
Railway applications — Railway project planning process — Guidance on railway project planning

*Applications ferroviaires — Processus de planification de projets
ferroviaires — Recommandations pour la planification de projets
ferroviaires*

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 269, *Railway applications*.

This first edition of ISO/TR 21245 cancels and replaces ISO/TR 21245-1:2016 and ISO/TR 21245-2:2016, which have been technically revised.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

Railway is a superior transport mode in terms of safety and transport capacity and has a very low environmental impact as compared to other modes. Owing to their highly public nature, railway systems can contribute to sustainable economic development in the world with the sound consideration of environment, by means of shortening and leading to predictable travelling time, reducing traffic congestion, developing distribution network, fostering tourism industry, etc.

With these merits of railways, the market of railway has been expanding worldwide, and some countries and regions have experiences of conducting railway projects. In fact, a wide variety of railways are planned across the world, such as urban transit systems for enhancing smoothness of intra-city traffic or improving connectivity with other transportation modes, high speed railways interoperable between different countries/lines or operated on a dedicated line with simple assets, and freight railway systems to transport bulk freight by heavy-haul trains or to reduce environmental impacts like CO₂ emission.

However, it is difficult to gain outcomes as expected due to the complexity of railway systems, as shown in 4.5, especially for organizations without accumulated experiences of railway projects.

Therefore, reviewing and organizing every factor smoothly and efficiently have been challenging due to a lack of standards for appropriate railway project planning.

This document provides guidance for a successful planning process, aimed at helping those engaged in railway project by identifying key points to be considered. It also helps those experienced in railway projects by avoiding:

- possible pitfalls in the planning process such as short-sightedness;
- lack of balanced consideration;
- reworking due to overlooking important factors;
- extra time and cost.

While ISO 21500 is a generic project management standard and does not provide guidance on or discuss any specific aspects in a project field, this document assists planners or decision makers involved in the railway project planning process by incorporating specific characteristics of railway projects.

The goal of this document is to achieve desirable planning of various railway projects which provide benefits to society by underlining key points of the planning process of railway projects to all players, such as planners, consultants, suppliers, governments, clients, capital investors, etc. For players who already have experiences of railway projects, this standard provide benefits where they can strengthen technical validities, plausibility, accountability, unintentional/balanced/harmonized fairness and open/clear/logical/persuasive (transparency) of their proposal, commercial products etc. This document can also be beneficial to players without an experience of railway projects as it provides knowledge to compensate for this lack of experience and thus promote an efficient planning of railway projects. As a result of these, deliverables based on this document will also give indirect benefits to other stakeholders including end users (passengers, consignors).

Railway applications — Railway project planning process — Guidance on railway project planning

1 Scope

This document provides guidance on railway project planning for decision making.

This document explores the key points of railway project planning, based upon the principles of ISO 21500, by incorporating characteristics specific to railway projects.

This document covers:

- the characteristics of railway projects;
- stakeholders and their needs/interests;
- conditions;
- the definition of each process in a railway project;
- key points of planning process;
- correlation and causality among principal factors to be considered.

This document can be used by any type of organization, including public, private or community organizations, and be applied to any type of railway project, irrespective of its complexity, size, duration, etc.

However, this document provides neither detailed requirements nor specific processes for:

- certification;
- deriving a unique solution (specification for particular systems/products);
- decision making itself.

Topics pertaining to general projects are addressed only within the context of railway projects.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 21500:2012, *Guidance on project management*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 21500 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <https://www.electropedia.org/>

3.1

administrative authority

person or organization that supervises, plans, funds or approves *railway projects* (3.18) in the planning process

3.2

condition

premise or constraint that *stakeholders* (3.22) involved in the project can find difficult to adjust or change

3.3

consignor

shipper, sender, party which, by contract with a carrier, consigns or sends goods with the carrier, or has them conveyed by the carrier

[SOURCE: ISO 26683-1:2013, 3.11, modified — “him has been replaced by “the carrier”.]

3.4

construction

erection of railway related facilities, rolling stock not included

3.5

construction contractor

person or organization that undertakes works as part of a *construction* (3.4) project by virtue of a contract with a client, such as the owner of infrastructure

3.6

decision making

adoption and authorization of a project plan

3.7

feasibility study

study to identify and analyse a problem and its potential solutions in order to determine their viability, costs, and benefits

[SOURCE: ISO/IEC 2382:2015, 2122680, modified — notes to entry have been removed.]

3.8

hazard

potential source of harm

[SOURCE: ISO/IEC Guide 51:2014, 3.2]

3.9

infrastructure manager

person or organization that is responsible in particular for establishing, managing and maintaining railway infrastructure

3.10

infrastructure operator

person or organization that operates infrastructure required for the functioning of the railway services

3.11

inputs

deliverables of planning work as candidates for *decision making* (3.6)

3.12

life cycle

consecutive and interlinked stages of a product system, from raw material acquisition or generation from natural resources to final disposal

[SOURCE: ISO 14025:2006, 3.20]

3.13**manager of rolling stock**

keeper of rolling stock

person or organization that is responsible in particular for managing and maintaining rolling stock

3.14**manufacturing**

production of railway vehicles and railway related products

3.15**need**

prerequisite identified as necessary to achieve an intended outcome, implied or stated

3.16**passenger**

person on board a train not belonging to the crew

[SOURCE: ISO 20283-5:2016, 3.1.2, modified — "ship" has been replaced by "train".]

3.17**pre-feasibility study**study that is to be conducted before a *feasibility study* (3.7) to identify the suitable scenario(s) from multiple alternatives**3.18****railway project**unique set of processes consisting of coordinated activities with start and end dates, performed to create or change a unique railway product, system, operation or *service* (3.21)

[SOURCE: ISO 21500:2012, 3.2, modified — clarified for railways.]

3.19**railway undertaking**

person or organization that is authorized to transport passengers or goods by railway and runs train or that only runs train

3.20**safety**

freedom from unacceptable risk of harm

[SOURCE: IEC 62278:2002, 3.35]

3.21**service**result of activities between a *supplier* (3.23) and a customer, and the internal activities carried out by the supplier to meet the requirements of the customer

[SOURCE: ISO/IEC Guide 14:2003, 2.2, modified — "client" was replaced by "customer".]

3.22**stakeholder**

individual or organization having a right, share, claim or interest in a system or in its possession of characteristics that meet their needs and expectations

[SOURCE: ISO/IEC 27032:2012, 4.45]

3.23**supplier**party that produces, provides, or furnishes an item or *service* (3.21)

[SOURCE: ISO 28219:2017, 3.11]

4 Specificities of railway projects

4.1 General

Railway projects should be considered with particular care due to their inherent specificities ([Figure 1](#)).

