list-style-type: none"> - Provide all information necessary to formulate plans/procedures for operation and maintenance - Implement operation and maintenance procedures - Record changes in the system configuration 	<ul style="list-style-type: none"> - Conduct post-commissioning review - Conduct in-service reviews as necessary - Continuous HOF monitoring and HOF incident analysis
12	Decommissioning	HOF Decommissioning	Establish decommissioning plan and related report	<ul style="list-style-type: none"> - Identify the HOF impact of decommissioning

3 Conclusion

SPPRAMSS-10217 - Conclusion

This document has described a generic process for the integration of HOF in change management of railway systems, aligned with the V-cycle from  SPPRAMSS-349 - [\[EN 50126-1:2017\]](#).

Missing element in version 1.0 and next version

Explain context with OD/EET

Further detail on the approaches, methods and outputs at each stage will be developed in future.

4 Annex A: Case study of Requirements definition for ERTMS

SPPRAMSS-10218 - Introduction to case study of Requirements definition for ERTMS

To get a clear picture of how to ensure that HOF is taken into account at each stage of the cycle, an analysis of the ERTMS requirements is given as an example.

On the basis of company's specific requirements, the ERTMS requirements have been analysed.

The company's specific requirements contain all the requirements relating to the construction of a new train (sprinter, intercity, double-decker train, etc.). For each new construction project, all the relevant set of requirements is selected and supplemented if necessary.

The aim of the analysis was to provide an overview of the relevant HOF requirements to be considered. To achieve this, categories and subcategories have been defined and linked to the HOF requirements. A first review of the requirements has been made to determine whether they were relevant and linked to HOFs.

To do this, a primarily rely was made on the experience from RAM (reliability, availability, and maintainability) and QHSE.

4.1 Categories

SPPRAMSS-10219 - Case study categories

From this analysis, the following categories have been identified as a methodological action when you are defining the requirements.

- **Check of the risk linked to human and organisational factors should be done:** There is a potential risk of error which can be made by the user and must therefore be considered from HOF's point of view. So, should be reviewed for each of these categories, linked with HOFs.
- **Technical Requirement:** If the requirement does not change, there is no HOF involvement. If a change takes place, HOFs must be involved.
- **Process Requirement:** If the requirement does not change, there is no HOF involvement. If a change takes place, HOFs must be involved.
- **Occupational Health & Safety and Ergonomics;** HOFs are automatically involved.
- **Workshop/Kick-off/Review;** Meetings where issues are discussed, and where HOFs needs to be involved. Remember to discuss use cases and specifically un-happy flows where collaboration with HOF is required. It is necessary to be precise about the role played by HOF, otherwise the message will not get through.

In the next step, the different sub-categories are going to be defined.

4.2 Sub-categories

SPPRAMSS-10220 - Case sub-study categories

The different sub-categories are detailed here. The purpose is to create a link between all the requirement of an operator and the corresponding requirements of the HOFs.

It often happens that multiple subcategories are assigned to a single requirement. Please note that each HOF requirement should be distinctly numbered and that only one HOF idea will be noted per point, as is the case for functional requirements.

- **Maintainability**

All aspects that are related to maintainability of the train/systems. It concerns maintenance that is carried out by maintenance and cleaning and takes place in maintenance depots and service locations or marshalling yards. Maintenance refers to both the work because of malfunctions or defects and regular maintenance, including helpdesk failures (for further handling after the malfunction has been dealt with between the helpdesk and the Driver). Aspects related to, for example, visibility, accessibility, and ease of maintenance in a robust manner, so the chance of incorrect assembly/disassembly as low as possible, etc.

- **Operability**

All aspects related to the moving service of the train (happy flow) including actions to be carried out when handling disruptions during the moving service (unhappy flow). Operability has all aspects in scope that are relevant during the running of the train, both for the workshops and technical Center as well as the help desk employee who remotely assists with malfunctions that arise in the driving service (implicit compliance of the product).

- **Performance related**

Aspects that are directly important for optimal performance (delays/cancellations of trains). So, these are the critical aspects on top of Maintainability and Operability (implicit; should not be a sub-category but more a consequence of all the requirements).

- **Occupational Health & Safety and Ergonomics**

All aspects in relation to working according to health and safety and considering the ability to work healthily (no harmful substances). It has a strong relationship with Maintainability, Operability and of course Safety.

- **Cybersecurity**

All aspects related to cybersecurity. Has a relationship with RAMS and specific accessibility requirements.

From the links established, it is possible to select the most relevant aspects. The idea is to use the company's risk matrix for this purpose. The most interesting aspects on which to focus on will be determined (this may vary from one carrier to another).

Experience shows that the knowledge gained are still too undetailed and need to be deepened so that the supplier is clear about what needs to be adjusted in the design, if possible. If it is not possible to adjust the design, you know what risk you are running and can consider mitigation measures in the processes. That has to be done in cooperation with the HOF specialists.

Each project management team will have to decide which are the relevant HOF requirements linked to his own project.

We will propose a non-exhaustive list of more generic HOF requirements; the specific HOF requirements chosen

by each management teams will be appended to it to set the complete relevant list.

5 Annex B: Case study on specification of a set of Maintainability requirements for HOF

SPPRAMSS-10221 - Introduction on the case study on specification of a set of Maintainability requirements for HOF

The present paragraph deals with the maintainability subcategory, as an example, introducing:

1. General definition of maintainability
2. Maintainability with examples of applicable requirements
3. HOF methods to verify the maintainability
4. Input assessment from RAM/LCC checklists

5.1 Definition of maintainability

SPPRAMSS-10227 - Introduction to maintainability

The Maintainability can be defined as the ability of an item under given conditions of use, to be retained in, or restored to, a state in which it can perform a required function, when Maintenance is performed under given conditions and using stated procedures and resources.

