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The International Railway Solution

The International Railway Solutions (IRS) are structured in a General Part and in some eventual Application Parts.

The General Part is valid worldwide, while the Application Parts are valid to a specific railway application, based on a geographical or on a service implementation.

The eventual Application Parts may thus be added according to the current needs of the Railway Operating Community.

Structure of the International Railway Solution:

IRS 60672 Implementation of a high-speed railway, feasibility phase

General part

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Foreword

An International Railway Solution (IRS) is a document drawn up by consensus and applied on a voluntary basis which aims to facilitate and harmonize railway operation. IRSs are gradually replacing UIC leaflets.

Members of the International Union of Railways (UIC) participate in the creation of IRSs, of which they benefit in full. Furthermore, marketing to railway stakeholders contributes to the sharing and harmonization of good practices, in accordance with UIC's primary goal.

While IRSs do not have the force of law, they are created and published in a professional manner and with technical approval on the basis of UIC procedures, and have full technical legitimacy in the railway sector.

The "General application" section constitutes the heart of the IRS and contains the working group's expertise applicable in the broadest manner. The addition of a "Specific application" aims to cover factors specific to a region, a type of service, etc.

While the application of this IRS is optional, some provisions shall be implemented in all cases to ensure correct application and maintain the system's cohesiveness. Certain operational circumstances require that specific provisions be systematically applied by all users of the document.

For the purposes of understanding, the user acknowledges that the expression of:

- obligation indicates requirements to be respected in order to comply with the expertise expressed in the document (usually "shall" in the present);
- recommendation indicates options that are favourable but not essential (usually "should" in the present);
- permission indicates options that are recognized but without consequence (usually "may", "need not" in the present);
- capacity indicates possibilities from a technical standpoint and not permissions or probabilities (usually "can" in the present).

Obligation, recommendation and capacity can be expressed in the negative to indicate prohibiting, non-recommendation and incapacity.

If applicable, notably for the purposes of compliance with a UIC approval, passages that are recommended or mandatory for the cohesiveness of the system will be accompanied by the letters "R" and "MCS" respectively.

This IRS reflects the following UIC working group expertise:

High-Speed IRS working group
Intercity & High-Speed Committee

It integrates in full or in part the following UIC leaflets:

Not applicable. (There are no UIC leaflets integrated in IRS 60672)

It complements the following standards:

Not applicable. (There are no standards complemented by IRS 60672)

The following IRSs constitute a complementary series:

IRS 60670 Implementation of a High-Speed Railway, Definition and Features
IRS 60671 Implementation of a High-Speed Railway, Emerging Phase
IRS 60673 Implementation of a High-Speed Railway, Design Phase
IRS 60674 Implementation of a High-Speed Railway, Construction Phase
IRS 60675 Implementation of a High-Speed Railway, Operation Phase

Summary

IRS 60672 is the third part of the Implementation of a High Speed Railway series, and specifies the elements required to assess the practicality of the proposed HSR project from a technical and economic perspective to help guide investment decision-making. It stipulating methods for assessment of a project's environmental impact, as well as revenues and costs, and outlines the steps involved in multi-criteria analysis, which considers the economic, environmental and social aspects of the various options with a view to selecting the best possible solution.

Normative references

International Union of Railways (UIC)

IRS 60670: Implementation of a high speed Railway. Definitions and features

IRS 60671: Implementation of a High-Speed Railway. Emerging phase

International Organization for Standardization (ISO)

ISO 31000:2009: Risk management — Principles and guidelines

Terms and definitions

Empowerment

The relevant statutory procedures, relating to environmental, railway safety and land acquisition issues in particular, are conducted during the empowerment stage in order to define a funding model and to facilitate a decision on whether to proceed with project implementation.

Environmental assessment

An environmental assessment is an evaluation of the environmental impact brought about by the proposed HSR project. During this stage, environmental impact assessments are conducted in respect of sensitive objects, and mitigation measures are introduced. An environmental management plan and environmental assessment report are prepared accordingly.

Feasibility study

The feasibility study assesses the practicality of the proposed HSR project. It examines technical and economic aspects to facilitate decision-making on investments. Studies typically cover technical criteria, infrastructure, stations and terminals, communications, signalling, traction power supply systems, rolling stock, land acquisition, RAMS, etc. Feasibility study outputs include feasibility design, cost estimates and funding options.

Financial & economic assessment

The financial assessment is performed to analyse revenues and costs in terms of infrastructure and operations, and to evaluate the profitability and financial viability of the proposed HSR project on the basis of financial forecasting.

The economic assessment is performed to analyse benefits and costs from all angles and to evaluate net benefits to society and the economic rationale for the proposed HSR project, based on the principle of rational allocation of resources.