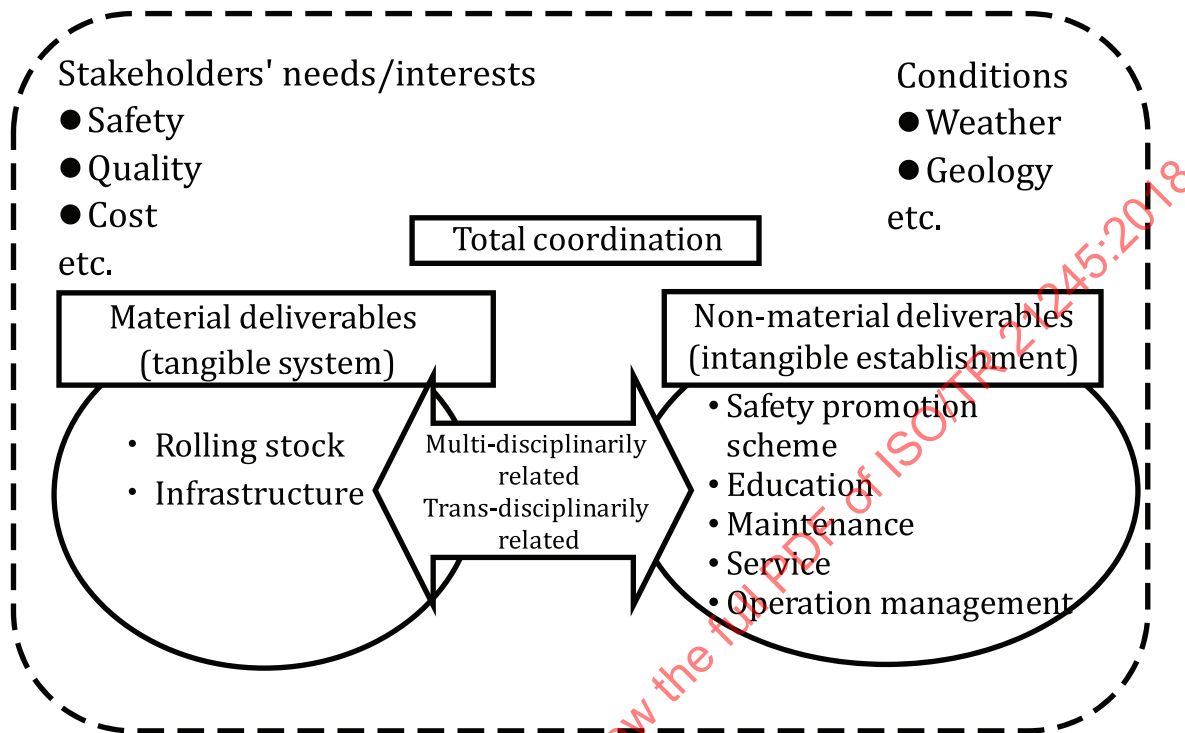


Figure 1 — Aspects of railway project

Among them, the following should be underlined: high capital investment, a large number of stakeholders involved with many interfaces, long life cycle, high system integration and complexity.

Due to the above mentioned specificities of the railway project and the factors (stakeholders' needs/interests and conditions), different solutions can be necessary to optimize the project outcome.

For the same reason, last minute change or inadequate balancing of factors can negatively impact the project schedule, cost or result (failure risk or maintainability requirements can increase).

4.2 Capital aspect of railway projects

Like many other important infrastructure projects, railway projects rely on high capital investment but also on long term capital immobilization. Very often, funding is entirely or significantly composed of public subsidies.

This specificity has to be considered when planning a project as it can have an impact on:

- project schedule and deadlines (potentially impacted by election, reduction of available public money, etc.);
- technical decisions (e.g. considering life cycle cost instead of investment cost);
- design choice (e.g. choosing a solution to be upgraded later).

Project funding aspects are not standard and depend on local context. Therefore, they should be considered on a case by case basis.

4.3 Stakeholders of railway projects

A railway system involves many stakeholders inside and outside of the project as an organic combination. It can impact its users, people living along the wayside or other transit systems in the area. Project stakeholders that should be considered in the planning process are presented in [Figure 2](#).

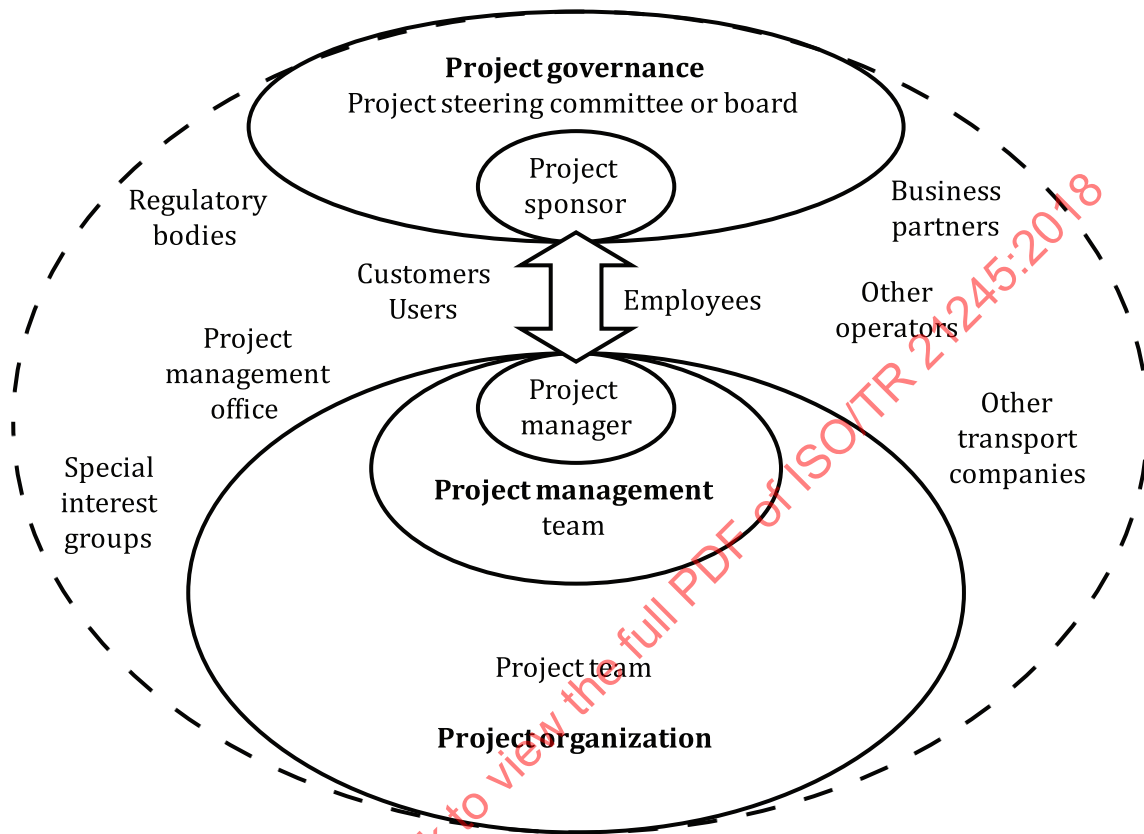


Figure 2 — Stakeholders of railway projects

Various stakeholders are involved throughout life of railway.

Each stakeholder has different goals and expectations. Identification of stakeholders and their needs is a key activity when initiating a railway project. Therefore, the factors listed in [Clause 8](#) should be considered in planning railway projects with the aim to define an optimally balanced solution as it can have an impact on:

- technical decisions (e.g. choosing a transportation system, number of seats);
- operation (e.g. maximum operational speed);
- cost and revenue (e.g. amount of fare paid, life cycle cost);
- public acceptance (e.g. impact on wayside, sustainability).

Project funding aspects can differ depending on local context. Therefore, they should be considered on a case by case basis.

4.4 Long life cycle of railway projects

A railway system is built and operated for a long time. Both the railway project itself and the subsequent operational phase last long. Therefore, a long-term perspective is always necessary when carrying out a railway project.

This specificity has an impact on:

- life cycle costs as well as initial costs from multilateral points of view;
- future traffic and therefore capacity;
- territorial organization/development;
- technical aspects (e.g. obsolescence management, integration of innovative solution).

Therefore, it is important to consider factors (stakeholder's needs/interests and conditions) on a reasonable timescale to avoid/limit/facilitate future adaptation.

4.5 High technical integration and complexity of railway systems

4.5.1 General

The railway system is to be understood as a complex aggregation of each part, component or subsystem, including their interfaces, which is necessary for a safe and sustainable (environment protecting) operation of trains on a dedicated network. In this document, a brief description of the subsystems is given.

This description and the related requirements formulated in consideration of the factors to be taken into account are intended to serve only as an example of appropriate planning since the classification of subsystems differs across countries and organizations.

In principle, railway subsystems can be classified as technical (for tangible assets) and functional (for intangible assets).

