RFC2

Handbook

Deliverable	D4 Handbook
Date	24.01.2024
Version	1-00

optimising railways

Project governance

Name	Entity	Role
Le Floch Yann	RFC2	Project leader
Chassagne Rébécca	SMA	Project manager
Pelte Kathleen	ACF	Steering committee
Vanbeveren Thomas	Infrabel	Steering committee
Urbain Pierre	SNCF Réseau	Steering committee
Forster Pol	CFL	Steering committee
Stauffer Floraine	TVS	Steering committee

Agenda

1. Context, scope, goals and methodology of the study
2. Assumptions
3. Handbook

sma

Presentation of RFC North Sea-Mediterranean (RFC2)

Source : RFC2 website

Rail Freight Corridors deals with the organization of capacity for freight traffic at an international scale.

Primary functions

– To coordinate IM's in order to elaborate pre-arranged international path for freight trains and to administrate the RU's requests for those PaPs,

– To facilitate the international coordination process on TCRs.

Additional production functions to monitor train performance and to launch problem-solving processes where the RFC identify low quality in terms of performance.

Additional support functions : to manage legal, financial and communication matters related with the administration of the RFC.
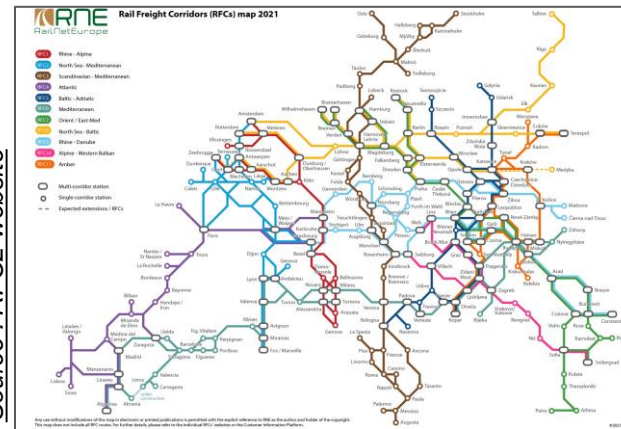
Presentation of RFC2

Source : RFC2 PoC : type of trains, 2021
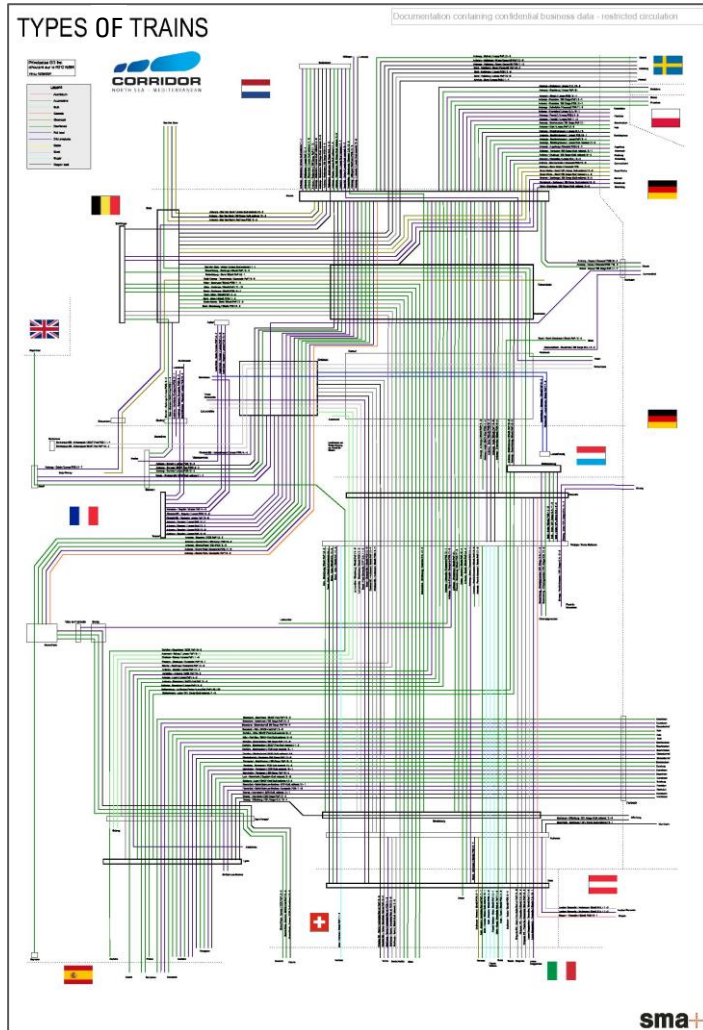
The RFC2 coordinates capacity issues mainly on :

– The Benelux ←→ Switzerland / Italy routes & South of France routes (more than 90% of the Benelux traffic continues to Italy)

– The Germany ←→ Spain routes,

– The UK ←→ Benelux & South of Europe routes,

– The Belgium ←→ North & Eastern Europe routes.

Source : RFC2 website

Cooperation takes place with other corridors in order to coordinate appropriately the capacity on multi-corridor routes (RFC Atlantic, RFC Mediterranean, RFC Rhine-Alpine, RFC North Sea Baltic).
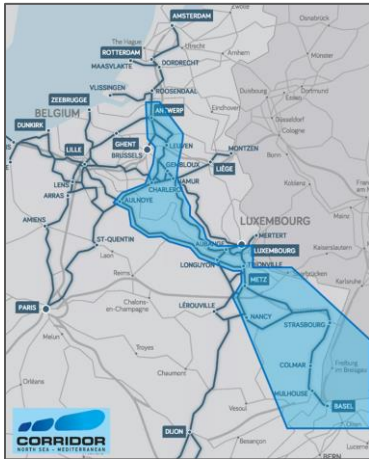
Context

- In the context of climate change, investments need to be done in favour of rail,

- The degraded state of the networks in many regions lead to a lot of works, which have capacity impacts,

- Since traffic does not usually start and end on a specific network exclusively, coordination methods, visualisations, platforms and tools are needed in a way to harmonize the capacity planning and production processes across the borders,

- The stakeholders involved in capacity planning and allocation processes work with a lot of different tools and don't have the adequate cross-border decision-making tools. Capacity KPIs are often not defined, and not calculated/computed. In view of this, there is a lack of transnational view in KPIs and processes,

- RailNetEurope is working on TTR project, which should lead to a big change of the planning processes across Europe, our initiative takes place in this TTR new capacity framework.

The Proof of Concept (see next page) has shown that the import and treatment of trains and TCRs are possible in a single tool, and that the production of capacity KPIs and visualisations is possible with manual or automatic methods. It has also highlighted some hurdles. It is now time to go a step further:

- Apply these methods on real data and larger scale in order to produce results that can lead to real decisions

- Go over the hurdles, especially the ones linked to the processes in order to produce all the capacity visualisations needed

- Work with the different stakeholders on capacity visualisations and help them to understand the differences between their national processes in order to improve the cross-border planning processes of paths and TCRs.

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Presentation of the PoC
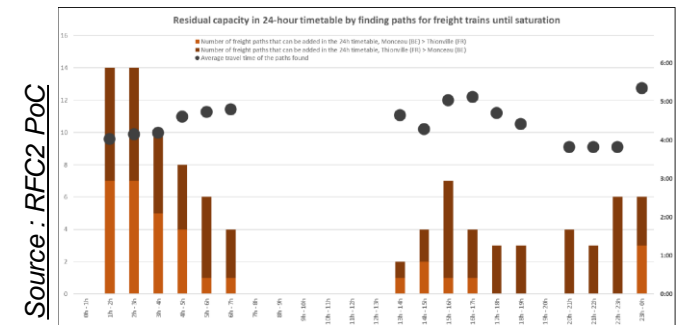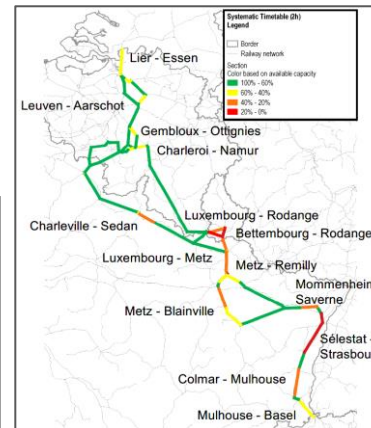
Goals & steps

Source : RFC2 PoC

The primary goal was to demonstrate the feasibility of an international freight capacity production process centred around an integrated railway timetabling platform. Highlighting the benefits of such a coordination through original, synthetic and schematic visualisations based on a single database was the main objective.

- Creation of a merged international Viriato database
- Import of 2-hour regular timetables
- Capacity analysis of 2-hour regular timetable
- Saturation by path search in 2-hour regular timetable
- Import of yearly timetables and TCR data
- Capacity analysis of 24-hour timetable
- Saturation by path search in 24-hour timetable
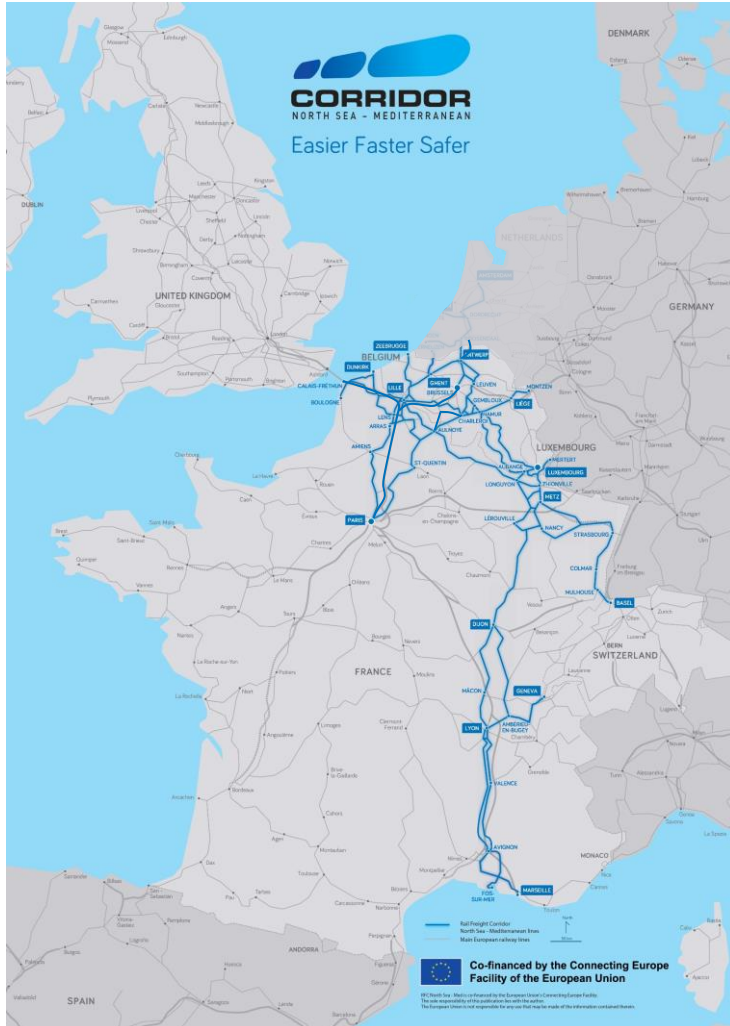- Production of KPIs and dedicated displays

Results achieved

The creation of a transnational merged database (planned infrastructure, trains, TCRs) is possible but some questions related to the IMs data models were raised. Important differences between planning processes which could jeopardise capacity analyses were highlighted.