Multicriteria analysis

Multicriteria analysis is a comprehensive analysis which takes into account the economic, environmental and social aspects of the various options available to identify the solution deemed to represent the best possible compromise. Multicriteria analysis is performed on the basis of traffic forecasts, construction and operating cost analysis, service patterns, environmental assessment and results of public consultation.

Preliminary design

The preliminary design is a professional design involving all relevant disciplines, based on survey data, approved feasibility design and mid-level estimated costs, in order to prepare preliminary design documents and general cost estimates.

List of abbreviations

AT	Auto Transformer
ATC	Automatic Train Control
B/C	Benefit Cost Ratio
BOT	Build-Operate-Transfer
CAPEX	Capital Expenditure
CBA	Cost Benefit Analysis
CCTV	Closed-Circuit Television
COSMOS	Computerized Safety Maintenance and Operation System
CTC	Centralized Traffic Control
CTCS	Chinese Train Control System
CWR	Continuously Welded Rail
EIRR	Economic Internal Rate of Return
ENPV	Economic Net Present Value
ERTMS	European Railway Traffic Management System
ETCS	European Train Control System
FIRR	Financial Internal Rate of Return
FNPV	Financial Net Present Value
GSM-R	Global System for Mobile Communications - Railway
HSR	High Speed Railway
HV	High Voltage
OCS	Overhead Contact System
OPEX	Operating Expense
PPP	Public Private Partnership
RAMS	Reliability, Availability, Maintainability and Safety
ROW	Right of Way

SHM

Structural Health Monitoring

TSITechnical Specifications for Interoperability for the
European Railway Systems

Implementation of a high-speed railway, feasibility phase

General Part

1 - Introduction

High Speed Railway (HSR) refers to any railway with commercial train service at the speed of 250km/h or higher ^a.

The design, construction and operation of a new HSR system is a complex task with many influences, stakeholders, requirements, challenges and objectives which must all be taken into account.

HSR system must comply with rigorous technical requirements with respect to design, construction and operation.

The HSR objectives are to:

- Support population and economic growth.
- Enable social and economic development in regional and urban areas.
- Relieve transport congestion of existing and future systems.
- Help support land use objectives designed to achieve sustainable ecological and environmental outcomes given continued urbanization, higher density living and the growth of regional centers.

The implementation process of an HSR project has five phases, i.e., emerging phase, feasibility phase, design phase, construction phase and operation phase.

a. The definition of HSR may differ depending on different countries.

2 - Stage 2: feasibility study

2.1 - Objectives

2.1.1 - Overall objectives of feasibility studies

Feasibility studies are vital in ensuring that projects will eventually take shape. They are also crucial for HSR implementation.

The overall objectives of feasibility studies are as follows:

- Identify possible undeveloped land corridors and/or existing corridors to support a HSR network.
- Establish mid-level construction cost estimates
- Undertake geotechnical investigations in targeted areas to determine corridor alignment.
- Identify the level of patronage compatible with an economically competitive and viable project.
- Survey potential travel patterns to help inform station location options and market analysis on the relative value of city centre and other city rail terminals, including possible links to airports.
- Assess the project's viability and sustainability in the context of public and private financing options and possible economic returns such as congestion relief and other infrastructure investment.

These objectives are achieved by building on previous stages, coordinating closely with other relevant ongoing studies, surveying stakeholders within the different corridors and identifying the most effective HSR options for each corridor.

This stage must provide an integrated design for the HSR, in which all of the system elements fit together to satisfy the requirements of the project and are capable of working interdependently when constructed.

2.1.2 - Additional objectives

Additional objectives of feasibility studies are as follows:

- Identify the most suitable technologies for the HSR project.
- Identify the need for - and benefits of - implementation of a HSR service
- Identify opportunities and concerns raised by local government within corridors regarding HSR service implementation.
- Define potential station locations, with pros and cons for each option.
- Identify opportunities to maximise use of existing transportation corridors.

- Identify recent and emerging vehicle and guideway technology innovations with the potential to minimise cost and environmental impact throughout the asset life cycle, including disposal.
- Identify systems that are interoperable in the primary corridors and that could be developed in phases.

2.1.3 - Feasibility factors

Feasibility factors include the following:

- Whether the proposed corridors have rail lines on which high-speed trains are running or can reasonably be expected to run.
- The forecasted ridership for the proposed corridors (IRS 60671).
- The percentage of corridors on which trains will be able to operate at maximum speed, taking into account such factors as topography and other traffic on the line
- The expected benefits to non-passengers, e.g. congestion relief on other modes of transportation servicing the corridors.
- The amount of federal, state and local financial support that can reasonably be anticipated for improvement of the line and related facilities.
- The level of cooperation from the owner of the right of way that can reasonably be expected when operating the HSR passenger service on the corridors.