5.2 Maintainability in company's specific requirements

SPPRAMSS-10229 - Examples of Maintainability in company's specific requirements

Following requirements may be considered as examples for Maintainability in company's specific requirements:

- **Health & Safety**, check on requirements for occupational health and safety (QHSE (Quality, Health, Safety and Environment) and legislation
 - In addition to EN 16362:2013 Railway applications - Ground based services – Water restocking equipment, clause 4.1.3, the filling coupling shall be equipped with a cap that, after opening, remains in the opened position. Closing shall be done with one single action.
- **Recognize audio/signals**, check HF whether they meet the requirements individually but also as a whole in the working environment (e.g. entire cabin);
 - The refurbishment & overhaul workshop system shall enable the driver to alert the environment of the Train set visually and acoustically that it is being remotely controlled. In order to provide a proper visibility of the train, and warn people in the surrounding of its presence, special lights may be used when train is being controlled remotely.
- **Helpdesk drivers and fault handling**, input for processes fault handling HF correct, correct data available to be able to do feasible and robust fault handling HF prove.
 - The TCMS shall monitor the collection and transmission of data to the NS wayside and log error messages if faults are detected in this process.
- **Manufacturability/equipment**, part of health and safety but also having the right equipment.
 - The workshop lifting points shall be positioned at a height of > 330 mm above top of rail, under the condition that the car body is in its lowest possible position.
- **Manufacturability, unambiguous and easy execution of tasks (efficient);**
 - If the driver has confirmed the proposed selection of passenger entry doors and the command

“release” is given, the door system shall release only the proposed selection of passenger entry doors.

- **Robustness, ability to perform tasks effectively.**
 - In addition to TSI Loc&Pas clause 4.2.6.1.2, build-up and accumulation of snow or ice or hail to the Train Set shall be prevented and shall not lead to malfunction, degraded functionality or failure of the Train Set.
- **RAM**, Assessment to RAM criteria;
 - The effectiveness of the maintenance programme shall be demonstrated by the means of RCM analyzes. A RCM analysis shall be delivered for each of the systems:
- **Cleaning**, execution of process cleaning on HF;
 - The exterior preservation system of the Train Set shall be compatible with the exterior cleaning agents. This shall be demonstrated during the Design Phase.
- **Robustness design**, more technical but with link to HOF;
 - The toilet system shall be fully functional in the operation modes “operate”, “ready” and “clean”.
- **Security within maintainability?** At the moment, we are focusing on accessibility and key policy of security equipment;
 - These logs shall be accessible for maintenance staff and shall be protected against alteration, deletion and other fraudulent actions.
- **Space claims**, make sure this is correct, so also check HOF, proactively;
 - The Train Set shall have in each driver's cab a cabinet with a 19 inch rack of 9U for additional IT systems, e.g. for additional parts of ATO, ETCS, FRMCS, TCMS. As several systems have to be integrated, the workspace of mechanics should be taken into account.
- **Access equipment**, see manufacturability and robustness;
 - The amplifier shall be installed in the driver's cab in such way that it is reachable by the mechanic for maintenance.
- **Interchangeability**, all health and safety aspects but also effective and efficient capture components take into account equipment.
 - Removing any piece of equipment shall be possible, if needed for recovery from failure or for scheduled maintenance, without having to operate on other pieces of equipment not directly involved with the specific maintenance action

5.3 HOF Methods and Techniques to Verify the Maintainability

SPPRAMSS-10230 - HOF Methods and Techniques to Verify the Maintainability

Following HOF methods and techniques may be applied in order to verify the Maintainability:

- Workload assessments
- Design Review
- Mock up
- Expert Review
- Usability assessment
- Use cases
- Workshops with End Users
- Validation/verification of the requirements (countermeasure review)
- Risk assessment/analysis
- Peer reviews
- Critical Task Analysis
- Ergonomic review
- Compliancy with national legislations and requirements
- Empirical investigations
- Simulations

5.4 Input Assessment from RAM/LCC Checklist

SPPRAMSS-10231 - Input Assessment from RAM/LCC Checklist

The following points serve as a checklist for the input assessment. The challenge is to derive, from them, an applicable method for assessing HOF and convert it into specifications for the supplier:

- Does the process consist of many steps that need to be carried out by the technician? Can steps in the process be automated? For example:
 - Is automation desirable?
 - Does automation make the task less secure?
 - Does automating make a difficult or busy task easier or does it make an already easy task more boring?
- Does an error message of the process make it clear in which process the error lies?
 - Is one type of error message used for multiple errors in the system?
 - Does the error message mention the process in which the error occurs?
 - Are there any other error messages similar to this one?
 - Does the error message make it clear what the next action should be?
- Is the process to be carried out complex?
 - Does a mechanic need to combine information from different sources to perform the job?
 - Does a technician need to remember information presented at the beginning of the job and apply it at the end of the process?
 - Do you need to collaborate with other officials?
- Is the process feasible?
 - Is the task/process often performed under time pressure? a) Regular process: What is the ratio between the time it takes for a process to be carried out and the time planned for it? b) In the event of an error message: does the error message cause the train to come to a standstill?
 - Is this process often carried out at the same time as another process? (Does the mechanic/operator need to multitask during this process?)
- How often does the task/process have to be completed?
 - Every shift, once a week, once a month, etc.
 - What are the chances that someone knows the right steps by heart?
 - Is there a task/process that needs to be completed more often and is similar in signalling to the current process to be evaluated (is there a possibility of confusion)?
 - Is there a chance that you will carry out the process too routinely and therefore make mistakes?
- Protection against improper operation (design):
 - Against switching on too quickly
 - Operation for too short or too long
 - Against acting differently than the prescribed procedure (wanting/having to act faster/time pressure)
 - Warning in case of "incorrect" action
- Environment:
 - Stress in the event of disruption (e.g. by travellers, other maintenance)
 - In case of delay in maintenance process, service
 - Is employed too late.
- Accessibility of plugs/cables of electrical/electronic equipment. Install cables/plugs in such a way that they are optimally accessible. For 19 equipment, use the entire width to distribute the plugs. Often there are a few blind plates, place them in the most optimal place. Example: wide blind plate and several plates with connectors. If the blind plate was half the width and spread over the width of the device, the accessibility

was better.