Using a database with consistent data at the "appropriate level of granularity" allows to produce KPIs, evaluations and visualisations which support the international harmonisation for trains and works, as well as the understanding of capacity stakes.

Source : RFC2 PoC

Source : RFC2 PoC

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Scope of the study

Geographical scope :

– All the French, Luxembourgian and Belgian sections of the RFC NSM.

– Additional sections : Mons –Maubeuge section (via the Quevy Feignie border point),

– The Highspeed lines between the BE/NL Border + Eurotunnel border and Paris

– Alternative itineraries will also be considered if needed/required

Time horizons and data considered :

– Infrastructure : topology and signalling performance

– Timetable : paths with timetables (with added times), track line and station track

– TCRs : closures and time penalties

→ 2021, 2022, 2023, 2024, 2025 : planned (different states) and real

Goals

Produce visualisations to understand capacity issues, and on this basis, suggest process improvements to capacity stakeholders.

– What is the **capacity currently available** ?

– How can the capacity be **increased** in the future ?

– What are the capacity **issues** (where, how much, what kind) ?

– How to **increase** capacity in these points ? How far ?

– How to create a capacity **transnational database** and use it ?

– Are there any **issues** in the capacity **processes** ?

– How can the **decision making process** about capacity be improved ?

– How can stakeholders manage a major **timetable change** ?

Go further than the PoC

– Work on **official** complete data,

– Add the import and analysis of the **real situation** data,

– Go further on the **365 days** analysis,

– Deepen the analysis on the **stations**,

– Identify some **measures** to have more capacity,

– Quantify the **additional capacity** that could be offered by different **measures**,

– Analyse the processes and the **entire capacity supply** chain, especially the **transnational aspects**,

– **Work with the stakeholders** to improve the visualisations and the capacity processes.

General approach

General methodology phases :

– **Collect, analyse and import** infrastructure, timetables and TCRs data of the 3 countries, of real circulation and TCRs, and planned data for short and middle-term in one single Viriato database,

– **Work on capacity KPIs and create visualisations** in order to characterise current and future available capacity, bottlenecks, and identify measures to increase available capacity,

– **Work on processes**, especially transnational aspects,

– **Discuss with the stakeholders** the capacity visualisations and outline how they can find their place in the different processes and make IT recommendations
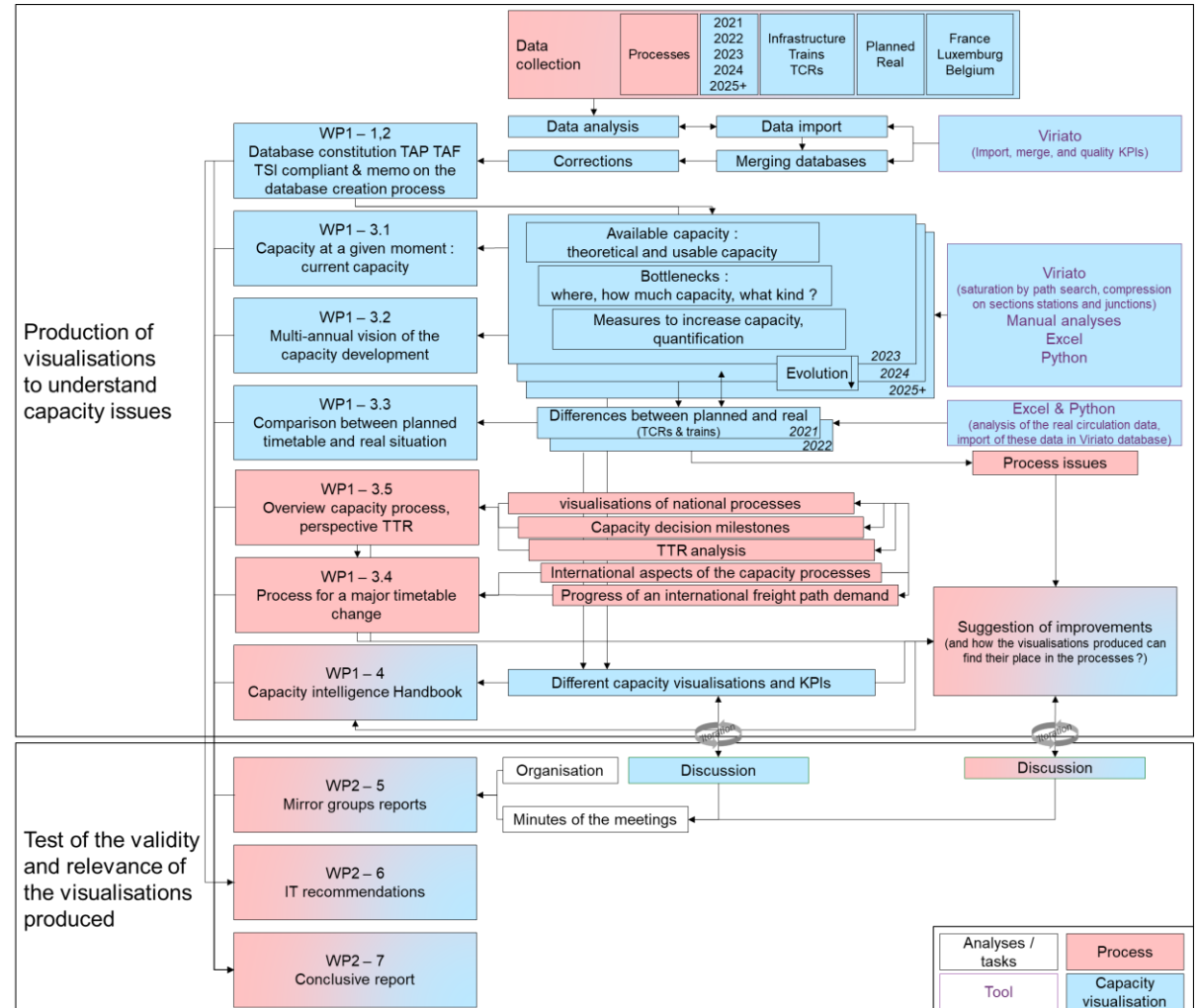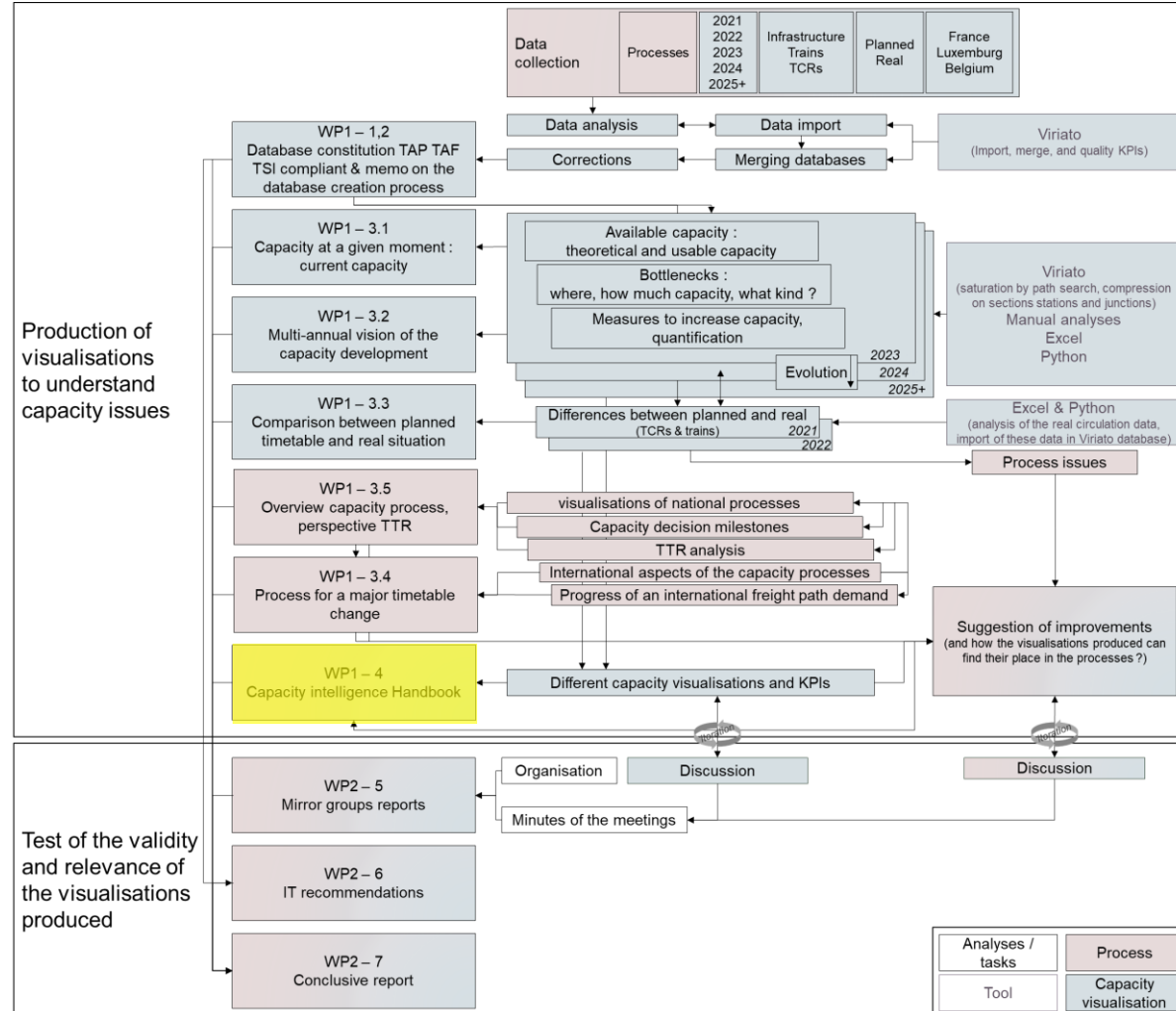
Deliverable 4

Agenda

Introduction

This chapter is a description of the general assumptions that have to be taken to produce the proposed capacity KPIs and visualisations.