4.5.2 Technical subsystems

4.5.2.1 Wayside facilities

Wayside facilities are understood to consist of the infrastructure, the energy power supply system for the train and the signalling system.

Infrastructure is understood as consisting of the track, engineering structures (bridges, tunnels, etc.), associated station infrastructure (platforms, zones of access, including the needs of persons with reduced mobility, etc.), safety and protective equipment. In order to ensure the safety of the railway system, it is essential to prevent hazards (e.g. from instability, fire, undesirable intrusions into installations, trains passing through stations).

Energy power supply is understood as consisting of the electrification system including overhead lines and on-board parts of the electric consumptions measuring equipment (if installed). The safe operation of the energy supply system is to be ensured (e.g. by avoiding interference between energy supply subsystem and the environment beyond specified limits).

Signalling equipment is understood as consisting of all the equipment necessary to command and control movements of trains authorized to travel on the network. The control, command and signalling system is to ensure a safe operation (e.g. even under specified degraded conditions).

4.5.2.2 Rolling stock

Rolling stock is understood as consisting mainly of the car body, on-board command and control system, current-collection devices, traction and energy conversion units, braking system, coupling system, running gear (bogies, axles, etc.) and suspension, doors, man/machine interfaces (driver, on-board staff and passengers).

Additional considerations may be necessary when they are assembled into a rolling stock.

4.5.3 Non-material deliverables

4.5.3.1 General

Non-material deliverables of a railway system include:

- traffic operation and management;
- maintenance;
- staff education.

They generally comprise scheme, rules, programs, procedures, education/training, etc.

4.5.3.2 Traffic operation and management

Traffic operation and management is to be understood as the procedures and related equipment enabling a coherent operation of the different structural subsystems, during both normal and degraded operation, including in particular training and train driving, traffic planning and management. Recommendations which are specific to traffic operation and management are as follows:

- alignment of the network operating rules and the qualifications of drivers and on-board staff and of the staff in the control centres should be such as to ensure safe operation, bearing in mind the different requirements of cross-border and domestic services (if relevant);
- the maintenance operations and intervals, the training and qualifications of the maintenance and control centre staff and the quality assurance system set up by the operators concerned in the control and maintenance centres should be such as to ensure a high level of safety.

4.5.3.3 Maintenance

Maintenance is to be understood as the procedures, associated equipment, logistics centres for maintenance work and reserves, allowing the mandatory corrective and preventive maintenance to ensure the required performance of the railway system. Recommendations which are specific to maintenance are as follows:

- the technical installations and the procedures used in the centres should ensure the safe operation of the subsystem and should not constitute a danger to health and safety;
- the technical installations and the procedures used in the maintenance centres should not exceed the permissible levels of nuisance with regard to the surrounding environment.

4.5.3.4 Staff education

A railway system involves ground personnel and crew members. Accordingly, to ensure that railway systems work safely and as planned, all personnel directly or indirectly involved in system operation and maintenance should be educated and trained. Such education and training should provide knowledge and skills to a level corresponding to that required for the job which the personnel is assigned to.

5 Overview of each process within a railway project

Like any other project, a railway project consists of controlled activities with start and end dates. For example, a new line project should start from a concept planning, then move to pre-FS (feasibility study), initiating FS, planning process, implementing process of detail designs, constructions, manufacturing, control process and closing process to output deliverables or final reports ([Figures 3](#) and [4](#)).

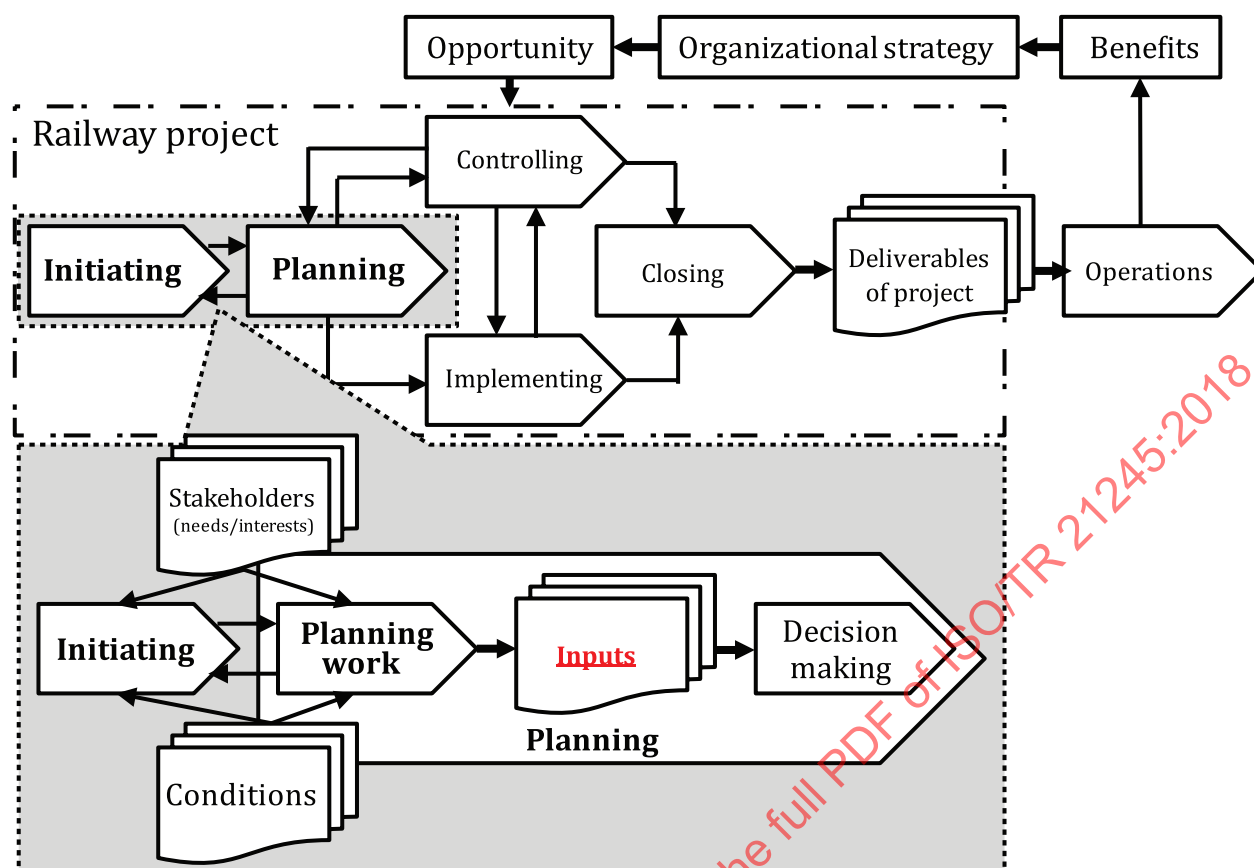


Figure 3 — Overview of a railway project

Each railway project is initiated, planned, executed and completed in accordance with the organizational strategy, depending on diverse opportunities, under organizational/project environment. And it pursues a continuous operation in order to obtain expected benefits utilizing the deliverables of project (Figure 4).