2.2 - Key points

2.2.1 - Design criteria

The railway's design is the cornerstone on which practically all the elements of line design are based. Design is considered a critical element of the project's overall development.

When designing the railway, the design criteria, design parameters and operating plan should first be considered.

At this stage, the following elements should be defined.

Main design parameters: running time, design speed, number of main tracks, gauge, distance between track centres, minimum curve radius, maximum gradient, length available for arrival/departure tracks, traction mode, locomotive type, train operation control system, control and command, minimum headway, life cycle.

Relationship between design speed and running time objectives :

- Reducing running time,
- Reducing travel time.

HSR design criteria shall comply with regional/national laws, regulations and technical standards, such as TSI in Europe and the Code for Design of High-Speed Railway (TB10621) in China.

2.2.2 - Civil works and track

The HSR layout should be defined for each corridor, providing a number of alternative options.

Technical specifications for civil works and track should be defined on the basis of design speed and line purposes.

If the design speed is greater than 350 km/h, the technical specifications shall be determined on the basis of research according to specific conditions.

- Alignment

- Track gauge: railway systems with 1,435 mm gauge.
- Minimum radius:

Speed (km/h)	Minimum curve radius (m)
250	2500 - 3500
300	3600 - 5000
350	5500 - 7250

- Maximum gradient: 25% - 35%
- Minimum distance between track centres:

Speed (km/h)	Distance between track centres (m)
250	4.2 - 4.6
300	4.5 - 4.8
350	4.7 - 5.0

- Track

- Ballasted or ballastless track.
- Typical cross section of a HSR: rail, sleeper and ballast (ballasted track) or slab (ballastless track), formation and protection layer and subsoil.
- Siding every 30-60 km.

- Gauge

- The loading gauge will define the cross section, including areas of protection.

- Earthworks: designed in accordance with track and rolling stock requirements.
- Tunnels must be designed with additional safety features (including emergency requirements) and with aerodynamic considerations in mind. The cross section must be properly defined.
 - Slabs are preferable to a ballasted superstructure in long tunnels.
- Bridges/viaducts
 - Interaction between bridge and track, including dynamic considerations and long-term structural deformation.
 - Topographic and geological conditions.

2.2.3 - Communications and signalling system

■ Control and command

Signalling systems comprise, inter alia, the train operation control system and train operation dispatching command system.

Key points for the selection of a signalling system include:

- Performance: the signalling system shall meet transport requirements.
- Interoperability: the signalling system shall ensure interoperability.
- Safety: safe train operation must be guaranteed.
- Availability/reliability: fault probability shall be reduced and system reliability improved.

Signalling must fulfil the following requirements:

- Cab signalling: real speed, maximum permitted speed, target speed and distance to travel.
- Continuous transmission of information and protection of the train.
- Automatic braking action.

HSRs shall use advanced train operation control systems, such as the European train control system (ETCS, E1, E2) in Europe, the Chinese train control System (CTCS, C2, C3) in China, and digital ATC in Japan or other train control systems fulfilling safety requirements.

HSRs shall use advanced train operation dispatching command systems, such as centralised traffic control (CTC) in China and Europe, and the computerised safety maintenance and operation system (COSMOS) in Japan.

■ Communications system

Communications systems include the following:

- Fixed telecommunications
 - Optical fibre network
 - Building and station structured wiring network
 - Digital data transmission network for the train control system
- Mobile communications
 - Wireless communication for voice messages and transmission of traffic control system data
 - Signal coverage and availability

2.2.4 - Traction power supply system

Traction power supply systems are designed to include the following:

- High power demand
- Voltage and traction power supply system
- Substations: every 50-100 km
- Autotransformer stations: approximately every 15 km
- Overhead contact line system (OCS)
- Power grid: HSR requires high voltage, and city networks are typically unable to supply the power required; therefore, it is important to identify a connection point to a high voltage network at this stage.

2.2.5 - Safety monitoring

- Security targets

Integrated system of measures for surveillance and protection of critical infrastructure such as stations, platforms, public areas, tunnels, terminals and installations for electricity, signalling and communications in order to help minimise opportunities for crime and to ease passenger fears in relation to crime, thus creating a safer and more secure environment.

- Safety monitoring and auxiliary detection system
 - Monitoring of natural hazards such as wind, rainfall, snow, earthquakes, karst erosion, etc.
 - Structural health monitoring (SHM) of singular structures.
 - Objects falling on track, dragged objects, hot box detector.
- Security equipment may be provided as needed
 - Closed-circuit television (CCTV)
 - Security check equipment
 - Access control system
 - Intrusion detection system

2.2.6 - Stations and terminals

The following should be defined in respect of stations and terminals for each of the options under consideration:

- Location: depending on ridership, planning, land acquisition and rail facilities.
- Number of tracks: depending on planned system capacity (ridership).
- Size: influences land acquisition.