- Configuration of ports. Often you can configure communication ports individually. Configure the ports in such a way that frequently used ports are easily accessible

6 Annex C- HOF Reference Documents

No proper WI for HOF references

All references contained in the HOF document shall be handled with WI type "Reference" in the next release of the document.

6.1 Directives

1. Council Directive of 12 June 1989 on the introduction of measures to encourage improvements in the safety and health of workers at work (89 / 391 /EEC)
2. Directive (EU) 2016/798 of the European Parliament and of the council of 11 May 2016 on railway safety

6.2 Regulations

1. Commission Delegated Regulation (EU) 2018/762 of 8 March 2018 establishing common safety methods on safety management system requirements pursuant to Directive (EU) 2016/798 of the European Parliament and of the Council and repealing Commission Regulations (EU) No 1158/2010 and (EU) No 1169/2010
2. Commission implementing Regulation 2020/572 of 24 April 2020 on the reporting structure to be followed for railway accident and incident investigation reports.
3. Regulation 2018/761 - Commission Delegated Regulation (EU) 2018/761 of 16 February 2018 establishing common safety methods for supervision by national safety authorities after the issue of a single safety certificate or a safety authorisation pursuant to Directive (EU) 2016/798 of the European Parliament and of the Council and repealing Commission Regulation (EU) No 1077/2012

6.3 International/European Standards and Specifications

1. EN 62682 Management of alarms systems for the process industries
2. EN 16186-1 "Railway applications - Driver's cab - Part 1: Anthropometric data and visibility"
3. EN 16186-3 "Railway applications - Driver's cab - Part 3: Design of displays for heavy rail vehicles"
4. UIC 651 Layout of Driver's Cabs in Locomotives, Railcars, Multiple-Unit Trains and Driving Trailers
5. ISO 11064-1 Ergonomic design of control centres - Part 1: Principles for the design of control centres
6. ISO 11064-4 Ergonomic design of control centres - Part 4: Layout and dimensions of workstations
7. ISO 10075-1 "Ergonomic principles related to mental workload - Part 1: General issues and concepts, terms and definitions"
8. ISO 10075-2 "Ergonomic principles related to mental workload - Part 2: Design principles"
9. ISO 10075-3 "Ergonomic principles related to mental workload - Part 3: Principles and requirements concerning methods for measuring and assessing mental workload"
10. ISO 20282: Ease of operation of everyday products
11. ISO 27500 series: The human-centred organization. Rationale and general principles
12. ISO 7250-3 Basic human body measurements for technological design - Part 3: Worldwide and regional design ranges for use in product standards
13. ISO 6385 on Ergonomics principles in the design of work systems
14. ISO 26800 Ergonomics - General approach, principles and concepts
15. EN-ISO 9241-110 (2020) Ergonomics of human-system interaction - Part 110: Interaction principles
16. EN-ISO 9241-210 (2019) Ergonomics of human-system interaction- Part 210: Human-centred design for interactive systems
17. EN-ISO 9241-392 (2015) Ergonomics of human-system interaction - Part 392: Ergonomic recommendations for the reduction of visual fatigue from stereoscopic images
18. ISO/IEC/IEEE 24748-4: 2016 – Systems and software engineering-Life cycle management Part 4: Systems engineering planning

19. EN 547 3 Safety of machinery - Human body measurements - Part 3: Anthropometric data
20. EN 894 3 Safety of machinery - Ergonomics requirements for the design of displays and control actuators
21. EN 1005-2 Human physical performance - Part 2: Manual handling of machinery and component parts of machinery
22. EN 1176-1 Playground equipment and surfacing - Part 1: General safety requirements and test method
23. ISO 1503 Spatial orientation and direction of movement - Ergonomic requirements
24. ISO 3864-1:2012 Graphical symbols - Safety colours and safety signs - Part 1: Design principles for safety signs and safety markings
25. ISO 5006 Earth-moving machinery - Operator's field of view - Test method and performance criteria
26. ISO 5349-2:2001 + Amd 1:2015 Mechanical vibration - Measurement and evaluation of human exposure to hand-transmitted vibration - Part 2: Practical guidance for measurement at the workplace
27. ISO 7010 Graphical symbols - Safety colours and safety signs - Registered safety signs
28. ISO 9186-1 Graphical symbols — Test methods — Part 1: Method for testing comprehensibility
29. ISO 10551 (2019) Ergonomics of the physical environment - Subjective judgement scales for assessing physical environments
30. ISO 11226 (2000) Ergonomics - Evaluation of static working postures
31. ISO 11228 Ergonomics - Manual handling
32. ISO 11429 Ergonomics - System of auditory and visual danger information signals
33. ISO 14738 Safety of machinery - Anthropometric requirements for the design of workstations for industries and services
34. ISO 15006 Road vehicles - Ergonomic aspects of transport information and control systems - Specifications for in-vehicle auditory presentation
35. ISO 15008 Road vehicles - Ergonomic aspects of transport information and control systems - Specifications and test procedures for in-vehicle visual presentation
36. ISO 15534-1:2000 Ergonomic design for the safety of machinery - Part 1: Principles for determining the dimensions required for openings for whole-body access into machinery
37. ISO 15534-2:2000 Ergonomic design for the safety of machinery - Part 2: Principles for determining the dimensions required for access openings
38. ISO 15534-3:2000 Ergonomic design for the safety of machinery – Part 3: Anthropometric data
39. ISO 15535 General requirements for establishing anthropometric databases
40. ISO 15536-1 Ergonomics - Computer manikins and body templates - Part 1: General requirements
41. ISO 16121-2:2011 Road vehicles - Ergonomic requirements for the driver's workplace in line-service buses - Part 2: Visibility
42. ISO 16121-3 Road vehicles - Ergonomic requirements for the driver's workplace in line-service buses - Part 3: Information devices and controls
43. ISO 16673:2017 Road vehicles - Ergonomic aspects of transport information and control systems - Occlusion method to assess visual demand due to the use of in-vehicle system
44. ISO 20176:2020 Road vehicles - H-point machine (HPM-II) Specifications and procedure for H-point determination
45. ISO 24505:2016 Ergonomics - Accessible design - Method for creating colour combinations taking account of age-related changes in human colour vision
46. ISO TR 16982 Ergonomics of human-system interaction - Usability methods supporting human-centred design
47. UNI EN 614-1:2009 Safety of machinery-Ergonomic Design Principles Part 1: Terminology and general principles
48. UNI EN 614-2:2009 Safety of machinery-Ergonomic Design Principles Part 2: Interactions between the design of machinery and work tasks
49. UNI EN 614-3:2010 Safety of machinery-Part 3: Ergonomic principles for the design of mobile machinery