The assumptions choices made for the project to edit the KPIs and visualisations are documented in the Deliverable "Capacity KPIs and visualisations".

The capacity planning tool is supposed to be documented : macroscopic or microscopic, how the network and circulation rules are modelled in it, etc..

To document the underlying database :

– Considered paths, TCRs and speed restrictions

– Considered steps in the capacity planning and allocation process,

– Precise station track allocation,

– Headways and separation times,

– Conflicts between trains and with TCRs,

– Train types,

– Duplicates,

– Frontiers links of the international paths

What was decided during this project phase is documented in the Deliverable "Database creation memo".

Diverse assumptions overview

– Markers choice : trains n°, origins, destinations, and level of confidence in those markers

– Geographical perimeter and time perimeter, rules to consider a path or not, rules to consider a TCR or not, with an attention point on the fact that sometimes the geographical and time perimeter have to be coherent for some KPIs, which leads to impactful choices

– Which itineraries are considered as "alternative"

– Which routes are considered and by which itineraries

– Definitions of peak / off-peak / night hours, "normal working days", if timetable has a low calendar stability, choice of representative days

– Choice of the value to represent, and method to aggregate KPIs when more that 1 day is analysed (median, average, minimum, maximum, etc.), and to aggregate 2 tracks / 2 directions on maps

Diverse assumptions overview

- List of the closures and speed restrictions types
- Colours of the represented TCRs and paths
- List of train types and attribution of a type for each path
- Level of precision (ex : 1 minute, 1 second, etc.)

Capacity consumption rate

- – Differences with UIC 406,

- – Network slicing,

- – Margins and runtimes,

- – Headway margins,

- – Stop times,

- – Consideration of TCRs,

- – Specific cases treatment (ex : 1 track, > 4 tracks, T1 or T2 planned TCRs, etc.),

- – Detailed method used for stations (switch areas considered or not, for example),

- – Considered paths (technical movements, empty runs, etc.),

- – Added margins,

- – Used thresholds.

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Agenda

1. Context, scope, goals and methodology of the study
2. Assumptions
3. **Handbook**

Overview of the KPIs and visualisations

Type of KPI / visualisation …
Bottlenecks list
KPIs and visualisations
Capacity consumption causes

… calculated on

All 365 days	**All 365 days**	**All 365 days**
10 – 20 days	**10 – 20 days**	**10 – 20 days**
1 day	1 day	1 day
Couldn't be calculated		

		Paths & TCRs	Paths	TCRs
Bottlenecks list	Capacity consumption & residual capacity	Capacity consumption rates on sections (map) Capacity consumption rates on junctions (map) Capacity consumption rates on stations (map) Residual capacity (map & graphic timetable) Residual capacity (histogram)	-	-
Capacity consumption causes	Capacity consumption analysis	Signalling performance (map) Share TCR & paths / type (maps & histogram)	Paths volumes (maps) Runtimes heterogeneity (map and histograms) Timetable optimisation : sections, junctions (maps) Timetable optimisation : sections, junctions (histograms) Timetable optimisation : wasted capacity (nb)	TCRs volume (map)
Toolbox	General structure	Graphic timetable (graphic timetable) Number of trains / type + TCRs (24h histogram)		Nominal TCR structure (map)
	Permeability	-	-	Rate of available capacity for a given path (rate on 1 or more itineraries)
	Alternative routes	-	-	Days/nights with TCRs on all itineraries (histogram)
	TCRs & Paths statistics	-	Runtimes, speeds, lengths (histograms & maps) Number of paths : year / weekdays (histograms) Number of paths (maps) Share of freight paths (map)	Planned capacity (maps & histograms) Typology of works day/night (pie chart) Typology of closure complete/partial (pie chart) Length, duration capacity planned (histograms)
	Calendar stability	Possible unique paths for a 365 days train (nb), or comparison between 1 day / 365 days compressions, level of graphic timetable transparency (%)	Nb of versions / days of circulation (histogram) Changed paths from a year to another (nb) Level of graphic timetable transparency (%) Variability of runtime for a route (histogram) Variability of itinerary for a route (map)	Days with the same planned TCR (nb) Level of graphic timetable transparency (%)
	Process stability	-	Stable planned paths across steps (rate)	Stable planned TCRs across steps (rate)
	Real-data analysis	-	Delay increase per section (map) Nb of planned paths / real trains (map) Delays across the year / country (histogram) Delays at departure / arrival (map)	Used length / planned length (rate) Used duration / planned duration (rate) Used TCRs / planned TCRs (rate)

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General information about calculation methods

After the Database constitution, from the database and the raw data, Excel databases are created, with TCRs and paths. These Excel databases are then used to extract KPIs and visualisation, with Python codes and GIS post-treatment. The Database in a capacity planning tool (it needs to be a planning tool and not only a visualisation tool) is used to run diverse algorithms, and the results are then also post-treated in Excel and GIS.

Some KPIs and visualisations proposed in this Deliverable are produced on the basis of the Excel databases, with Python codes and post-processing in GIS, and some others are produced on the basis of the planning tool database, with specific algorithms, and post-processing in Excel and GIS.

	Paths & TCRs	Paths	TCRs
Capacity consumption & residual capacity	Capacity consumption rates on sections (map) Capacity consumption rates on junctions (map) Capacity consumption rates on stations (map) Residual capacity (map & graphic timetable) Residual capacity (histogram)	-	-
Capacity consumption analysis	Signalling performance (map) Share TCR & paths / type (maps & histogram)	Paths volumes (maps) Runtimes heterogeneity (map and histograms) Timetable optimisation : sections, junctions (maps) Timetable optimisation : sections, junctions (histograms) Timetable optimisation : wasted capacity (nb)	TCRs volume (map)
General structure	Graphic timetable (graphic timetable) Number of trains / type + TCRs (24h histogram)		Nominal TCR structure (map)
Permeability	-	-	Rate of available capacity for a given path (rate on 1 or more itineraries)
Alternative routes	-	-	Days/nights with TCRs on all itineraries (histogram)
TCRs & Paths statistics	-	Runtimes, speeds, lengths (histograms & maps) Number of paths : year / weekdays (histograms) Number of paths (maps) Share of freight paths (map)	Planned capacity (maps & histograms) Typology of works day/night (pie chart) Typology of closure complete/partial (pie chart) Length, duration capacity planned (histograms)
Calendar stability	Possible unique paths for a 365 days train (nb), or comparison between 1 day / 365 days compressions, level of graphic timetable transparency (%)	Nb of versions / days of circulation (histogram) Changed paths from a year to another (nb) Level of graphic timetable transparency (%) Variability of runtime for a route (histogram) Variability of itinerary for a route (map)	Days with the same planned TCR (nb) Level of graphic timetable transparency (%)
Process stability	-	Stable planned paths across steps (rate)	Stable planned TCRs across steps (rate)
Real-data analysis	-	Delay increase per section (map) Nb of planned paths / real trains (map) Delays across the year / country (histogram) Delays at departure / arrival (map)	Used length / planned length (rate) Used duration / planned duration (rate) Used TCRs / planned TCRs (rate)

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General information about calculation methods

The different capacity KPIs and visualisations building methods, hurdles, and assumptions are detailed in this deliverable

Main assumptions for this specific KPI

The chosen assumptions for the edited capacity KPIs and visualisations are detailed in the Deliverable "Capacity KPIs and visualisations", in the 2nd chapter and in the 1st annex of the document.
Here are the lists of needed assumptions that have to be taken to produce the different KPI / visualisation.
The databases are supposed to be already built (see Deliverable "Database constitution memo").

Hurdles

Hurdles that have been encountered, which have limited the analysis perimeter (for example on 1 day instead of 365), which have prevented the proposed KPI calculation, are listed here, as well as relevant attention points.

Method

On the basis of the databases, used methods are detailed here, to understand the different steps that have to be realised to produce each capacity KPI and visualisation.

Capacity consumption rates

	Paths & TCRs	Paths	TCRs
Capacity consumption & residual capacity	Capacity consumption rates on sections (map) Capacity consumption rates on junctions (map) Capacity consumption rates on stations (map) Residual capacity (map & graphic timetable) Residual capacity (histogram)	-	-
Capacity consumption analysis	Signalling performance (map) Share TCR & paths / type (maps & histogram)	Paths volumes (maps) Runtimes heterogeneity (map and histograms) Timetable optimisation : sections, junctions (maps) Timetable optimisation : sections, junctions (histograms) Timetable optimisation : wasted capacity (nb)	TCRs volume (map)
General structure	Graphic timetable (graphic timetable) Number of trains / type + TCRs (24h histogram)		Nominal TCR structure (map)
Permeability	-	-	Rate of available capacity for a given path (rate on 1 or more itineraries)
Alternative routes	-	-	Days/nights with TCRs on all itineraries (histogram)
TCRs & Paths statistics	-	Runtimes, speeds, lengths (histograms & maps) Number of paths : year / weekdays (histograms) Number of paths (maps) Share of freight paths (map)	Planned capacity (maps & histograms) Typology of works day/night (pie chart) Typology of closure complete/partial (pie chart) Length, duration capacity planned (histograms)
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Process stability	-	Stable planned paths across steps (rate)	Stable planned TCRs across steps (rate)
Real-data analysis	-	Delay increase per section (map) Nb of planned paths / real trains (map) Delays across the year / country (histogram) Delays at departure / arrival (map)	Used length / planned length (rate) Used duration / planned duration (rate) Used TCRs / planned TCRs (rate)

Main assumptions for this specific KPI

– Homogeneous sections (slicing), junctions, stations

– Time windows (entire days, peak hours, etc.)