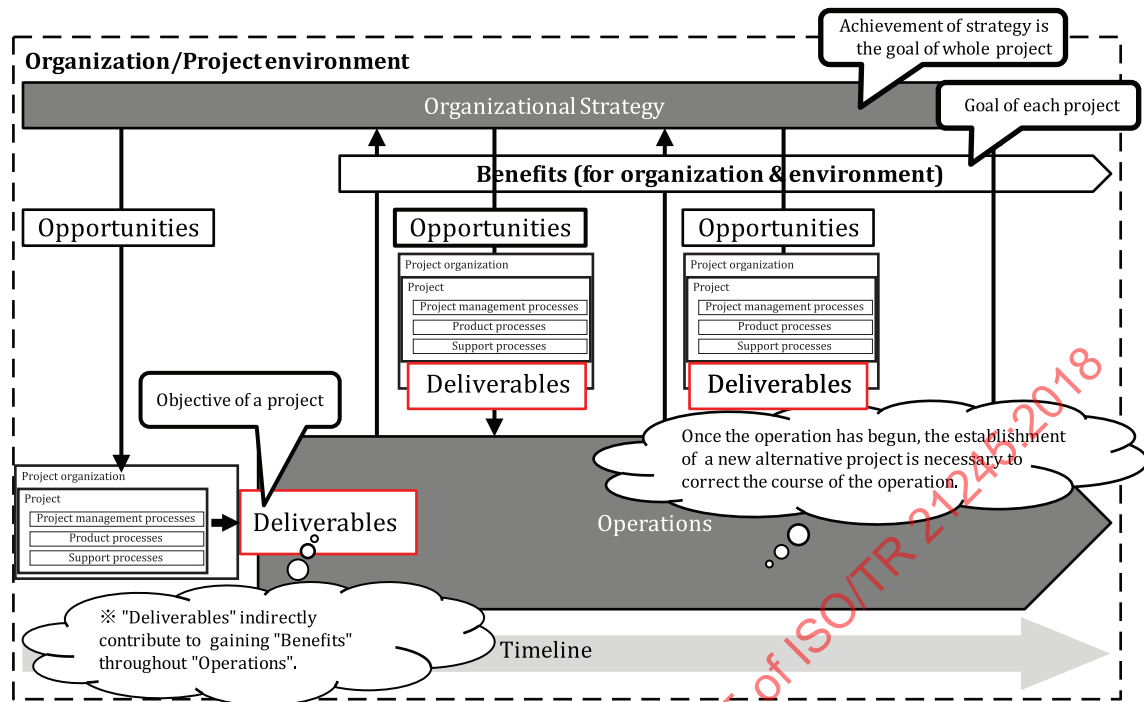


Figure 4 — Overview of railway projects and operations concept and their relationships

6 Guidance for initiating process and planning process

Initiating process and planning process are important for, and have impact on, the performance of railway projects. Once a railway project moves to the implementation process, it becomes harder to modify the plan. The more advanced the project is, the more difficult it is to implement modifications. Such planning failure can bring negative impact for the operation phase because the railway system has specific characteristics such as being composed by many various subsystems, each being extensive, and the operation phase is significantly long.

Failure of planning can occur if critical factors are overlooked and if correlation and causality among factors are overlooked.

It is essential to take into account the important general needs/interests, to specify what the client wants, to understand that there are correlation and causality among all factors and to recognize that there are various ways to solve the problems. The scope of this document is from listing initial basic factors in the initiating process ([Clause 7](#)) to arranging planned basic factors for deriving inputs in the planning work ([Figure 5](#)). Inputs information delivered by a rational planning process such as a project concept/project scope/basic plan, technical alternatives, performance/functional requirements facilitates proper decision making. The basic factors are listed in [Clause 8](#) and [Clause 9](#).

The planning work consists of consideration of correlation and causality of factors ([Clause 10](#)), prioritization and weighting factors ([Clause 11](#)) and seeking solution for coordinating/balancing factors ([Clause 12](#)). Listing factors, considering correlation and causality, prioritizing and weighting, and seeking solution can be carried out in a flexible manner, i.e. not necessarily in a sequential order but for example proceeding back and forth many times or thinking things together or separately.

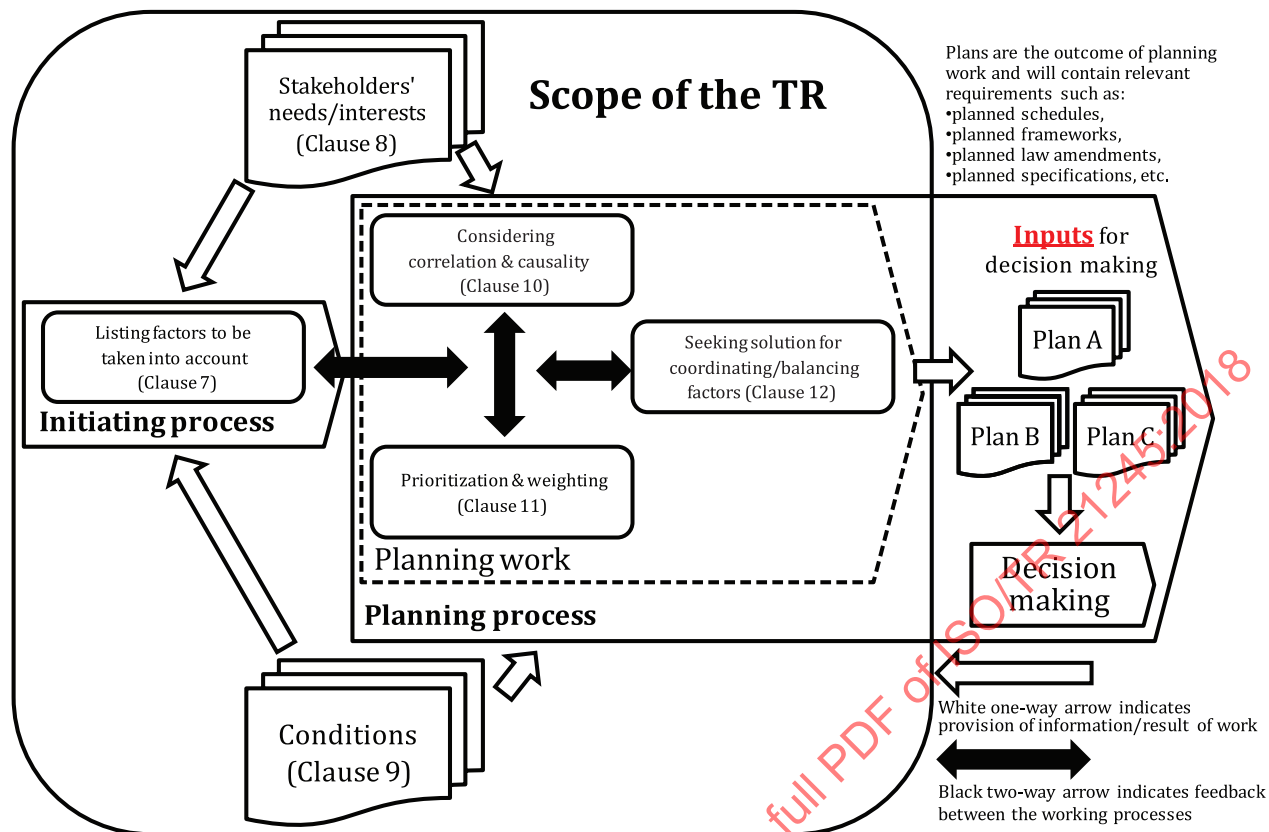


Figure 5 — Overview of initiating process and planning process

7 Listing factors to be taken into account

For initiating process of a railway project, it is important to identify and optimize the needs/interests of all stakeholders who are developing, operating railway (such as railway operator stakeholders directly involved in the railway projects), or who are affected by the railway projects (such as passengers or people living around the railway involved in the project indirectly).

The first thing to do in initiating process is to think about what factors to take into account.

Factors are categorized as basic factors and specific factors. The basic factors consist of the purposes of project themselves and of universal factors. Specific factors include unique project-by-project viewpoints, which are not listed in [Clause 8](#) and [Clause 9](#). An example of specific factors is given in [Annex C](#).

8 Railway project stakeholders needs and interests

8.1 General

Identification of stakeholders and their respective responsibility in the project is a key element to succeed in listing all needs/interests.

The following list of stakeholders and the related needs/interests cannot be treated as exhaustive. Further effort is necessary to adopt the list according to each project context.

Stakeholder's needs/interests in railway projects should also carefully be collected, analyzed and taken into account in the planning process of the project. This clause specifies typical needs/interests classified by stakeholder category.