6.4 National Standards and Specifications

1. GEGN8613 Iss 1 – Application of human factors within safety management systems (RSSB standard)
2. AS/NZS ISO 45001:2018 "Occupational health and safety management systems - Requirements with guidance for use"
3. AS/NZS 4804:2001 Occupational health and safety management systems — General guidelines on principles, systems and supporting techniques
4. AS 4292.1—2006 Railway safety management Part 1: General requirements
5. T MU HF 00001 ST New South Wales Human Factors Integration-General Requirements v.3.0, 8 June 2018
6. NEN 3087 (2011) Ergonomics - Visual ergonomics: background, principles and implementation
7. Safety Management Systems for Aviation- Book 6 Human factors and human performance
8. VDI 4006 Blatt 1:2015-03 Human Reliability – Ergonomic Requirements and methods of Assessment
9. VDI 4006 Blatt 2:2017-11 Human Reliability – Methods for quantitative assessment of human reliability
10. VDI 4006 Blatt 3:2013-08 Human reliability - Methods for event analysis regarding human behaviour

6.5 Scientific papers

Balfe, N. (2023). H-FIT: Assessing the human factors impact of proposed changes to the railway. In D. Golightly, R. Charles & N. Balfe (Eds), Proceedings of the Ergonomics and Human Factors Conference, 2023.

6.6 ERA Documents

1. 20230816 Guidance on HOF in change management
2. How-to Question the HOF 5x5 Factors for Change Management 2023_06

6.7 Websites

1. <https://www.nngroup.com/articles/ten-usability-heuristics/> (Nielsen Norman Group "10 Usability Heuristics for User Interface Design" - nngroup.com/articles/ten-usability-heuristics)
2. [Home - RailHOF](#)
3. [Safety Culture | ERA \(europa.eu\)](#)
4. [Human and Organisational Factors \(HOF\) | ERA \(europa.eu\)](#)
5. [Common Safety Methods | ERA \(europa.eu\)](#)
6. [Human factors integration: Guidance for inspectors \(UK Office of Road and Rail\)](#)
<https://www.orr.gov.uk/media/15720>

7 Annex D- Analysis and consideration of HOF standards

SPPRAMSS-10232 - Analysis and consideration of HOF standards

Hereunder an analysis of some applicable HOF Standards is reported as an example.

Number	Title	Summary/ Scope	Relevant Elements
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Number	Title	Summary/ Scope	Relevant Elements
EN- ISO 10075 (2017) Part 1	Ergonomic principles related to mental workload - Part 1: General issues and concepts, terms and definitions	This document defines terms in the field of mental workload, covering mental stress and mental strain, and short- and long-term, positive and negative consequences of mental strain. It also specifies the relations between these concepts.	3.1 Definitions - mental stress and mental strain 3.2 Consequences of mental strain - facilitating & impairing effects
EN- ISO 10075 (1996) Part 2	Ergonomic principles related to mental workload - Part 2: Design principles	This part provides guidance on the design of work systems, including task and equipment design and design of the workplace, as well as working conditions, emphasizing mental workload and its effects.	1. General principles - fit the work system to the user. Intensity and duration of exposure to workload. 4.2 Guidelines concerning fatigue 4.2.2 Intensity of mental workload - i.e. Complexity of task requirements; Ambiguity of information; Parallel vs. serial processing; Working memory load; Accuracy of information processing; Time pressure 4.2.3 Temporal distribution of workload - i.e. Duration of working hours; Time off between successive workdays or shifts; Time of day; Shift work; Breaks and rest pauses 4.3 Guidelines concerning monotony - One of the main conditions leading to the development of monotony as defined in this standard, is a task with a narrowly restricted field of attention, with low to medium levels of cognitive task difficulty, repetitive performance requirements, and little variation in task or environmental conditions, especially if performed over extended periods of time. (See approaches to avoid this & ways to decrease monotony). 4.4 Guidelines concerning reduced vigilance - see what to Avoid 4.5 Guidelines concerning satiation
EN-ISO 10075 (2004) Part 3	Ergonomic Principles related to mental workload - Part 3: Principles and Requirements concerning methods for measuring	This part of ISO 10075 establishes principles and requirements for the measurement and assessment of mental	3. Terms and definitions - see properties of instruments 4. Measurement and assessment of mental workload