– Headways and separation times

– Runtimes (with or without reserve and additional times)

– Method for TCRs (in particular 1 track/2)

– Method for stations (ex : UIC 406 with switches areas)

– Method for sections > 2 tracks

Hurdles

– Data quality

  – Heterogeneous data : runtimes, headways, separation times, TCRs, trains & TCRs at frontiers, etc.

  – Timetable with conflicts or duplicates

  – Uncomplete modelling of the infrastructure

– Cohabitation of many different methods can lead to understanding problems

Method
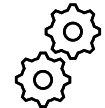
– For each junction and section, compress the given timetable, with all trains placed at the minimum headway / separation time after the previous ones

– Place the 1st train of the sequence at the end

– Calculate the time window used by the compressed timetable and compare to the total time window

– Represent the results in maps using thresholds

– For stations, see detailed method in D3.1, 3.2, 3.3

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Residual capacity

	Paths & TCRs	Paths	TCRs
Capacity consumption & residual capacity	Capacity consumption rates on sections (map) Capacity consumption rates on junctions (map) Capacity consumption rates on stations (map) **Residual capacity (map & graphic timetable) Residual capacity (histogram)**	-	-
Capacity consumption analysis	Signalling performance (map) Share TCR & paths / type (maps & histogram)	Paths volumes (maps) Runtimes heterogeneity (map and histograms) Timetable optimisation : sections, junctions (maps) Timetable optimisation : sections, junctions (histograms) Timetable optimisation : wasted capacity (nb)	TCRs volume (map)
General structure	Graphic timetable (graphic timetable) Number of trains / type + TCRs (24h histogram)		Nominal TCR structure (map)
Permeability	-	-	Rate of available capacity for a given path (rate on 1 or more itineraries)
Alternative routes	-	-	Days/nights with TCRs on all itineraries (histogram)
TCRs & Paths statistics	-	Runtimes, speeds, lengths (histograms & maps) Number of paths : year / weekdays (histograms) Number of paths (maps) Share of freight paths (map)	Planned capacity (maps & histograms) Typology of works day/night (pie chart) Typology of closure complete/partial (pie chart) Length, duration capacity planned (histograms)
Calendar stability	Possible unique paths for a 365 days train (nb), or comparison between 1 day / 365 days compressions, level of graphic timetable transparency (%)	Nb of versions / days of circulation (histogram) Changed paths from a year to another (nb) Level of graphic timetable transparency (%) Variability of runtime for a route (histogram) Variability of itinerary for a route (map)	Days with the same planned TCR (nb) Level of graphic timetable transparency (%)
Process stability	-	Stable planned paths across steps (rate)	Stable planned TCRs across steps (rate)
Real-data analysis	-	Delay increase per section (map) Nb of planned paths / real trains (maps) Delays across the year / country (histogram) Delays at departure / arrival (map)	Used length / planned length (rate) Used duration / planned duration (rate) Used TCRs / planned TCRs (rate)

## Main assumptions for this specific KPI

– Origin/destination couples, itineraries

– Runtimes and runtimes potential extension (%)

– Potential added stops and acceleration/deceleration times

– Rules when running in a 1track/2 closure

– Rules when meeting a temporary speed restriction (margins)

– Rules for the stations track occupation planning

Hurdles

– A high calendar instability can lead to a too complex problem for the path search algorithms

– Missing track occupation information in the database leads to ignoring capacity in stations and partial result

– Conflicts in the given timetable (paths/paths or paths/TCRs) requires a algorithm able to ignore it

– Data quality : infrastructure modelling is crutial

Method

– For the chosen routes, by directions (at the same time or separately), look for as many conflict-free paths as possible in the paths and TCRs context

– Represent them in a graphic timetable

– Represent the number of added paths per hour and their performance (runtime) in a histogram

– Represent the usable residual capacity in a map by counting the number of added paths per section

Signalling performance

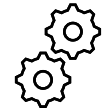|	Paths & TCRs	Paths	TCRs
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Main assumptions for this specific KPI

- Network slicing for headways (homogeneity regarding signalling performance)

- Choice of the represented value :

  - For junctions, average value or highest value (most unfavourable trains succession),

  - For sections, value between 2 of the most common trains on the section, or highest value (more unfavourable train succession)

Hurdles

- Separation times and headways can be calculated with different methods, and sometimes not comparable across the networks,

- Headways can be given with a variable level of precision, depending on the use it has (capacity planning : could be a macroscopic network slicing, capacity allocation : sometimes microscopic network slicing) and the way it's calculated

Method

- For the chosen network, represent on a map :

  - By points, the separation times at junctions

  - By edges, headways on lines, (highest value of the 2 directions)

  - Choose the colours according to the highest and lowest values of the network

Capacity sharing

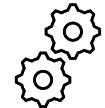|	Paths & TCRs	Paths	TCRs
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Permeability	-	-	Rate of available capacity for a given path (rate on 1 or more itineraries)
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Real-data analysis	-	Delay increase per section (map) Nb of planned paths / real trains (map) Delays across the year / country (histogram) Delays at departure / arrival (map)	Used length / planned length (rate) Used duration / planned duration (rate) Used TCRs / planned TCRs (rate)

Main assumptions for this specific KPI

– Method (especially attribution of the consumed capacity to the different trains and TCRs)

– Chosen train types (here freight / passenger, but can also be empty / commercial for ex.)

Hurdles

– Data quality

  – Heterogeneous data : runtimes, headways, separation times, TCRs, trains & TCRs at frontiers, etc.

  – Timetable with conflicts or duplicates

  – Uncomplete modelling of the infrastructure

  – Uncomplete data : train types (empty, high speed, etc.)

Method

– 3 timetable compression are realised, with TCRs and freight trains, without TCRs and freight trains, with freight trains but no TCRs,

– The difference of sections compression rates is used to calculate the shares, and represent it on maps

– Other method (seen in the PoC) is to estimate capacity consumption for trains using the runtime difference with the average runtime for the section

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Paths volume

	Paths & TCRs	Paths	TCRs
Capacity consumption & residual capacity	Capacity consumption rates on sections (map) Capacity consumption rates on junctions (map) Capacity consumption rates on stations (map) Residual capacity (map & graphic timetable) Residual capacity (histogram)	-	-
Capacity consumption analysis	Signalling performance (map) Share TCR & paths / type (maps & histogram)	**Paths volumes (maps)** Runtimes heterogeneity (map and histograms) Timetable optimisation : sections, junctions (maps) Timetable optimisation : sections, junctions (histograms) Timetable optimisation : wasted capacity (nb)	TCRs volume (map)
General structure	Graphic timetable (graphic timetable) Number of trains / type + TCRs (24h histogram)		Nominal TCR structure (map)
Permeability	-	-	Rate of available capacity for a given path (rate on 1 or more itineraries)
Alternative routes	-	-	Days/nights with TCRs on all itineraries (histogram)
TCRs & Paths statistics	-	Runtimes, speeds, lengths (histograms & maps) Number of paths : year / weekdays (histograms) Number of paths (maps) Share of freight paths (map)	Planned capacity (maps & histograms) Typology of works day/night (pie chart) Typology of closure complete/partial (pie chart) Length, duration capacity planned (histograms)
Calendar stability	Possible unique paths for a 365 days train (nb), or comparison between 1 day / 365 days compressions, level of graphic timetable transparency (%)	Nb of versions / days of circulation (histogram) Changed paths from a year to another (nb) Level of graphic timetable transparency (%) Variability of runtime for a route (histogram) Variability of itinerary for a route (map)	Days with the same planned TCR (nb) Level of graphic timetable transparency (%)
Process stability	-	Stable planned paths across steps (rate)	Stable planned TCRs across steps (rate)
Real-data analysis	-	Delay increase per section (map) Nb of planned paths / real trains (map) Delays across the year / country (histogram) Delays at departure / arrival (map)	Used length / planned length (rate) Used duration / planned duration (rate) Used TCRs / planned TCRs (rate)

Main assumptions for this specific KPI

– Network slicing

Hurdles

– Trains which pass 2 times by the same point have to b treated carefully

Method

– For the chosen network slicing, represent on a map the number of planned paths (width)

– Paths volumes could also be displayed with colours on the map according to their departure time (entry time on the section)

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Runtimes heterogeneity

	Paths & TCRs	Paths	TCRs
Capacity consumption & residual capacity	Capacity consumption rates on sections (map) Capacity consumption rates on junctions (map) Capacity consumption rates on stations (map) Residual capacity (map & graphic timetable) Residual capacity (histogram)	-	-
Capacity consumption analysis	Signalling performance (map) Share TCR & paths / type (maps & histogram)	Paths volumes (maps) Runtimes heterogeneity (map and histograms) Timetable optimisation : sections, junctions (maps) Timetable optimisation : sections, junctions (histograms) Timetable optimisation : wasted capacity (nb)	TCRs volume (map)
General structure		Graphic timetable (graphic timetable) Number of trains / type + TCRs (24h histogram)	Nominal TCR structure (map)
Permeability	-	-	Rate of available capacity for a given path (rate on 1 or more itineraries)
Alternative routes	-	-	Days/nights with TCRs on all itineraries (histogram)
TCRs & Paths statistics	-	Runtimes, speeds, lengths (histograms & maps) Number of paths : year / weekdays (histograms) Number of paths (maps) Share of freight paths (map)	Planned capacity (maps & histograms) Typology of works day/night (pie chart) Typology of closure complete/partial (pie chart) Length, duration capacity planned (histograms)
Calendar stability	Possible unique paths for a 365 days train (nb), or comparison between 1 day / 365 days compressions, level of graphic timetable transparency (%)	Nb of versions / days of circulation (histogram) Changed paths from a year to another (nb) Level of graphic timetable transparency (%) Variability of runtime for a route (histogram) Variability of itinerary for a route (map)	Days with the same planned TCR (nb) Level of graphic timetable transparency (%)
Process stability	-	Stable planned paths across steps (rate)	Stable planned TCRs across steps (rate)
Real-data analysis	-	Delay increase per section (map) Nb of planned paths / real trains (map) Delays across the year / country (histogram) Delays at departure / arrival (map)	Used length / planned length (rate) Used duration / planned duration (rate) Used TCRs / planned TCRs (rate)