Among these needs/interests, safety cannot be ignored. Therefore, safety analyses are carried out to minimize the risk of harm. These can be complemented by, for instance, safety evaluations by railway authorities or others (e.g. Reference [16], local regulations/rules).

Collection of stakeholder's needs/interests, which enables efficient adjustment and implementation of countermeasures against risks from earlier processes of the project, may be achieved by setting up a council of experts, public hearings, carrying out assessments, or any appropriate communication.

8.2 Administrative authorities

Administrative authorities have a legislative responsibility/right to influence the railway project through their actions such as issuing orders or permissions, providing guidance, and making recommendations.

The classification of administrative authorities depends on each region and country. Typically, in Europe, they may be classified into the following two types:

- the authorities in charge of checking compliance (safety, security, health, environment, etc.), who give opinions or authorizations, with no or very limited financial interest in the project;
- the authority (or authorities) in charge of providing funds, loans, voting taxes, etc. and who can be interested in project fallout (growth, tax incomes, etc.).

Typically, administrative authorities' needs/interests include:

- safety compliance (e.g. safety related applicable laws, legal requirements and regulations), which is a potential restriction for the project;
- security compliance, which is a potential restriction for the project;
- health protection, which is a potential restriction for the project;
- development and economic growth at different scales (national/regional/local), which can result from the required transport;
- availability of financial resources (e.g. funds, subsidies, tax reductions, loans), which potentially affects the planning of the project;
- protection of environment, including assessment of environmental impact, which is any change to the environment, whether adverse or beneficial, wholly or partially resulting from an organization's environmental aspects;
- connectivity with other transport modes.

8.3 Passengers

Passengers' needs/interests can vary largely depending on purpose of travel, distance of travel, age, physical characteristics, budget, etc.

Typically, passengers' needs/interests include:

- safety as one of the most important needs/interests;
- security (e.g. avoid crimes and mitigate their consequences);
- health protection (e.g. vibration, noise, pollution or exposure to other harmful emissions);
- comfort (e.g. cleanliness, thermal conditions, ergonomics, smell, noise, brightness, available services and amenities);
- accessibility (e.g. adapted information, obstacle free route, connectivity);

- service performance (reliability, availability, punctuality, frequency, cancellation, staff presence, information accuracy and timeliness, etc.);
- affordability of fare or the state in which fare is reasonably set;
- total time to destination (including timetable/headway and time spent waiting for a train or to change from one line to another at a station);
- vehicle design (e.g. exterior and interior designs, preference based on cultural or religious background);
- supplemental in-station/on-board services, which correspond to usage of railway (e.g. in-station shopping, information, luggage storage, restrooms, baby changers).

8.4 Consignors

Consignors are generally interested in cheap and resilient transport capacities, which can correspond to the goods they intend to load/consign/fill.

Typically, consignors' needs/interests include:

- system capacity (e.g. maximum payload; maximum size; maximum weight; custom requirement) and features (e.g. special equipment such as ventilation, refrigeration, heating) including safety; when transporting dangerous goods;
- safety to avoid damage to goods upon loading, transportation and unloading;
- transport service performance (reliability, availability, punctuality, frequency, cancellation, information accuracy and timeliness and delivery accuracy for destination, etc.);
- logistics service performance (information availability and accuracy, connectivity, ease of dispatching and receiving goods, ease of clearing customs);
- affordability of fare or coordination among operators including other transport modes;
- total time to destination;
- added values (IT, loading service, etc.).

8.5 Owners of rolling stock

The owner of a rolling stock is not necessarily a railway company. Investors (e.g. banks) can also have this role.

Typical owners of rolling stock usually focus on the return on investment (profit), which is gained by a good balance of payments or funding (for example by a government).

8.6 Owners of infrastructure

Owners of infrastructure, being state owned or privately owned (private networks, railways located on industrial production sites, etc.), usually focus on the return on investment (profit/service achieved).

8.7 Managers (keepers) of rolling stock

Regardless of whether they also own rolling stock or operate the railway for their own purposes, the managers (keepers) of rolling stock have the responsibility of managing assets (including leasing) and planning maintenance activity (retrieving vehicles from services) as well as its execution.

NOTE 1 Maintenance can be carried out in-house or outsourced. It is carried out either on a preventive basis (preventive maintenance) or upon occurrence of failure (corrective maintenance), upon consideration of reliability and criticality of a system or product. Inspection and monitoring can be necessary for maintenance.

The needs/interests of managers (keepers) of rolling stock generally include:

- safety, reliability, availability and maintainability, which covers aspects of product/system and maintenance processes;
- profit improvement, which is affected by life-cycle cost and revenue;
- life-cycle cost, which is the cost of an asset or its parts throughout its life cycle (operation of railway project deliverables), while fulfilling its performance requirements;

NOTE 2 Life-cycle cost consists of initial costs (e.g. cost of rolling stock, cost of public relations, tender preparation costs), running costs (e.g. cost of maintenance, which is necessary to maintain the required performance of facilities, taxes and other public charges) and decommissioning costs. It is important to allocate resources properly in order to reduce total life-cycle cost.

Typical factors affecting life-cycle cost include:

- revenue (e.g. charges/rents paid by users of the rolling stock);
- project funding (including subsidy);
- quality, including product quality (see ISO 9001), such as the degree of workmanship and the degree to which a set of inherent characteristics fulfils requirements (except reliability, availability and maintainability);
- compliance with existing applicable laws and regulations;
- time to place in service (delay);
- network connectivity between and within railways, such as railway ferries, piggybacks and park-and-rides;
- vehicle/network compatibility in order to expand the area of use of the rolling stock.

In maintenance, the following factors can be taken into account:

- capacity of maintenance facilities;
- technical capability (training) of workers for maintenance;
- supply of replacement.

8.8 Infrastructure managers

Infrastructure manager roles include managing infrastructures so as to develop the traffic on the network, optimize maintenance costs, etc.

NOTE 1 Maintenance can be carried out in-house or outsourced. It is carried out either on a preventive basis (preventive maintenance) or upon occurrence of failure (corrective maintenance), in consideration of reliability and criticality of a system or product. Inspection and monitoring can be necessary for maintenance.

The needs/interests of infrastructure managers generally include:

- safety, reliability, availability and maintainability, which covers aspects of product/system and maintenance processes;
- profit improvement, which is affected by life-cycle cost and revenue;
- life-cycle cost, which is the cost of an asset or its parts throughout its life cycle (operation of railway project deliverables), while fulfilling its performance requirements.

NOTE 2 Life-cycle cost consists of initial cost (e.g. cost of construction, purchasing relevant products/systems, cost for public relations, preparation cost), running cost (e.g. cost of maintenance, which is necessary for maintaining the required performance of the facilities) and decommissioning cost. It is important to allocate resources properly in order to reduce total life-cycle cost.

Typical factors affecting life-cycle cost include:

- taxes and other public charges incurred;
- revenue (e.g. charges/rents paid by the users of the infrastructure);
- project funding (including subsidy);
- quality, including product quality (see ISO 9001), such as the degree of workmanship, and the degree to which a set of inherent characteristics fulfils requirements (except reliability, availability and maintainability);
- compliance with existing applicable regulations;
- time to place in service (delay);
- railway network connectivity between and within railways, such as railway ferries, piggybacks and park-and-rides;
- vehicle/network compatibility.

In maintenance, the following factors can be taken into account:

- capacity of maintenance facilities;
- technical capability (training) of workers for maintenance;
- supply of replacement.

8.9 Railway undertakings

Railway undertakings' main responsibility is to transport passengers or goods from an origin to a destination in safe conditions.