	and assessing mental workload	workload and specifies the requirements for measurement instruments. The standard provides information for choosing appropriate methods and provides information on aspects of assessing and measuring mental workload to improve communication among	<p>4.1 General principles: There is no single best way to assess mental workload, since the most appropriate way to assess or measure mental workload will depend on the purpose of the assessment, which may require the assessment of different aspects of mental workload, the use of different techniques of measurement, and different degrees of precision.</p> <p>Thus, the model of workload assessment used in this part of ISO 10075 has a three-dimensional structure. It takes into account:</p> <ul style="list-style-type: none"> *different aspects of mental workload, e.g. mental stress, mental strain, mental fatigue, etc., *different techniques of measurement, e.g. task analysis, performance assessment, subjective ratings or psychophysiological measurement, and the parties involved. *different degrees of precision, e.g. measurement at an orienting, screening or accurate level of measurement. <p>Different techniques may be used to assess mental workload, with some techniques being more suitable for some domains of measurement than others. In particular, the following techniques can be applied:</p> <ul style="list-style-type: none"> • physiological measurements: these methods provide information about physiological states of employees under given work conditions; • subjective scaling: these methods provide information on how employees subjectively assess different aspects of mental workload at their work stations, e.g. using psychometric scales, and how they feel about their work conditions; • performance assessment: these methods offer the possibility to evaluate human mental and psychomotor performance under given work conditions, e.g. in order to assess decrements or variations in performance due to the effects of mental workload;
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			<ul style="list-style-type: none"> • job and task analysis: these methods assess task elements, physical and psychosocial work conditions, environmental conditions and the organization of the work process as sources of mental workload. <p>NOTE: No instruments recommended - checklist provided for choosing instruments taking properties</p>
EN-ISO 9241-110 (2020)	Ergonomics of human system interaction - Part 110: Interaction Principles	<p>This standard describes principles for interaction between a user and a system that are formulated in general terms (i.e. independent of situations of use, application, environment or technology). This document provides a framework for applying those interaction principles and the general design recommendations for interactive systems. While this document is applicable to all types of interactive systems, it does not cover the specifics of every application domain (e.g. safety critical systems, collaborative work, artificial intelligence features).</p>	<p>4 Interaction principles (7 principles noted) - Recommendations for each principle</p>
EN- ISO 9241-210 (2019)	Ergonomics of human system interaction- Part 210: Human-centred design for interactive systems	<p>This standard provides requirements and recommendations for human-centred design principles and activities throughout the life cycle of computer-based interactive systems. It is intended to be used by those managing design processes, and is concerned with ways in which both hardware and software components of interactive systems can enhance human–system interaction.</p>	<p>4 Rationale for adopting human-centred design- i.e. increasing the productivity of users and the operational efficiency; improving user experience; reducing discomfort and stress.</p> <p>5 Principles of human-centred design) the design is based upon an explicit understanding of users, tasks and environments (see 5.2); b) users are involved throughout design and development (see 5.3); c) the design is driven and refined by user-centred evaluation (see 5.4); d) the process is iterative (see 5.5); e) the design addresses the whole user experience (see 5.6); f) the design team includes multidisciplinary skills and perspectives (see 5.7).</p>

Number	Title	Summary/ Scope	Relevant Elements
EN- ISO 9241-392 (2015)	Ergonomics of human system interaction - Part 392: Ergonomic recommendations for the reduction of visual fatigue from stereoscopic images	This part of ISO 9241 Establishes recommendations for reducing the potential visual discomfort and visual fatigue experienced during viewing of stereoscopic images under defined viewing conditions. Visual fatigue and discomfort might be produced by the stereoscopic optical stimulus of disparate images that were presented binocularly	<p>When a person views a three-dimensional object, the lateral distance between the eyes provides each with a slightly different retinal image. The fusion of these retinal images by the brain provides a single percept with an associated sense of depth termed as stereopsis.</p> <p>4.2 Review of factors</p> <p>4.2.1 General</p> <p>This part of ISO 9241 focuses on the major factors that have the potential to induce visual discomfort and visual fatigue during viewing of stereoscopic images. These factors, listed below, have been empirically determined and are widely recognized in the scientific literature. Since these factors are affected by the viewing conditions, such as the viewing distance, the viewing conditions should also be specified.</p> <p>5 Ergonomic recommendations</p> <p>5.1 General</p> <p>This part of ISO 9241 intends to reduce the potential for visual discomfort and visual fatigue induced in the viewers who watch stereoscopic images in appropriate viewing conditions.</p> <p>Annex C: Numerical values to be considered for assessment of visual fatigue and discomfort (detailed values provided)</p>

Number	Title	Summary/ Scope	Relevant Elements
ISO 11226 (2000)	Ergonomics Evaluation of static working postures	<p>Pain, fatigue and disorders of the musculoskeletal system may result from sustained inadequate working postures that may be caused by poor work situations.</p> <p>Musculoskeletal pain and fatigue may themselves influence posture control which can increase the risk of errors and may result in reduced quality of work or production, and in hazardous situations. Good ergonomic design is a basic requirement to avoid these adverse effects.</p> <p>This International Standard establishes Ergonomic recommendations for different work tasks. This standard provides information to those involved in design, or redesign, of work, jobs and products who are familiar with the basic concepts of ergonomics in general and working postures in particular. It specifies recommended limits for static working postures without any or only with minimal external force exertion, while taking into account body angles and time aspects. It is designed to provide guidance on the assessment of several task variables, allowing the health risks for the working population to be evaluated.</p>	<p>3. 1 Introduction - Work tasks and operations should provide for sufficient physical and mental variation - also variation in working postures.</p> <p>3.3 Determination of working postures - There are various ways to determine working postures, e.g. observation, photography/video, 3-dimensional optoelectronic or ultrasound measuring systems, body-mounted measuring devices such as inclinometers and goniometers. The appropriate method depends, amongst other things, on the accuracy of determination required by the evaluation. In most cases, direct observation (without measuring systems/devices) will do. However, for more precise determination of working postures, measuring systems/devices may be necessary.</p> <p>3.4 to 3.7 Particular posture parameters for i.e. trunk inclination, head inclination, neck flexion/extension, upper arm elevation, and extreme joint positions.</p>
EN-ISO 26800 (2011)	Ergonomics - General approach, principles and concepts	<p>This International Standard presents the general ergonomics approach and specifies basic ergonomics principles and concepts. These are applicable to the design and evaluation of tasks, jobs, products, tools, equipment, systems, organizations, services, facilities and environments, in order to make them compatible with the characteristics, the needs and values, and the abilities and limitations of people. The provisions and guidance</p>	<p>3 The ergonomics approach - Ergonomics (or human factors) has been defined by the International Ergonomics Association (IEA), the federation of ergonomics and human factors societies from around the world, as "the scientific discipline concerned with the understanding of the interactions among human and other elements of a system, and the profession that applies theory, principles, data and methods to design in order to optimize human well-being and overall system performance"[21]. This includes the specific goals of</p>