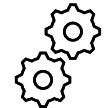## Main assumptions for this specific KPI

– Network slicing has an impact on this KPI, as the short sections will automatically be more heterogeneous

Hurdles

– Heterogeneity and data quality for paths : runtimes, reserves, added times, and data importation

– Network slicing has an important role : it could be interesting to change the network slicing to avoid too small sections, but as the runtimes heterogeneity KPI is an entry data to know which thresholds have to be used in the capacity consumption rates analyses, it's more relevant to keep the same slicing, with the small sections, as they have to be homogeneous

Method
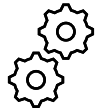
– Considering all the trains in the section, calculate the standard deviation of the planned runtimes

– Represent on a map

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Timetable optimisation : paths order

	Paths & TCRs	Paths	TCRs
Capacity consumption & residual capacity	Capacity consumption rates on sections (map) Capacity consumption rates on junctions (map) Capacity consumption rates on stations (map) Residual capacity (map & graphic timetable) Residual capacity (histogram)	-	-
Capacity consumption analysis	Signalling performance (map) Share TCR & paths / type (maps & histogram)	Paths volumes (maps) Runtimes heterogeneity (map and histograms) Timetable optimisation : sections, junctions (maps) Timetable optimisation : sections, junctions (histograms) Timetable optimisation : wasted capacity (nb)	TCRs volume (map)
General structure	Graphic timetable (graphic timetable) Number of trains / type + TCRs (24h histogram)		Nominal TCR structure (map)
Permeability	-	-	Rate of available capacity for a given path (rate on 1 or more itineraries)
Alternative routes	-	-	Days/nights with TCRs on all itineraries (histogram)
TCRs & Paths statistics	-	Runtimes, speeds, lengths (histograms & maps) Number of paths : year / weekdays (histograms) Number of paths (maps) Share of freight paths (map)	Planned capacity (maps & histograms) Typology of works day/night (pie chart) Typology of closure complete/partial (pie chart) Length, duration capacity planned (histograms)
Calendar stability	Possible unique paths for a 365 days train (nb), or comparison between 1 day / 365 days compressions, level of graphic timetable transparency (%)	Nb of versions / days of circulation (histogram) Changed paths from a year to another (nb) Level of graphic timetable transparency (%) Variability of runtime for a route (histogram) Variability of itinerary for a route (map)	Days with the same planned TCR (nb) Level of graphic timetable transparency (%)
Process stability	-	Stable planned paths across steps (rate)	Stable planned TCRs across steps (rate)
Real-data analysis	-	Delay increase per section (map) Nb of planned paths / real trains (map) Delays across the year / country (histogram) Delays at departure / arrival (map)	Used length / planned length (rate) Used duration / planned duration (rate) Used TCRs / planned TCRs (rate)

## Main assumptions for this specific KPI

– When the tool switches paths (optimisation level), paths are switches with each other on a 30 min basis

– All the assumption from "capacity consumption rates" also apply here

Hurdles

– It should be interesting to have an idea of the commercial constraints, to eliminate some timetables among all the possible timetables

– This KPI requires a high automatic calculation capacity

Method

– Apply the capacity consumption rates method for junctions and sections, for all the possible timetables, by changing the path order

– Represent on histograms the capacity consumption for : the one which consumes the less capacity, the one which consumes the most capacity, and the given timetable

– Comparison between those 3 values will give the level of optimisation (path order) to represent on maps

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Timetable optimisation : wasted capacity

	Paths & TCRs	Paths	TCRs
Capacity consumption & residual capacity	Capacity consumption rates on sections (map) Capacity consumption rates on junctions (map) Capacity consumption rates on stations (map) Residual capacity (map & graphic timetable) Residual capacity (histogram)	-	-
Capacity consumption analysis	Signalling performance (map) Share TCR & paths / type (maps & histogram)	Paths volumes (maps) Runtimes heterogeneity (map and histograms) Timetable optimisation : sections, junctions (histograms) Timetable optimisation : wasted capacity (nb)	TCRs volume (map)
General structure	Graphic timetable (graphic timetable) Number of trains / type + TCRs (24h histogram)		Nominal TCR structure (map)
Permeability	-	-	Rate of available capacity for a given path (rate on 1 or more itineraries)
Alternative routes	-	-	Days/nights with TCRs on all itineraries (histogram)
TCRs & Paths statistics	-	Runtimes, speeds, lengths (histograms & maps) Number of paths : year / weekdays (histograms) Number of paths (maps) Share of freight paths (map)	Planned capacity (maps & histograms) Typology of works day/night (pie chart) Typology of closure complete/partial (pie chart) Length, duration capacity planned (histograms)
Calendar stability	Possible unique paths for a 365 days train (nb), or comparison between 1 day / 365 days compressions, level of graphic timetable transparency (%)	Nb of versions / days of circulation (histogram) Changed paths from a year to another (nb) Level of graphic timetable transparency (%) Variability of runtime for a route (histogram) Variability of itinerary for a route (map)	Days with the same planned TCR (nb) Level of graphic timetable transparency (%)
Process stability	-	Stable planned paths across steps (rate)	Stable planned TCRs across steps (rate)
Real-data analysis	-	Delay increase per section (map) Nb of planned paths / real trains (map) Delays across the year / country (histogram) Delays at departure / arrival (map)	Used length / planned length (rate) Used duration / planned duration (rate) Used TCRs / planned TCRs (rate)

Main assumptions for this specific KPI

– How to consider stations / freight yards : some capacity on a section seems wasted : trains run with 5' headways whereas they could run with 4' according to the signalling, but actually it's the station at the beginning of the section which has an exit headway between trains of 5'

– It has to be measured on a small perimeter (sections, junctions), where trains can be planned to optimise capacity

– What happens before / after the chosen sections / junctions

Hurdles

– This KPI can be non relevant / harder to calculate in a situation with heterogeneous runtimes, in this situation the solution is to consider a important point, regarding capacity, instead of an entire section

– If the capacity considered here as a loss is consciously added between paths as a "robustness" factor, maybe the planning headways have to be increased, or empty paths have to be included in the timetable (if those measures can have an impact of robustness, which is not studied here)

Method

– At the chosen point or at different points of the chosen section, measure for each train succession the difference between :

  – The minimum separation time / headway

  – The planned separation time / headways

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TCRs volumes

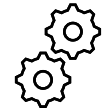|	Paths & TCRs	Paths	TCRs
Capacity consumption & residual capacity	Capacity consumption rates on sections (map) Capacity consumption rates on junctions (map) Capacity consumption rates on stations (map) Residual capacity (map & graphic timetable) Residual capacity (histogram)	-	-
Capacity consumption analysis	Signalling performance (map) Share TCR & paths / type (maps & histogram)	Paths volumes (maps) Runtimes heterogeneity (map and histograms) Timetable optimisation : sections, junctions (maps) Timetable optimisation : sections, junctions (histograms) Timetable optimisation : wasted capacity (nb)	TCRs volume (map)
General structure	Graphic timetable (graphic timetable) Number of trains / type + TCRs (24h histogram)		Nominal TCR structure (map)
Permeability	-	-	Rate of available capacity for a given path (rate on 1 or more itineraries)
Alternative routes	-	-	Days/nights with TCRs on all itineraries (histogram)
TCRs & Paths statistics	-	Runtimes, speeds, lengths (histograms & maps) Number of paths : year / weekdays (histograms) Number of paths (maps) Share of freight paths (map)	Planned capacity (maps & histograms) Typology of works day/night (pie chart) Typology of closure complete/partial (pie chart) Length, duration capacity planned (histograms)
Calendar stability	Possible unique paths for a 365 days train (nb), or comparison between 1 day / 365 days compressions, level of graphic timetable transparency (%)	Nb of versions / days of circulation (histogram) Changed paths from a year to another (nb) Level of graphic timetable transparency (%) Variability of runtime for a route (histogram) Variability of itinerary for a route (map)	Days with the same planned TCR (nb) Level of graphic timetable transparency (%)
Process stability	-	Stable planned paths across steps (rate)	Stable planned TCRs across steps (rate)
Real-data analysis	-	Delay increase per section (map) Nb of planned paths / real trains (map) Delays across the year / country (histogram) Delays at departure / arrival (map)	Used length / planned length (rate) Used duration / planned duration (rate) Used TCRs / planned TCRs (rate)

Main assumptions for this specific KPI

– TCRs « fenêtres de surveillance » « blancs-travaux » have sometimes to be excluded for the TCR statistical analyses and representations, but not always

Hurdles

– Data quality and homogeneity

– Differences of "capacity language" between countries can lead to differences in representations and interpretations

Method

– For the considered year, add all the planned TCRs in duration x days x km (width), and represent it on a map by sections, with also elements of typology as for example day/night repartition (colour), or type of closure (label)

General structure

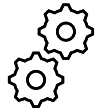|	Paths & TCRs	Paths	TCRs
Capacity consumption & residual capacity	Capacity consumption rates on sections (map) Capacity consumption rates on junctions (map) Capacity consumption rates on stations (map) Residual capacity (map & graphic timetable) Residual capacity (histogram)	-	-
Capacity consumption analysis	Signalling performance (map) Share TCR & paths / type (maps & histogram)	Paths volumes (maps) Runtimes heterogeneity (map and histograms) Timetable optimisation : sections, junctions (maps) Timetable optimisation : sections, junctions (histograms) Timetable optimisation : wasted capacity (nb)	TCRs volume (map)
General structure	Graphic timetable (graphic timetable) Number of trains / type + TCRs (24h histogram)		Nominal TCR structure (map)
Permeability	-	-	Rate of available capacity for a given path (rate on 1 or more itineraries)
Alternative routes	-	-	Days/nights with TCRs on all itineraries (histogram)
TCRs & Paths statistics	-	Runtimes, speeds, lengths (histograms & maps) Number of paths : year / weekdays (histograms) Number of paths (maps) Share of freight paths (map)	Planned capacity (maps & histograms) Typology of works day/night (pie chart) Typology of closure complete/partial (pie chart) Length, duration capacity planned (histograms)
Calendar stability	Possible unique paths for a 365 days train (nb), or comparison between 1 day / 365 days compressions, level of graphic timetable transparency (%)	Nb of versions / days of circulation (histogram) Changed paths from a year to another (nb) Level of graphic timetable transparency (%) Variability of runtime for a route (histogram) Variability of itinerary for a route (map)	Days with the same planned TCR (nb) Level of graphic timetable transparency (%)
Process stability	-	Stable planned paths across steps (rate)	Stable planned TCRs across steps (rate)
Real-data analysis	-	Delay increase per section (map) Nb of planned paths / real trains (map) Delays across the year / country (histogram) Delays at departure / arrival (map)	Used length / planned length (rate) Used duration / planned duration (rate) Used TCRs / planned TCRs (rate)