The needs/interests of railway undertakings generally include:

- operational safety, which comprises not only passengers' safety but also related employees' safety and safety related to third parties;
- security, which prevents acts of vandalism against railway operation;
- operation/operation cost (e.g. energy cost, labour cost, lease fee, track access charge);
- budget for investment (e.g. for upgrading or retrofitting);
- revenue (e.g. subsidies; fare, which collection is to be carried out securely by preventing steal ride);
- vehicle/network compatibility, including energy (e.g. type, quality and stable supply of energy);
- reliability of rolling stock and infrastructure;
- availability of rolling stock and infrastructure;
- transport system capacity offer and demand to deliver appropriate operation service.

NOTE Transport system capacity consists of train capacity and frequency. Evaluation of transport demands is the basis for railway undertakings to ensure that transport system capacity fits the transport demand.

Continuous evaluation of transport demand is necessary in order to adapt capacities, such as size and numbers of trains operated and tonnage.

8.10 Infrastructure operators

Infrastructure operators' main responsibility is to plan the allocation of network capacities, traffic management (including in degraded conditions) and timetabling to ensure daily smooth operation.

The needs/interests of infrastructure operators generally include:

- operational safety, which comprises not only passengers' safety but also related employees' safety and safety related to third parties;
- security, which is to prevent acts of vandalism against railway operation;
- reliability of rolling stock and infrastructure;
- availability of rolling stock and infrastructure;
- transport system capacity to deliver appropriate operation service.

NOTE Transport capacity consists of train capacity and frequency. Evaluation of transport demands is the basis for infrastructure operators to ensure that transport system capacity fits the transport demand.

Continuous evaluation of transport demand is necessary in order to adapt capacities, such as size and numbers of trains operated and tonnage.

8.11 Construction contractors/suppliers

Construction contractors and suppliers usually focus on planning activities as for project or contract management but also on investment and development of appropriate resources including manpower.

Different contracts can be distinguished as follows:

- construction contract (e.g. civil engineering and architectural contract);
- manufacturing contract (e.g. design, engineering, manufacturing, managing to deliver rolling stock and components).

The needs/interests of construction contractors/suppliers generally include:

- quality;
- cost;
- contract conditions (e.g. schedule/price/specification);
- market demand;
- tender procedure;
- selection and qualification of subcontractors;
- compliance;
- vehicle/network compatibility.

8.12 Persons/organizations engaged in related transport modes

Related transport modes designate modes connected to or competing with the objective railway line, such as other railway lines, buses, taxis, private cars, motorcycles, bicycles, trucks, ships, etc.

They sometimes need to plan activities related to the development of a railway project to either adjust their transport services to compete with the railway corresponding to the project or to connect to the project and benefit from improved intermodality.

The needs/interests of persons/organizations engaged in related transport modes generally include:

- changes in transport demand induced by the project;
- compatibility/interface management.

8.13 Others

Other impacted people or business include:

- stakeholders with economic interests;
- landowners;
- developers who engage in development according to urban planning;
- any business that already exists along the railway corresponding to the project;
- managers of infrastructure or facilities that will be affected by the project (roads, rivers, electric lines, gas/water pipes, etc.);
- stakeholders with social interests;
- wayside residents;
- road users.

They can be interested in project planning in order to influence the project.

Their related needs/interests generally include:

- safety and security (e.g. crossings, crime prevention, privacy protection);
- quality of life, which can be improved by preventing adverse impact of railways [e.g. noise, vibration, pollution (air, water, land), electromagnetic fields, smell, landscape degradation, shadowing effects];
- eventuality of forced removal due to interference/proximity of planned route/site with/to existing property/right.

9 Conditions

9.1 General

While stakeholders' needs and interests are often subjective, either organizational or personal, conditions are usually indigenous and difficult to alter/change. The following list of conditions cannot be treated as exhaustive. Further effort is necessary to enrich the list.

9.2 Natural conditions

9.2.1 Geology/topography

Geology/topography to be taken into account while planning the project includes, but is not limited to, the following:

- gradient;
- elevation;

- vertical difference;
- proximity to sea;
- proximity to volcano;
- seismic risk;
- width of river, lake, strait, canyon, hole, crater;
- depth of river, lake, strait, canyon, hole, crater;
- proximity to river, lake or pond;
- pedological difference;
- nature of soil;
- soil stability;
- soil fraction.

For example information of specific conditions, see IEC 62498 series.

9.2.2 Weather and climate

Weather and climate to be taken into account while planning the project include, but are not limited to, the following:

- temperature;
- humidity;
- precipitation;
- snow/ice/blizzard;
- fog;
- wind;
- sand (or dust) storm;
- typhoons, hurricanes and other natural disasters.

9.2.3 Other natural conditions

Other natural conditions to be taken into account while planning the project include, but are not limited to, the following:

- presence of vermin (animals and insects);
- presence of trees near the tracks;
- protected natural area/national park;
- protected species (animals and plants).

9.3 Economic and social conditions affecting railway projects

9.3.1 General

Economic and social conditions to be taken into account while planning the project are presented in the following subclauses.

9.3.2 Urbanism and population

The following factors of urbanism and population can affect traffic demand and project cost, as they can be critical in terms of easiness of land acquisition, necessity of underground railway and necessity of noise/vibration and air pollution countermeasures:

- construction density;
- protected monument;
- population distribution;
- population ratio (age, occupation, smokers, disabled people, etc.);
- population prospects.

Generally, there are two cases in which a railway construction and a town development are associated: either the railway starts operation ahead of the town development, or the town development takes the lead or proceeds in parallel with the railway construction.

9.3.3 Industrial environment

Industrial environment to be taken into account while planning the project includes the following:

- proximity to classified industrial area;
- proximity to power plants;
- proximity to wasteland;
- effect of industrial pollution on soil, air and water.

9.3.4 Other obstacles

Other obstacles to be taken into account while planning the project include the following:

- archaeological finds;
- culture;
- religion;
- law (custom, localisation, rate of local production in equipment).

9.3.5 Civil works, networks and systems

Civil works, networks and systems to be taken into account while planning the project include the following:

- energy grids and networks;
- communication networks;
- water pipes;

- road;
- other existing railway;
- airport;
- seaport;
- other networks (gas, sanitation, etc.).

9.4 Existing railway system facilities

Existing railway system facilities to be taken into account while planning the project include the following:

- train depot;
- gauge;
- envelope;
- platform length/width;
- train-set length;
- tunnels;
- viaducts;
- bridges.

10 Consideration of correlation and causality of factors

In the planning process of a railway project, correlation and causality among factors should be carefully considered. Refer to [Annex A](#), in which the concept of “causality”, meaning a cause-result relationship, and that of “correlation”, meaning the interdependency of two factors, are shown with illustrations. A railway system involves various stakeholders having different needs/interests, which makes it necessary to prioritize and weight such factors appropriately by considering each of them. In doing so, the existence of correlation and causality relationships among some of these factors should be recognized and considered. While it might be difficult for those without enough knowledge and experience to accurately estimate the extent to which a certain factor influences other factors, it is still useful and important to understand the relations among the factors that are in many cases complicatedly intertwined.

Causality is a cause-result relationship between factors. It exists when one factor influences another factor.

Correlation is the interdependence between two factors, i.e. the direction (positive or negative) and the extent to which one factor influences or is influenced by the other. There are three types of correlation:

- positive correlation is a relationship between two factors in which both factors move in tandem. When one factor decreases, the other factor also decreases and vice versa;
- in negative correlation, one factor increases as the other decreases and vice versa;
- independent correlation means there is no correlation between two factors.

In statistics, a perfect positive correlation between two variables is represented by the value +1 of correlation coefficient between two variables, while 0 indicates no correlation and -1 indicates a perfect negative correlation.

11 Prioritization and weighting

In the planning process of a railway project, relevant factors should be prioritized and weighted with careful consideration.

It is unrealistic to presume that all needs/interests can be satisfied. For example, budget and comfort, project deadline and availability of resources can conflict with each other. Coordination and balancing of factors are important in such cases.