		<p>given by this International Standard are intended to improve the safety, performance, effectiveness, efficiency, reliability, availability and maintainability of the design outcome throughout its life cycle, while safeguarding and enhancing the health, well-being and satisfaction of those involved or affected.</p>	<p>facilitating task performance, safeguarding and enhancing the safety, health and well-being of the worker, or the user/operator of products/equipment, by optimizing tasks, equipment, services, the environment or, generally speaking, all elements of a system and their interactions. Achieving these goals potentially contributes to sustainability and to social responsibility.</p> <p>Ergonomics addresses the interactions between the humans and other components of a system, such as other humans, machines, products, services, environments and tools, as appropriate. This includes taking into account the following factors: purpose of the system, product or service (see 4.2); characteristics of the intended target population (see 4.2.2); goals to be achieved and tasks to be performed (see 4.2.3); existing constraints (e.g. legacy equipment or processes, economic or legal issues); factors of the physical, organizational and social environment (see 4.2.4); life cycle and any dynamic changes within it (see Clause 6).</p> <p>Ergonomics addresses the interactions between the humans and other components of a system, such as other humans, machines, products, services, environments and tools, as appropriate. This includes taking into account the following factors: purpose of the system, product or service (see 4.2); characteristics of the intended target population (see 4.2.2); goals to be achieved and tasks to be performed (see 4.2.3); existing constraints (e.g. legacy equipment or processes, economic or legal issues); factors of the physical, organizational and social environment (see 4.2.4); life cycle and any dynamic changes within it (see Clause 6).</p> <p>Ergonomics addresses the interactions between the humans and other components of a</p>
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		<p>system, such as other humans, machines, products, services, environments and tools, as appropriate. This includes taking into account the following factors: purpose of the system, product or service (see 4.2); characteristics of the intended target population (see 4.2.2); goals to be achieved and tasks to be performed (see 4.2.3); existing constraints (e.g. legacy equipment or processes, economic or legal issues); factors of the physical, organizational and social environment (see 4.2.4); life cycle and any dynamic changes within it (see Clause 6).</p> <p>4.2 Principles of ergonomics - Human-centered, Target population, Task oriented, Environmental context</p> <p>4.3 Criteria-based evaluation</p> <p>Evaluation of the ergonomic design outcome of any system, product or service shall be based on established ergonomics criteria, regardless of whether or not it was designed following an ergonomics-based design process. Ergonomics criteria can be related to the following: human performance; health, safety and well-being; satisfaction</p> <p>5 Concepts in ergonomics - important to consider, i.e. system concept, load-effects concept, useability, accessibility</p> <p>6.2 Requirements for ergonomics-orientated design Process</p>
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Number	Title	Summary/ Scope	Relevant Elements
ISO 1503 (2008)	Spatial orientation and direction of movement — Ergonomic requirements	It is essential for the safety and usability of any system or product that the relationship between the direction of its controls intended by a user/operator and the resulting direction of movement of the target object be standardized. This International Standard sets out design principles, procedures, requirements and recommendations for the spatial orientation and direction of movement of controls and displays used in tool machines, industrial robots, office machines, earth-moving machinery, transportation (automobiles, railway electric cars/rolling stock, aircraft, ships, etc.), information, daily commodities, public utilities and the operational components of building facilities. It lays down basic requirements for determining the operating direction of controls and the moving directions or changing states of the target object, as well as other relations.	4.2 Ergonomic design of user interface (UI) with respect to orientation and direction. The ergonomic design of a UI includes anthropometric aspects (e.g. body size, hand reach envelopes, visual field), cognitive aspects (e.g. compatibility of information displays/controls, human error tolerance), physiological capability aspects in information processing (e.g. workload, information processing speed, accuracy), and environmental aspects (e.g. illumination, colour, noise). 4.4 Design requirements/recommendations for human machine interface (HMI).

Number	Title	Summary/ Scope	Relevant Elements
EN-ISO 10551 (2019)	Ergonomics of the physical environment - Subjective Judgement scales for assessing physical environments	<p>People are exposed to a range of physical environments which can affect their health and safety, comfort and performance. An important method for assessing physical environments, particularly when considering psychological constructs such as comfort or satisfaction, is to use subjective scales that can be used to ask people how they feel about their physical environment. That is whether they find it too hot, whether there is any noise and if it is annoying, if the light is too bright, is it "smelly" and so on. The correct use of Subjective scales can help understand how people find the environment, in a cost-effective way. The information can be applied to report on the environmental quality and to work out how to improve the environment. This document presents principles and examples of practical application for the construction of appropriate subjective scales for use in the assessment and evaluation of the physical environment. It does not standardize particular scales. It considers scales of perception, comfort, preference, acceptability, expression form and tolerance, and environmental components such as thermal, visual, air quality, acoustic and vibration.</p>	<p>4 Subjective judgement scales for physical environments: Principles of scale construction and use</p> <p>5 Perceptual, evaluation and preferential judgement scales - It is important to distinguish between more objective ratings, such as sensations, and affective or evaluative ratings, such as comfort and pleasure. In everyday language, however, these dimensions are often confounded and distinctions are not made. In addition, the richness of the semantics for describing environments and responses to them depends on individuals, their experiences, their language and their culture, when investigating physical environments. Therefore, it is sometimes useful to first investigate the psychological dimension (or constructs) which individuals and groups use to describe their world.</p> <p>The following important issues should be considered when constructing questionnaires:</p> <ul style="list-style-type: none"> — question specificity; — language; — clarity; — leading questions; — prestige; — bias; — embarrassing questions; — hypothetical questions; and — impersonal questions. <p>6 Personal acceptability statement and tolerance scales</p>