Key points for station planning

- Number of stations
 - Consider city/region size and population to plan for one or more stations.
 - At least one station should be in the city centre, where possible.
 - Adjacent stations should be planned in accordance with urban/regional plans and accessibility (commuter rail and highways).
- Functional layout
 - Avoid dead-end layouts for new stations.
Shunting schemes are more suitable for new intermediate stations.
 - Platform width shall meet passengers' needs when boarding/alighting from trains.
 - Depots should be easily accessible from stations.
 - Consider and define the operations to be performed at the depot or station (cleaning, catering, etc.) and ensure that sufficient space is provided.
- Accessibility
 - Plan for new public transport lines to be integrated at new stations, optimised to minimise access time.
 - Car parks should be provided in city centres. Taxi queues and boarding procedures should be streamlined to reduce waiting times.
 - Plan for commuter line access and interchanges.
- Interchange/transfers
 - Optimise interchanges to/from access modes at new stations.
 - Ensure that plans are developed with simplicity and rapid transfer times in mind.
- Ticketing and security control
 - Provide facilities and equipment in sufficient quantities to ensure that demand can always be met satisfactorily, even at peak times.
 - Queuing and passenger bottlenecks increase the time and space required for passenger throughput.
- Commercial centres at stations

- Due consideration must be given to the neighbourhood and to accessibility.
- Revenues from commercial/office space may be substantial.
- Urban and real estate operations around the station
 - Stations that are easily accessible at regional, national or international level may encourage plan-ning of new urban operations or models in the city/region
 - Substantial revenues may contribute to HSR construction or maintenance costs and improve service levels.

2.2.7 - Rolling stock

The type of rolling stock required should be determined at this stage. This will depend on ridership, speed and service type.

■ Different types of trains

- Concentrated or distributed power
- Conventional or articulated trains
- Single or double deck
- Tilting trains
- Variable gauge trains

■ Main characteristics

Self-propelled, fixed composition and bi-directional trains can be used for HSR, with main cha-racteristics as follows:

- Trainset length depends on demand; it is generally about 200 m to 400 m.
- For example, an eight-carriage trainset is approximately 200 m long.
- High traction power.
- AC power supply: 15 or 25 kV.
- Maximum axle load: 17 t.
- Compatible with infrastructure (gauge, wheel/rail, voltage, access doors with platforms, signalling systems, minimum curve radius, pantograph and catenary contact, etc.).
- Aerodynamic design: a good car design will reduce pressure variation for passengers in tunnels.
- Electric brakes/pneumatic brakes.
- Control circuits must be redundant.

■ Commercial requirements

The following requirements must be defined during this stage:

- Journey time
- Commercial classes: business, club and coach
- Seats (number and type)
- Impaired mobility passengers
- Onboard catering services
- Onboard equipment: air conditioning, audio/video, internet, public telephone,
- nursery, plug sockets, etc.

■ Rolling stock maintenance

It is essential that the rolling stock provided is fully operational for commercial service, completely safe, and offers the required levels of reliability and availability at the right cost.

Different types of maintenance workshops may be required, depending on the number of train-sets to be maintained, the network size and different levels involved.

Rolling stock maintenance shall meet operational requirements and usually covers the following:

- 24 hours, 365 days a year
- Preventive and corrective maintenance
- Vandalism and minor accident repairs
- Exterior and interior cleaning
- Facilities maintenance
- Technical support

2.2.8 - Draft operating and maintenance plan

- Infrastructure
 - Workshop
 - Equipment
- Communications, signalling, traction power supply system
 - Workshop
 - Equipment
- Rolling Stock
 - Define location and size of depots and workshops
 - Depot and workshop layout
 - Maintenance equipment in depots and workshops

2.2.9 - Right of way (ROW) and land acquisition

Land acquisition depends on ROW. Land acquisition requirements may be established after the layout for each corridor has been agreed.

Regulations must be reviewed and existing facilities identified.

■ Land acquisition requirements

HSRs require temporary and permanent land acquisition.

- Permanent land is land to be acquired throughout the expected life cycle of the HSR project.
- All permanent land will be subject to expropriation and title deed registration in the name of the railway authority.
- In forested areas and at crossings with watercourses or other infrastructure installations for which title deed transfer and registry is not possible, separate protocols should be put in place to secure the relevant rights.
- Temporary land is acquired on a temporary basis, and includes all lands required in addition to permanently acquired land in order to carry out construction and installation of the HSR and associated facilities and installations.

■ Right of way preservation and acquisition

This will include identification of "at-risk" parcels, preparation of survey documents and legal descriptions, and acquisition negotiations.

- Identification of "at-risk" land parcels