Therefore, prioritizing and weighting of requirements and conditions are to be clearly explained to developers, designers, consultants, suppliers and sponsors, etc., for a better understanding of the desired results.

Experts or organizations who have enough knowledge and experiences in railway projects are able to prioritize and weight with a consideration of correlation and causality on factors described in the following clause. However, prioritizing and weighting can be carried out without consideration of correlation and causality since they can be processed individually. Even consultants or suppliers may not be aware of all conditions.

Even when only specific factors are clarified, basic factors should also be applied to coordination and evaluation in the weighting process for deriving desirable plans or requirements.

An example of an application of this document is to prioritize factors of the railway project as shown in [Table 1](#). Appropriate deliverables of the railway project may be clarified by covering, checking up and prioritizing exhaustive factors. Each factor can have a synergistic, consistent, compatible or a trade-off (incompatible) relationship with other factors. Especially for the factors having a trade-off relationship, coordination and compromise are necessary to avoid making and approving plans for projects with unachievable goals. [Table 2](#) gives an example of a condition list.

Table 1 — Example of a list of stakeholders' needs/interests and classification of priorities

Stakeholders	Needs/interests	Classification of priority	Relationship
Managers of infrastructure	Safety	A+	
	Profit	A+	
	Life-cycle cost	Initial cost	} conflict
		Running cost	
		Decommissioning cost	
		Related tax	
	Project funding	A+	
	Charge/rents	A+	
	Quality	A–	
	Compliance	A–	
	Time to place in service	A–	
	Network connections with and within railways	A–	
	Vehicle/network compatibility	A–	
	Reliability, availability and maintainability	A+	

Table 1 (continued)

Stakeholders	Needs/interests	Classification of priority	Relationship
Railway undertakings	Operational safety	A+	
	Cost of railway operation/operational cost	A+	
	Budget for investment	A–	
	Fare/subsidy	A–	
	Energy	A–	
	Transport capacity	A–	
	Fare collection	B	
	Security	A–	
	Transport capacity offer		
	Reliability of rolling stock and infrastructure		
	Availability of rolling stock and infrastructure		
Construction/manufacturing contractors	Quality	A–	
	Cost		
	Contract schedule/delay		
	Contract price		

Table 2 — Example of list of conditions

Conditions	Objects	Detail/relevant information
Park	Hakone National Park	Environmental Law
River	Sakai River	Depth: 10 m Width: 50 m

12 Seeking solutions

In the planning process of a railway project, it is essential for a planner to seek a solution for coordinating/balancing factors. Since a railway system is an aggregation of subsystems, changes in a tiny factor of a subsystem will potentially affect the whole system. Therefore, planning railway projects with the understanding of correlation, causality, prioritization and weighting among factors is a good practice to optimize the project outcome. This process is important and the project planner should coordinate each factor properly by discussing with consultants and supplier, or making adjustment to needs among various stakeholders, which depends on each project and project manager's intention.

Some examples are given in [Annex A](#). It is important to recognize that the priority or weight given to the factors considered can eventually affect solutions, sometimes greatly. There are various ways to coordinate different factors and to implement the coordination. Persons or organizations with much knowledge and experience can have special solutions. It can be preferable to illustrate effects for factors. If planners know a common method, discussion with them can be smoother and clearer, and the deliverables can be closer to expectations.

There are some common methods for making adjustments among various factors as shown below:

- changing prioritization or weight of factors: amending specific factors based on the result of reviewing changes of need or interest on basic factors without insisting on initial specific factors;
- compromise: if two basic factors have a relationship of negative impact, it is essential to balance the whole system by decreasing prioritization or weight to some extent of either factor or both factors;

- consensus: when planners coordinate the needs of various stakeholders directly, it can be difficult to accept both needs. In such cases, planners can choose consensus by showing the profitable structure of the whole system instead of seeking complete agreement among stakeholders;
- request (proposal) of innovative resolution: it is possible to resolve the relationship with negative impact by calling innovative solutions from a planner to consultants or suppliers, or by proposing innovative products or systems from consultants or suppliers to planner. It is desirable to do a final check at the level of basic factors because this method can cause positive or negative synergy with other factors;
- others: consultants and suppliers with a great deal of experiences of being in charge of many projects sometimes have unique solutions as well as common solutions. Therefore, counselling sessions can be effective in order to make better plans and reduce time and cost when a planner is stuck with some problems. It is desirable for planners and project managers to do a final check at the level of basic factors.

13 Case study

[Annex B](#) is a case study showing how this document can be used as guidance for railway project planning.

As described above, the essential aspects in the planning process of a railway project are:

- 1) think about what factors are to be taken into account;
- 2) consider correlation and causality among factors;
- 3) consider priority and weight of factors;
- 4) seek a solution for coordinating/balancing factors.

In [Annex B](#), some simplified examples of applying the above key points to project planning are illustrated to help understand how this document works.

Annex A (informative)

Example of correlation and causality of factors

A.1 Improvement of HVAC performance

An example of HVAC for railway vehicle is shown in [Figure A.1](#). This case premises that the purpose of this project is the improvement of cabin comfort. Improvement of HVAC performance is considered as the first approach for this purpose. This improvement can surely bring cabin comfort in terms of temperature. Improvement of HVAC performance is the cause, and cabin temperature is the result in this causality.

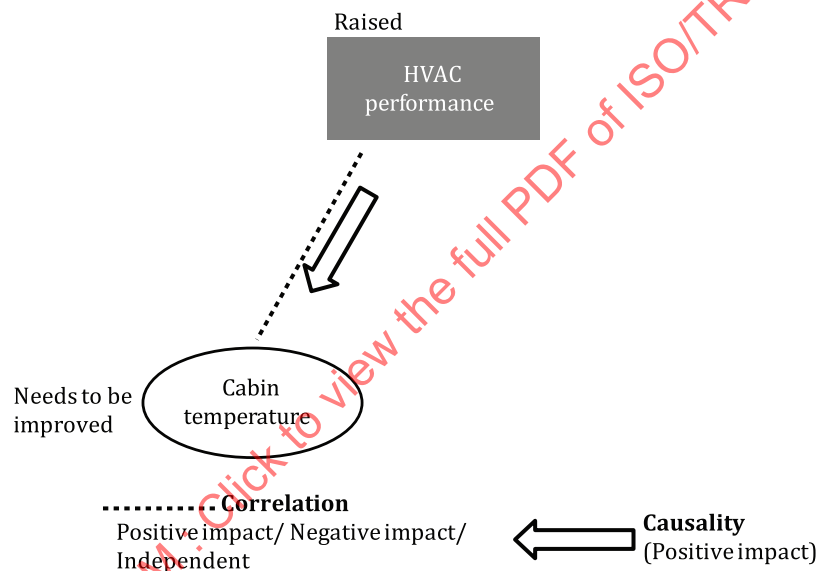


Figure A.1 — Example of improvement of cabin comfort by improvement of HVAC performance

On the other hand, it can also increase equipment size, which can lead to a decrease in cabin space through the adjustment of equipment size as shown in [Figure A.2](#). Planning HVAC performance without enough consideration of these relations, especially the possibly negative correlation between cabin temperature and cabin space resulting from HVAC performance improvement, can jeopardize cabin comfort as a result. Thus, it is important to analyze the relation of each factor carefully.