Number	Title	Summary/ Scope	Relevant Elements
EN-ISO 11064-1 (2000)	Ergonomic design of control centres - Part 1: Principles for the design of control centres	This part of ISO 11064 specifies ergonomic principles, recommendations and requirements to be applied in the design of control centres, as well as in the expansion, refurbishment and technological upgrades of control centres. Driven by demands for safer, more reliable and efficient operations, innovations in information technology have led to the increased use of automation and centralized supervisory control in the design of user-system interfaces and their associated operational environments. Notwithstanding these developments, the operator has retained a critical role in monitoring and supervising the behaviour of these complex automated systems. As the scale of automated solutions has grown, so have the consequences of equipment and human failures.	4 General considerations and principles of ergonomic design: 4.2 Principle 1: Application of a human-centred design approach 4.3 Principle 2: Integrate ergonomics in engineering practice 4.4 Principle 3: Improve design through iteration – The incorporation of information obtained from operational experiences, that is operational feedback, is of particular importance in this iterative process (see Figure 1). 4.5 Principle 4: Conduct situational analysis 4.6 Principle 5: Conduct task analysis 4.7 Principle 6: Design error-tolerant systems 4.8 Principle 7: Ensure user participation 4.9 Principle 8: Form an interdisciplinary design team 4.10 Principle 9: Document ergonomic design basis 5 Framework for an ergonomic design process - outlined in Figure 2
EN-ISO 11064-4 (2013)	Ergonomic design of control centres - Part 4: Layout and dimensions of workstations	This part of ISO 11064 establishes ergonomic requirements, recommendations and guidelines for the design of workplaces in control centres. All types of control centres are covered, including those for the process industry, transport and dispatching systems and emergency services. Although this part of ISO 11064 is primarily intended for non-mobile control centres, many of the principles are relevant to mobile centres such as those found on ships, locomotives, and aircraft. The standard covers control workstation design with particular emphasis on layout and dimensions. It is applicable primarily to seated, visual display based	4 Initial control workstation layout considerations The starting point for control workstation design (shape and dimensions) is a list of work tasks and related work characteristics. The human operator may need certain facilities, such as displays, input devices and communication equipment. 5 Factors determining control workstation design 5.1 General user considerations 5.1.1 General requirements- Designs should accommodate from the 5th to the 95th percentiles of dimensions of the intended user population. Workstations shall be designed according to human capabilities, limitations and needs. 5.1.2 User requirements - The layout and dimensioning of control workstations shall be governed by the anthropometric dimensions of the user and any requirements for

		<p>workstations, although control workstations at which operators stand are also addressed. These different types of control workstation are to be found in applications such as transportation control, process control and security installations. Most of these workstations now incorporate flat-display</p>	<p>movement to accomplish his/her tasks. (See Figs 2-4).</p> <p>5.2 Visual tasks</p> <p>The basic visual tasks are detection and identification (see Annex A).</p> <p>5.2.1 General visual considerations - eye height, visual distance, normal line of sight.</p> <p>5.2.2 General visual recommendations - identification of characters depend on legibility (its contrast, font style, colour, size, etc.); normal line of sight in seated position.</p> <p>5.3 Auditory tasks</p> <p>5.3.1 General auditory considerations – Control workstations may be equipped with a variety of sound generating devices. They may be used in alerting operators to normal (e.g. feedback, phone) and abnormal events.</p> <p>Can be mounted in a variety of locations depending on operating practices.</p> <p>5.3.2 General auditory requirements and recommendations - sound producing devices (speakers), alarm indications, background noise are addressed.</p> <p>5.4 Working postures</p> <p>5.4.1 Posture considerations - The ergonomic requirements are determined by the nature of the task and operator needs for postural change</p> <p>5.4.2 Posture requirements and recommendations - addressing viewing distance, chairs, forearm support, etc (see Table 2) screens for the presentation of information.</p> <p>6. Control workstation layout - Control workstation layout shall take account of the tasks to be carried out at the workstation.</p> <p>6.1 General layout considerations</p> <p>6.1.1 Displays - considerations: multiple displays (central position, viewing angle, number of screens).</p> <p>6.1.2 Controls - consideration of type control, i.e. data input, control, viewing.</p> <p>6.2 Layout requirements See Figure 4. for the key anthropometric and control</p>
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			<p>workstation dimensions. The greater mobility offered from a standing posture may allow for the more remote positioning of secondary displays and controls on a standing only workstation.</p> <p>6.2.1 Displays - Display characteristics, including contrast, flicker, jitter, character-font and -size, all contribute to legibility. Apart from legibility, viewing conditions like viewing distance and ambient lighting determine the operator's perception of information.</p> <p>6.2.2 Controls</p> <p>15 Principles (a to o) for locating controls on control workstations. Amongst others, the following are specified: Keyboard placement and slope; forearm support; ambidextrous devices; height of keyboards; emergency controls.</p> <p>7 Control workstation dimensions</p> <p>See Fig 2 for seated and standing control work station dimensions.</p>
EN 547-3	Safety of machinery - Human body measurements - Part 3: Anthropometric data	This European Standard specifies current requirements for human body measurements (anthropometric data) that are required by EN 547-1 and EN 547-2 for the calculation of access opening dimensions as applied to machinery.	<p>4.1 Human body measurements - See Table 1 for the human body measurements necessary to calculate the size of access openings taking account of the known range of body sizes within Europe.</p> <p>4.2 Descriptions of human body measurements - Table 2 provides notations of specific human body measurements.</p>