Main assumptions for this specific KPI

– Choice of itineraries

– Parts of the itineraries where alternative itineraries exist

– TTR capacity model representation way :

  – Choice of sections

  – Choice of point where trains are counted

Hurdles

– It can be illegible :

  – If too much itineraries

  – If too much days and high calendar instability

– TTR capacity model representation way :

  – Way to add TCRs representation if needed (see PoC)

  – Needs to visualise also the graphic timetable to avoid representing a non conflict-free timetable

Method

– Create a time/space representation in the capacity planning tool

– Load and display TCRs and paths for the chosen day(s)

– Add some information about alternative itineraries

– Identify main traffics and TCRs to help the understanding

– For each homogeneous section, count the trains by types at 1 chosen point, evaluate the capacity used for TCR, to represent the section in TTR capacity model way

General planned TCRs structure

	Paths & TCRs	Paths	TCRs
Capacity consumption & residual capacity	Capacity consumption rates on sections (map) Capacity consumption rates on junctions (map) Capacity consumption rates on stations (map) Residual capacity (map & graphic timetable) Residual capacity (histogram)	-	-
Capacity consumption analysis	Signalling performance (map) Share TCR & paths / type (maps & histogram)	Paths volumes (maps) Runtimes heterogeneity (map and histograms) Timetable optimisation : sections, junctions (maps) Timetable optimisation : sections, junctions (histograms) Timetable optimisation : wasted capacity (nb)	TCRs volume (map)
General structure	Graphic timetable (graphic timetable) Number of trains / type + TCRs (24h histogram)		Nominal TCR structure (map)
Permeability	-	-	Rate of available capacity for a given path (rate on 1 or more itineraries)
Alternative routes	-	-	Days/nights with TCRs on all itineraries (histogram)
TCRs & Paths statistics	-	Runtimes, speeds, lengths (histograms & maps) Number of paths : year / weekdays (histograms) Number of paths (maps) Share of freight paths (map)	Planned capacity (maps & histograms) Typology of works day/night (pie chart) Typology of closure complete/partial (pie chart) Length, duration capacity planned (histograms)
Calendar stability	Possible unique paths for a 365 days train (nb), or comparison between 1 day / 365 days compressions, level of graphic timetable transparency (%)	Nb of versions / days of circulation (histogram) Changed paths from a year to another (nb) Level of graphic timetable transparency (%) Variability of runtime for a route (histogram) Variability of itinerary for a route (histogram)	Days with the same planned TCR (nb) Level of graphic timetable transparency (%)
Process stability	-	Stable planned paths across steps (rate)	Stable planned TCRs across steps (rate)
Real-data analysis	-	Delay increase per section (map) Nb of planned paths / real trains (map) Delays across the year / country (histogram) Delays at departure / arrival (map)	Used length / planned length (rate) Used duration / planned duration (rate) Used TCRs / planned TCRs (rate)

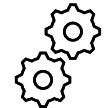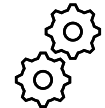## Main assumptions for this specific KPI

– Choice of period : in some countries there are 3 or 4 main timetable periods, corresponding to TCRs structures, so these periods could be relevant for this analysis, but in other countries, there is a "main structure" planned for an entire year, or pluriannual

– FR : TCRs « fenêtres de surveillance » « blancs-travaux » are excluded for the TCR statistical analyses

Hurdles

– It can be unrealistic if high calendar instability (the represented structure is then less representative of the year)

– Differences of "capacity language" between countries can lead to differences in the TCRs structure representation and interpretation : ex : "fenêtres génériques" in FR are TCR planned but not always used, whereas in BE planned TCRs are mostly used by real work

Method

– Analyse all the TCRs planned and produce 2 maps :

  – 1st one is the most common TCR, which occurs most often during the year, by section and/or station (the most common situation could also be "no TCR")

  – 2nd one is the most common speed restriction

  – Represent by colour the day/night character, by width the duration in hours, the type of closure (complete, partial, etc.), and the number of times it occurs

TCRs alignment analysis (permeability)

	Paths & TCRs	Paths	TCRs
Capacity consumption & residual capacity	Capacity consumption rates on sections (map) Capacity consumption rates on junctions (map) Capacity consumption rates on stations (map) Residual capacity (map & graphic timetable) Residual capacity (histogram)	-	-
Capacity consumption analysis	Signalling performance (map) Share TCR & paths / type (maps & histogram)	Paths volumes (maps) Runtimes heterogeneity (map and histograms) Timetable optimisation : sections, junctions (maps) Timetable optimisation : sections, junctions (histograms) Timetable optimisation : wasted capacity (nb)	TCRs volume (map)
General structure	Graphic timetable (graphic timetable) Number of trains / type + TCRs (24h histogram)		Nominal TCR structure (map)
Permeability	-	-	Rate of available capacity for a given path (rate on 1 or more itineraries)
Alternative routes	-	-	Days/nights with TCRs on all itineraries (histogram)
TCRs & Paths statistics	-	Runtimes, speeds, lengths (histograms & maps) Number of paths : year / weekdays (histograms) Number of paths (maps) Share of freight paths (map)	Planned capacity (maps & histograms) Typology of works day/night (pie chart) Typology of closure complete/partial (pie chart) Length, duration capacity planned (histograms)
Calendar stability	Possible unique paths for a 365 days train (nb), or comparison between 1 day / 365 days compressions, level of graphic timetable transparency (%)	Nb of versions / days of circulation (histogram) Changed paths from a year to another (nb) Level of graphic timetable transparency (%) Variability of runtime for a route (histogram) Variability of itinerary for a route (map)	Days with the same planned TCR (nb) Level of graphic timetable transparency (%)
Process stability	-	Stable planned paths across steps (rate)	Stable planned TCRs across steps (rate)
Real-data analysis	-	Delay increase per section (map) Nb of planned paths / real trains (map) Delays across the year / country (histogram) Delays at departure / arrival (map)	Used length / planned length (rate) Used duration / planned duration (rate) Used TCRs / planned TCRs (rate)

Main assumptions for this specific KPI

– Chosen itineraries and runtimes → chosen paths

– Calculated here independently for both directions

– If calculating for 2 directions : if there is a TCRs "1 track / 2" with possibility of opposite direction circulation, the 2 directions trains are placed in batteries of ½h

Hurdles

– Choice of the day regarding TCRs calendar variations

– Choice of itineraries when alternative itineraries exist but with worse runtimes and characteristics

– Calculating method for "1 track/2" planned TCRs

– Differences of "capacity language" between countries can lead to differences in the TCRs structure representation and interpretation

Method

– For 1 itinerary : place all the possible given paths, with no path deformation (added runtime), without conflicts with TCRs, every minute on the graphic timetable, and calculate the number of possible paths (/ 1440)

– For > 1 itineraries : for each departure minute of the 24h, search for one itinerary where path can be set, with no deformation and no conflict with TCRs, calculate the amount of minutes where the answer is positive, divided by 1440, and characterise the quality of the founded itineraries

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TCRs planning analysis about alternative routes

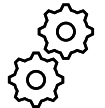|	Paths & TCRs	Paths	TCRs
Capacity consumption & residual capacity	Capacity consumption rates on sections (map) Capacity consumption rates on junctions (map) Capacity consumption rates on stations (map) Residual capacity (map & graphic timetable) Residual capacity (histogram)	-	-
Capacity consumption analysis	Signalling performance (map) Share TCR & paths / type (maps & histogram)	Paths volumes (maps) Runtimes heterogeneity (map and histograms) Timetable optimisation : sections, junctions (maps) Timetable optimisation : sections, junctions (histograms) Timetable optimisation : wasted capacity (nb)	TCRs volume (map)
General structure	Graphic timetable (graphic timetable) Number of trains / type + TCRs (24h histogram)		Nominal TCR structure (map)
Permeability	-	-	Rate of available capacity for a given path (rate on 1 or more itineraries)
Alternative routes	-	-	Days/nights with TCRs on all itineraries (histogram)
TCRs & Paths statistics	-	Runtimes, speeds, lengths (histograms & maps) Number of paths : year / weekdays (histograms) Number of paths (maps) Share of freight paths (map)	Planned capacity (maps & histograms) Typology of works day/night (pie chart) Typology of closure complete/partial (pie chart) Length, duration capacity planned (histograms)
Calendar stability	Possible unique paths for a 365 days train (nb), or comparison between 1 day / 365 days compressions, level of graphic timetable transparency (%)	Nb of versions / days of circulation (histogram) Changed paths from a year to another (nb) Level of graphic timetable transparency (%) Variability of runtime for a route (histogram) Variability of itinerary for a route (map)	Days with the same planned TCR (nb) Level of graphic timetable transparency (%)
Process stability	-	Stable planned paths across steps (rate)	Stable planned TCRs across steps (rate)
Real-data analysis	-	Delay increase per section (map) Nb of planned paths / real trains (map) Delays across the year / country (histogram) Delays at departure / arrival (map)	Used length / planned length (rate) Used duration / planned duration (rate) Used TCRs / planned TCRs (rate)

Main assumptions for this specific KPI

– Chosen routes and itineraries (for each route, choose 2 or more alternative itinerary, with acceptable runtimes and conditions),

– Definition of the TCRs which have an important impact on capacity : here "surveillance", TCRs less than 4h, and TCRs 1 track/2 are not considered

Hurdles

– Interpretation : the goal is to have a macroscopic view of the TCRs planning, it's possible to have a night where a TCR is planned, but some capacity is still available

– If the visualisation is produced for days and nights, a complementary analysis could have to be done to link the "impacted" days and the "impacted" nights