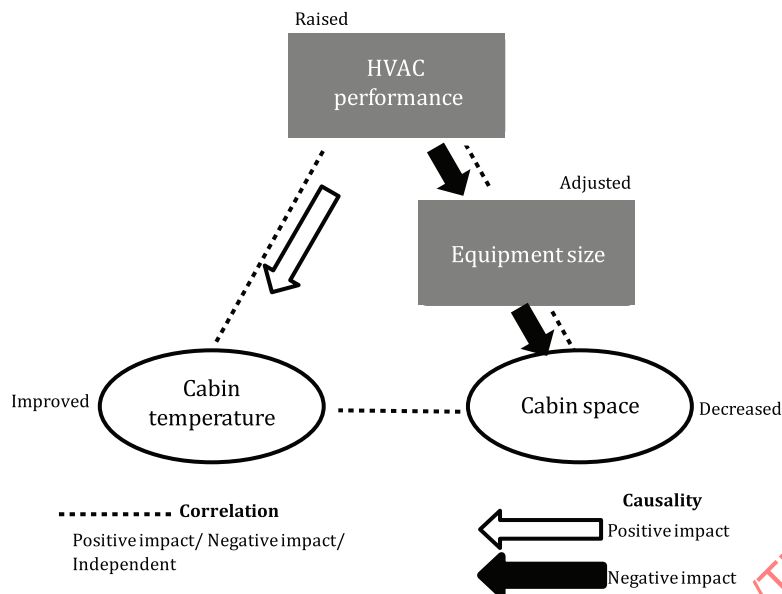


Figure A.2 — Example of improvement of cabin comfort

A.2 Development of new type of bogie

A.2.1 Correlation and causality of factors

Examples of correlation and causality in the development of a new type of bogie are shown in Figures A.3 to A.5. Enhancement of bogie rigidity is one option for safety improvement. At the same time, this can lead to an increase in bogie weight, which can bring unfavourable influence in terms of energy consumption (Figure A.3), track maintenance (Figure A.4) and vibration/noise (Figure A.5). As a result, the correlation relation between safety and energy consumption can be negative via various factors if the correlation with each factor cannot be recognized.

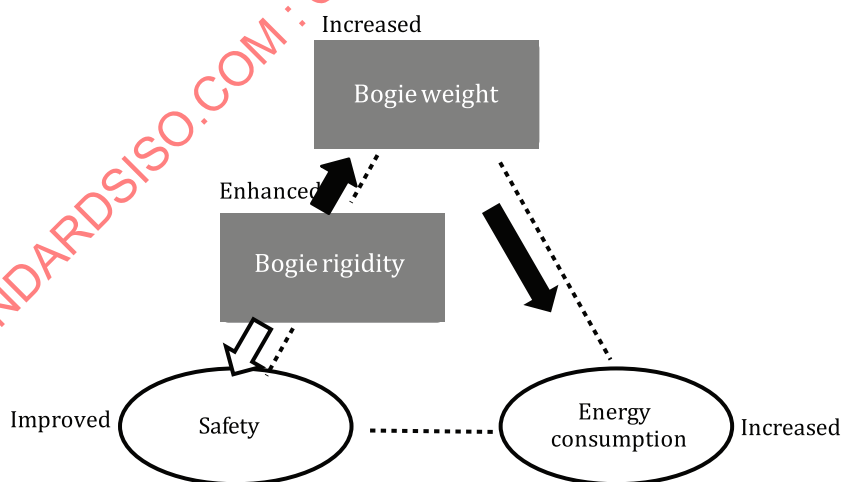


Figure A.3 — Example of safety improvement of bogie (correlation with energy consumption)

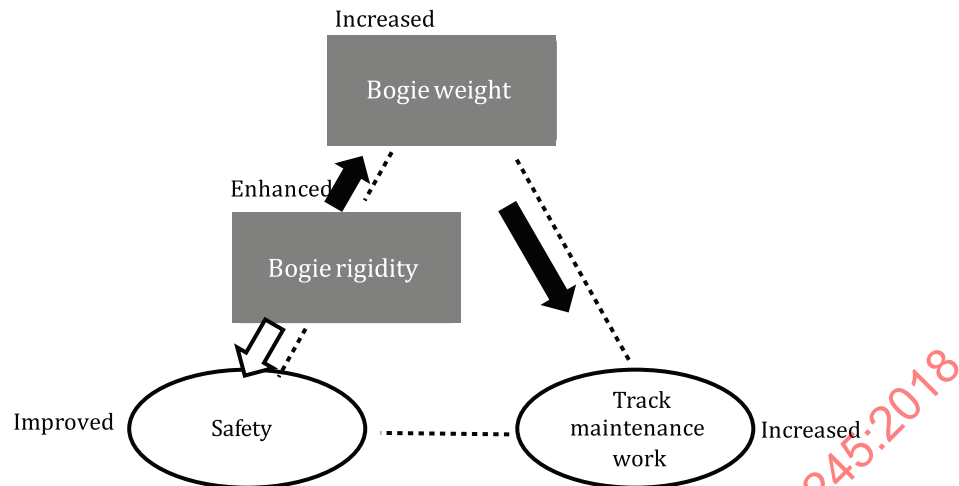


Figure A.4 — Example of safety improvement of bogie (correlation with track maintenance)

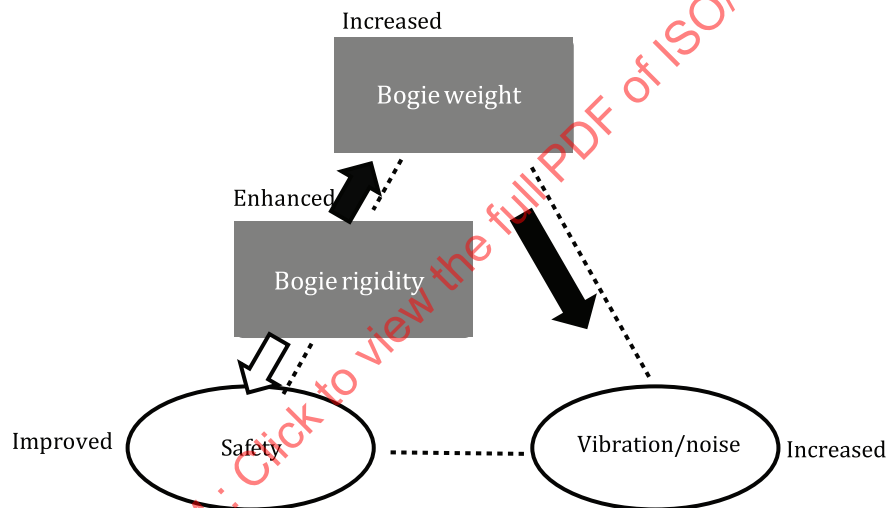


Figure A.5 — Example of safety improvement of bogie (correlation with vibration/noise)

A.2.2 Solution for coordinating/balancing factors

An innovative solution for satisfying both basic factors is to control bogie weight by applying light weight material ([Figure A.6](#)).

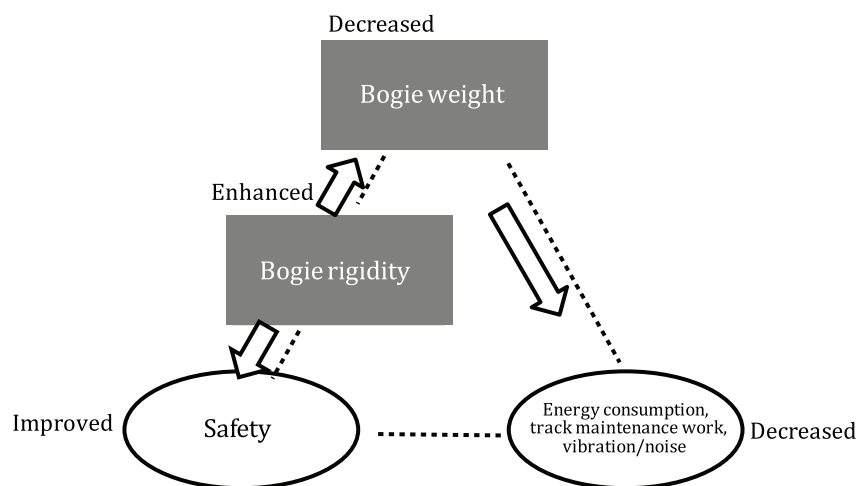


Figure A.6 — Example of safety improvement by applying innovative solution