Number	Title	Summary/ Scope	Relevant Elements
EN 16186-1	Railway applications - Driver's cab – Part 1: Anthropometric data and visibility	<p>This part of EN 16186 applies to driver's cabs of Electrical Multiple Unit (EMU), Diesel Multiple Unit (DMU), railcars, locomotives and driving trailers.</p> <p>This part of EN 16186 applies to driver's desks installed on the left, on the right, or in a central position in the driver's cab.</p> <p>This part of EN 16186 defines:</p> <ul style="list-style-type: none"> — anthropometric data; — visibility conditions from the driver's cab, including forward visibility and the reference positions of line-side signals to be considered; — assessment methods. <p>This standard is not intended to be applicable for tramways, metros and light rail vehicles.</p>	<p>4.1 General</p> <p>This clause defines the anthropometric data on which the requirements for cab forward visibility are based (See Fig 1 & 2 for body size measurements).</p> <p>5.2 Forward visibility requirements are stipulated (i.e. The position of the eye points shall be defined by using Figure B.1 for fixed foot rest only or Figure B.2 for fixed seat only or Figure B.3 for seat and foot rest both vertically adjustable.)</p> <p>5.3 Windscreen requirements are stipulated (i.e. windscreen characteristics, cleaning devices, windscreen sun protection devices, windscreen de-icing and demisting).</p> <p>6 Lateral visibility</p> <p>For locomotives, cabs shall be provided with at least one opening side window on each side, in order to, for example, communicate with ground level staff. For vehicles other than locomotives, cabs should be provided with at least one opening side window on each side.</p> <p>7 Rear visibility</p> <p>The cab shall be designed to allow the driver to have a rear view of each side of the train at stand still. For locomotives and driving coaches intended to be used in a train composition with a locomotive, it shall be at the same time possible to operate the emergency brake.</p>

Number	Title	Summary/ Scope	Relevant Elements
EN 16186-3	Railway applications - Driver's cab – Part 3: Design of displays for heavy rail vehicles	This document specifies all necessary design rules and associated assessment criteria as well as guidance concerning the design of information and the corresponding user interfaces of driver's cabs. It considers the tasks the driver has to carry out and human factors. This document specifies how information is arranged and displayed.	Information designed according to this document is deemed to fulfil the following basic principles: - be clear, correct and necessary; - indicate its priority, whether by positioning, size, colour, sounds, sound levels, etc.; - minimize confusion of the driver; - prevent unnecessary distraction of the drivers' attention while performing their normal duties. 5 Characteristics of displays and visible or audible information - specific requirements pertaining to the following are provided: 5.2.2 Screen organization and dimensions 5.2.3 Luminance 5.2.4 Colours 5.2.5 Symbols 5.2.6 Text 5.2.7 Loudspeaker 5.3 User/display interaction 5.3.1 Buttons 5.3.2 Keyboards 5.4 Input of data 5.4.2 Entering (alpha)numeric characters 5.4.3 Input fields 5.4.4 Input for predefined data 5.4.5 Acknowledgements 5.5 Troubleshooting 5.5.1 Fault indication requesting driver warning and acknowledgement (troubleshooting process)

Number	Title	Summary/ Scope	Relevant Elements
EN 894-3	Safety of machinery – Ergonomics requirements for the design of displays and control actuators	This European Standard gives guidance on the selection, design and location of control actuators so that they are adapted to the requirements of the operators, are suitable for the control task in question and take account of the circumstances of their use. It applies to manual control actuators used in equipment for occupational and private use.	4 Selection procedure Many types of manual control actuators are available from push-buttons to hand wheels. Each type is suited to particular task requirements and to certain operator capabilities. Environmental factors (e.g. illumination, vibration) and organisational factors (e.g. team work, workstation separation) also have to be considered. The selection procedure involves three steps which are carried out in an iterative manner. These are: task evaluation and information collection; intermediate selection of control families; identification of suitable control types. 5 Task evaluation and information collection The division of tasks between the operator and the equipment should have been determined early in the design process in accordance with the recommendations in EN 614 -1 and EN 894 -1.
EN 1005-2	Safety of machinery – Human physical performance - Part 2	This European Standard applies to the manual handling of machinery, component parts of machinery and objects processed by the machine (input/output) of 3 kg or more, for carrying less than 2 m. The standard provides data for ergonomic design and risk assessment concerning lifting, lowering and carrying in relation to the assembly/erection, transport and commissioning (assembly, installation, adjustment), operation, fault finding, maintenance, setting, teaching or process changeover and decommissioning, disposal and dismantling of machinery.	The standard makes recommendations for the design of machinery with and without manual handling. Risk assessments are proposed for the design of machinery and parts.

Number	Title	Summary/ Scope	Relevant Elements
NEN 3087 (2011) (Netherlands standard for ISO 9355)	Ergonomics – Visual ergonomics: background, principles and implementation	This standard relates to the perceptibility and visibility to humans of objects and information (signals, graphic signs, screen and display information, etc.), as well as to the prevention of disturbance, unsafe conditions and discomfort resulting from their visual processing.	<ul style="list-style-type: none"> 4.4.2 Central versus peripheral vision 4.4.3 Adaptation rate 4.4.4 Contrast sensitivity 4.4.6 Colour vision 4.7 Visual factors and working posture 5.2.2 Nature of light, illumination, lighting 5.2.3 Light and light level in displays 5.5 Observing distances 5.7 Cyclic variation in exposure - flickering light source 5.8 Experience of the visual environment – Luminance ratios 6. Active acquisition of information 6.2.6 Signs