– Differences of "capacity language" between countries can lead to differences in representations and interpretations

Method

– After having filtered the data according to the assumptions

– Consider each day and each night of the chosen period

– For each route, check if at least 1 itinerary / day and night has no TCR

– Represent all the days and nights which have 0 itinerary without TCRs, per route, in a histogram

TCRs statistics

	Paths & TCRs	Paths	TCRs
Capacity consumption & residual capacity	Capacity consumption rates on sections (map) Capacity consumption rates on junctions (map) Capacity consumption rates on stations (map) Residual capacity (map & graphic timetable) Residual capacity (histogram)	-	-
Capacity consumption analysis	Signalling performance (map) Share TCR & paths / type (maps & histogram)	Paths volumes (maps) Runtimes heterogeneity (map and histograms) Timetable optimisation : sections, junctions (maps) Timetable optimisation : sections, junctions (histograms) Timetable optimisation : wasted capacity (nb)	TCRs volume (map)
General structure	Graphic timetable (graphic timetable) Number of trains / type + TCRs (24h histogram)		Nominal TCR structure (map)
Permeability	-	-	Rate of available capacity for a given path (rate on 1 or more itineraries)
Alternative routes	-	-	Days/nights with TCRs on all itineraries (histogram)
TCRs & Paths statistics	-	Runtimes, speeds, lengths (histograms & maps) Number of paths : year / weekdays (histograms) Number of paths (maps) Share of freight paths (map)	Planned capacity (maps & histograms) Typology of works day/night (pie chart) Typology of closure complete/partial (pie chart) Length, duration capacity planned (histograms)
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Process stability	-	Stable planned paths across steps (rate)	Stable planned TCRs across steps (rate)
Real-data analysis	-	Delay increase per section (map) Nb of planned paths / real trains (map) Delays across the year / country (histogram) Delays at departure / arrival (map)	Used length / planned length (rate) Used duration / planned duration (rate) Used TCRs / planned TCRs (rate)

Main assumptions for this specific KPI

– TCRs « fenêtres de surveillance » « blancs-travaux » have sometimes to be excluded for the TCR statistical analyses and representations, but not always

Hurdles

– Data quality and homogeneity

– Differences of "capacity language" between countries can lead to differences in representations and interpretations

Method

– Use the TCR and speed restrictions database to calculate and represent :

– The volume of planned capacity for TCRs (nb hours x nb of days x nb of km)

– The typology : days / night, 2 tracks / 1 tracks, etc.

– Different statistics : length, duration, etc.

Paths statistics

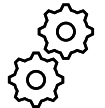|	Paths & TCRs	Paths	TCRs
Capacity consumption & residual capacity	Capacity consumption rates on sections (map) Capacity consumption rates on junctions (map) Capacity consumption rates on stations (map) Residual capacity (map & graphic timetable) Residual capacity (histogram)	-	-
Capacity consumption analysis	Signalling performance (map) Share TCR & paths / type (maps & histogram)	Paths volumes (maps) Runtimes heterogeneity (map and histograms) Timetable optimisation : sections, junctions (maps) Timetable optimisation : sections, junctions (histograms) Timetable optimisation : wasted capacity (nb)	TCRs volume (map)
General structure	Graphic timetable (graphic timetable) Number of trains / type + TCRs (24h histogram)		Nominal TCR structure (map)
Permeability	-	-	Rate of available capacity for a given path (rate on 1 or more itineraries)
Alternative routes	-	-	Days/nights with TCRs on all itineraries (histogram)
TCRs & Paths statistics	-	Runtimes, speeds, lengths (histograms & maps) Number of paths : year / weekdays (histograms) Number of paths (maps) Share of freight paths (map)	Planned capacity (maps & histograms) Typology of works day/night (pie chart) Typology of closure complete/partial (pie chart) Length, duration capacity planned (histograms)
Calendar stability	Possible unique paths for a 365 days train (nb), or comparison between 1 day / 365 days compressions, level of graphic timetable transparency (%)	Nb of versions / days of circulation (histogram) Changed paths from a year to another (nb) Level of graphic timetable transparency (%) Variability of runtime for a route (histogram) Variability of itinerary for a route (map)	Days with the same planned TCR (nb) Level of graphic timetable transparency (%)
Process stability	-	Stable planned paths across steps (rate)	Stable planned TCRs across steps (rate)
Real-data analysis	-	Delay increase per section (map) Nb of planned paths / real trains (map) Delays across the year / country (histogram) Delays at departure / arrival (map)	Used length / planned length (rate) Used duration / planned duration (rate) Used TCRs / planned TCRs (rate)

Main assumptions for this specific KPI

Hurdles

– Data quality and homogeneity

– Differences of "capacity language" between countries can lead to differences in representations and interpretations

Method

– Use the TCR and speed restrictions database to calculate and represent :

  – Per section : the speeds, the number of paths per type

  – Per country : the departure/arrival runtimes, speeds, km, etc.

  – The number of paths / type can also be interesting on different time perimeter : weekday, year, etc.

Paths & TCRs calendar stability

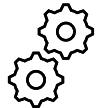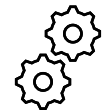|	Paths & TCRs	Paths	TCRs
Capacity consumption & residual capacity	Capacity consumption rates on sections (map) Capacity consumption rates on junctions (map) Capacity consumption rates on stations (map) Residual capacity (map & graphic timetable) Residual capacity (histogram)	-	-
Capacity consumption analysis	Signalling performance (map) Share TCR & paths / type (maps & histogram)	Paths volumes (maps) Runtimes heterogeneity (map and histograms) Timetable optimisation : sections, junctions (maps) Timetable optimisation : sections, junctions (histograms) Timetable optimisation : wasted capacity (nb)	TCRs volume (map)
General structure	Graphic timetable (graphic timetable) Number of trains / type + TCRs (24h histogram)		Nominal TCR structure (map)
Permeability	-	-	Rate of available capacity for a given path (rate on 1 or more itineraries)
Alternative routes	-	-	Days/nights with TCRs on all itineraries (histogram)
TCRs & Paths statistics	-	Runtimes, speeds, lengths (histograms & maps) Number of paths : year / weekdays (histograms) Number of paths (maps) Share of freight paths (map)	Planned capacity (maps & histograms) Typology of works day/night (pie chart) Typology of closure complete/partial (pie chart) Length, duration capacity planned (histograms)
Calendar stability	Possible unique paths for a 365 days train (nb) or comparison between 1 day / 365 days compressions, level of graphic timetable transparency (%)	Nb of versions / days of circulation (histogram) Changed paths from a year to another (nb) Level of graphic timetable transparency (%) Variability of runtime for a route (histogram) Variability of itinerary for a route (map)	Days with the same planned TCR (nb) Level of graphic timetable transparency (%)
Process stability	-	Stable planned paths across steps (rate)	Stable planned TCRs across steps (rate)
Real-data analysis	-	Delay increase per section (map) Nb of planned paths / real trains Delays across the year / country (histogram) Delays at departure / arrival (map)	Used length / planned length (rate) Used duration / planned duration (rate) Used TCRs / planned TCRs (rate)

Main assumptions for this specific KPI

– Choice of

– Paths

– Itineraries

– Paths hypotheses (added stops, runtimes, etc.)

Hurdles

– A high calendar instability (which is measured here) can lead to a too complex problem for the path search algorithm

– If too complex on 365 days, this method can also be processed without week-ends, on 313 days

– For compressions, it could be difficult to eliminate the strictly overlying paths

– Method to measure the graphic timetable "transparency"

Method

– In the 365 days paths and TCRs context, try to insert a unique path, with no different versions

– Try this for as many different paths as possible

– The number of different paths that can be added for 365 days with no versions measures calendar stability

– Comparisons between timetable compressions (paths & TCRs) for 1 days or 365 days, and graphic timetable "transparency" on 365 days could also be held

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Paths calendar stability

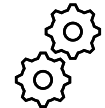|	Paths & TCRs	Paths	TCRs
Capacity consumption & residual capacity	Capacity consumption rates on sections (map) Capacity consumption rates on junctions (map) Capacity consumption rates on stations (map) Residual capacity (map & graphic timetable) Residual capacity (histogram)	-	-
Capacity consumption analysis	Signalling performance (map) Share TCR & paths / type (maps & histogram)	Paths volumes (maps) Runtimes heterogeneity (map and histograms) Timetable optimisation : sections, junctions (maps) Timetable optimisation : sections, junctions (histograms) Timetable optimisation : wasted capacity (nb)	TCRs volume (map)
General structure	Graphic timetable (graphic timetable) Number of trains / type + TCRs (24h histogram)		Nominal TCR structure (map)
Permeability	-	-	Rate of available capacity for a given path (rate on 1 or more itineraries)
Alternative routes	-	-	Days/nights with TCRs on all itineraries (histogram)
TCRs & Paths statistics	-	Runtimes, speeds, lengths (histograms & maps) Number of paths : year / weekdays (histograms) Number of paths (maps) Share of freight paths (map)	Planned capacity (maps & histograms) Typology of works day/night (pie chart) Typology of closure complete/partial (pie chart) Length, duration capacity planned (histograms)
Calendar stability	Possible unique paths for a 365 days train (nb) or comparison between 1 day / 365 days compressions, level of graphic timetable transparency (%)	Nb of versions / days of circulation (histogram) Changed paths from a year to another (nb) Level of graphic timetable transparency (%) Variability of runtime for a route (histogram) Variability of itinerary for a route (map)	Days with the same planned TCR (nb) Level of graphic timetable transparency (%)
Process stability	-	Stable planned paths across steps (rate)	Stable planned TCRs across steps (rate)
Real-data analysis	-	Delay increase per section (map) Nb of planned paths / real trains (map) Delays across the year / country (histogram) Delays at departure / arrival (map)	Used length / planned length (rate) Used duration / planned duration (rate) Used TCRs / planned TCRs (rate)

Main assumptions for this specific KPI

– Thresholds to consider paths as "identical" across the year (ex : same stops, same rolling stock, less than 1' difference at arrival or departure)

Hurdles

– "Versions" (variants) are not always identified in the data, sometimes the train n° is changed

– From a year to another, the trains n° can change

– Method to measure the graphic timetable "transparency"

Method

– Calculate the number of different versions of a train, compared to the total number of days the train runs

– Calculated (day per day) the number of added, deleted, changes paths across the years (answers ≠ paths requests)

– For the "graphic timetable transparency", display all the paths and measure the available capacity

– Calculate and represent the variability of the runtimes and itinerary for a same train or route in the time perimeter

TCRs calendar stability

|	Paths & TCRs	Paths	TCRs
Capacity consumption & residual capacity	Capacity consumption rates on sections (map) Capacity consumption rates on junctions (map) Capacity consumption rates on stations (map) Residual capacity (map & graphic timetable) Residual capacity (histogram)	-	-
Capacity consumption analysis	Signalling performance (map) Share TCR & paths / type (maps & histogram)	Paths volumes (maps) Runtimes heterogeneity (map and histograms) Timetable optimisation : sections, junctions (maps) Timetable optimisation : sections, junctions (histograms) Timetable optimisation : wasted capacity (nb)	TCRs volume (map)
General structure	Graphic timetable (graphic timetable) Number of trains / type + TCRs (24h histogram)		Nominal TCR structure (map)
Permeability	-	-	Rate of available capacity for a given path (rate on 1 or more itineraries)
Alternative routes	-	-	Days/nights with TCRs on all itineraries (histogram)
TCRs & Paths statistics	-	Runtimes, speeds, lengths (histograms & maps) Number of paths : year / weekdays (histograms) Number of paths (maps) Share of freight paths (map)	Planned capacity (maps & histograms) Typology of works day/night (pie chart) Typology of closure complete/partial (pie chart) Length, duration capacity planned (histograms)
Calendar stability	Possible unique paths for a 365 days train (nb), or comparison between 1 day / 365 days compressions, level of graphic timetable transparency (%)	Nb of versions / days of circulation (histogram) Changed paths from a year to another (nb) Level of graphic timetable transparency (%) Variability of runtime for a route (histogram) Variability of itinerary for a route (map)	Days with the same planned TCR (nb) Level of graphic timetable transparency (%)
Process stability	-	Stable planned paths across steps (rate)	Stable planned TCRs across steps (rate)
Real-data analysis	-	Delay increase per section (map) Nb of planned paths / real trains (map) Delays across the year / country (histogram) Delays at departure / arrival (map)	Used length / planned length (rate) Used duration / planned duration (rate) Used TCRs / planned TCRs (rate)

Main assumptions for this specific KPI

– Thresholds to consider TCRs as "identical" across the year, or other chosen time perimeter (ex : same length, same duration, same type)

Hurdles

– Method to measure the graphic timetable "transparency"

Method
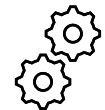
– For the considered perimeter, count the number of days for which the TCRs planning is the same (same TCRs at the same place, with same type, duration and schedule)

– Compare this number to the total amount of days with TCRs in the considered time perimeter

– For the "graphic timetable transparency", display all the TCRs and measure the available capacity

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Paths process stability

	Paths & TCRs	Paths	TCRs
Capacity consumption & residual capacity	Capacity consumption rates on sections (map) Capacity consumption rates on junctions (map) Capacity consumption rates on stations (map) Residual capacity (map & graphic timetable) Residual capacity (histogram)	-	-
Capacity consumption analysis	Signalling performance (map) Share TCR & paths / type (maps & histogram)	Paths volumes (maps) Runtimes heterogeneity (map and histograms) Timetable optimisation : sections, junctions (maps) Timetable optimisation : sections, junctions (histograms) Timetable optimisation : wasted capacity (nb)	TCRs volume (map)
General structure	Graphic timetable (graphic timetable) Number of trains / type + TCRs (24h histogram)		Nominal TCR structure (map)
Permeability	-	-	Rate of available capacity for a given path (rate on 1 or more itineraries)
Alternative routes	-	-	Days/nights with TCRs on all itineraries (histogram)
TCRs & Paths statistics	-	Runtimes, speeds, lengths (histograms & maps) Number of paths : year / weekdays (histograms) Number of paths (maps) Share of freight paths (map)	Planned capacity (maps & histograms) Typology of works day/night (pie chart) Typology of closure complete/partial (pie chart) Length, duration capacity planned (histograms)
Calendar stability	Possible unique paths for a 365 days train (nb), or comparison between 1 day / 365 days compressions, level of graphic timetable transparency (%)	Nb of versions / days of circulation (histogram) Changed paths from a year to another (nb) Level of graphic timetable transparency (%) Variability of runtime for a route (histogram) Variability of itinerary for a route (map)	Days with the same planned TCR (nb) Level of graphic timetable transparency (%)
Process stability	-	Stable planned paths across steps (rate)	Stable planned TCRs across steps (rate)
Real-data analysis	-	Delay increase per section (map) Nb of planned paths / real trains (map) Delays across the year / country (histogram) Delays at departure / arrival (map)	Used length / planned length (rate) Used duration / planned duration (rate) Used TCRs / planned TCRs (rate)

Main assumptions for this specific KPI

- Thresholds to consider paths as "identical" across capacity process steps (ex : same stops, same rolling stock, less than 1' difference at arrival or departure)

- Dates where the data is extracted from the planning and allocation tools

Hurdles

- Data availability :
  - Requires a way to link in the capacity process tool(s) the paths across the different steps (paths are often anonymous when planned upstream, and even if they are not, they have a number which can change)
  - To be interesting, the KPI should be completed with an analysis of the causes of instability, so these data should be available (IM, RU, other changes causes)

Method

- From a capacity planning and allocation process step to the next one, calculate the % of trains/days which are identical

- Next method, but considering the day before circulation (also possible with real data), compared to diverse other milestones

- Represent the trains/days across the capacity process steps : added, deleted, changed

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TCRs process stability

	Paths & TCRs	Paths	TCRs
Capacity consumption & residual capacity	Capacity consumption rates on sections (map) Capacity consumption rates on junctions (map) Capacity consumption rates on stations (map) Residual capacity (map & graphic timetable) Residual capacity (histogram)	-	-
Capacity consumption analysis	Signalling performance (map) Share TCR & paths / type (maps & histogram)	Paths volumes (maps) Runtimes heterogeneity (map and histograms) Timetable optimisation : sections, junctions (maps) Timetable optimisation : sections, junctions (histograms) Timetable optimisation : wasted capacity (nb)	TCRs volume (map)
General structure		Graphic timetable (graphic timetable) Number of trains / type + TCRs (24h histogram)	Nominal TCR structure (map)
Permeability	-	-	Rate of available capacity for a given path (rate on 1 or more itineraries)
Alternative routes	-	-	Days/nights with TCRs on all itineraries (histogram)
TCRs & Paths statistics	-	Runtimes, speeds, lengths (histograms & maps) Number of paths : year / weekdays (histograms) Number of paths (maps) Share of freight paths (map)	Planned capacity (maps & histograms) Typology of works day/night (pie chart) Typology of closure complete/partial (pie chart) Length, duration capacity planned (histograms)
Calendar stability	Possible unique paths for a 365 days train (nb), or comparison between 1 day / 365 days compressions, level of graphic timetable transparency (%)	Nb of versions / days of circulation (histogram) Changed paths from a year to another (nb) Level of graphic timetable transparency (%) Variability of runtime for a route (histogram) Variability of itinerary for a route (map)	Days with the same planned TCR (nb) Level of graphic timetable transparency (%)
Process stability	-	Stable planned paths across steps (rate)	Stable planned TCRs across steps (rate)
Real-data analysis	-	Delay increase per section (map) Nb of planned paths / real trains (map) Delays across the year / country (histogram) Delays at departure / arrival (map)	Used length / planned length (rate) Used duration / planned duration (rate) Used TCRs / planned TCRs (rate)

Main assumptions for this specific KPI

– Thresholds to consider TCRs as "identical" across capacity process steps (ex : same length, same duration, same type)

– Dates where the data is extracted from the planning and allocation tools

Hurdles

– Data availability :

 – Requires a way to link in the capacity process tool(s) the TCRs across the different steps (upstream, planned TCRs cover large periods, whereas downstream, they are more splitted into small periods)

 – To be interesting, the KPI should be completed with an analysis of the causes of instability, so these data should be available (IM, RU, other changes causes)

Method

– From a capacity planning and allocation process step to the next one, calculate the % of TCRs which are identical

– Next method, but considering the day before operation (also possible with real data), compared to diverse other milestones

– Represent the TCR evolution across the capacity process steps : added, deleted, changed

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Analysis of operational measures

|	Paths & TCRs	Paths	TCRs
Capacity consumption & residual capacity	Capacity consumption rates on sections (map) Capacity consumption rates on junctions (map) Capacity consumption rates on stations (map) Residual capacity (map & graphic timetable) Residual capacity (histogram)	-	-
Capacity consumption analysis	Signalling performance (map) Share TCR & paths / type (maps & histogram)	Paths volumes (maps) Runtimes heterogeneity (map and histograms) Timetable optimisation : sections, junctions (maps) Timetable optimisation : sections, junctions (histograms) Timetable optimisation : wasted capacity (nb)	TCRs volume (map)
General structure	Graphic timetable (graphic timetable) Number of trains / type + TCRs (24h histogram)		Nominal TCR structure (map)
Permeability	-	-	Rate of available capacity for a given path (rate on 1 or more itineraries)
Alternative routes	-	-	Days/nights with TCRs on all itineraries (histogram)
TCRs & Paths statistics	-	Runtimes, speeds, lengths (histograms & maps) Number of paths : year / weekdays (histograms) Number of paths (maps) Share of freight paths (map)	Planned capacity (maps & histograms) Typology of works day/night (pie chart) Typology of closure complete/partial (pie chart) Length, duration capacity planned (histograms)
Calendar stability	Possible unique paths for a 365 days train (nb), or comparison between 1 day / 365 days compressions, level of graphic timetable transparency (%)	Nb of versions / days of circulation (histogram) Changed paths from a year to another (nb) Level of graphic timetable transparency (%) Variability of runtime for a route (histogram) Variability of itinerary for a route (map)	Days with the same planned TCR (nb) Level of graphic timetable transparency (%)
Process stability	-	Stable planned paths across steps (rate)	Stable planned TCRs across steps (rate)
Real-data analysis	-	Delay increase per section (map) Nb of planned paths / real trains (map) Delays across the year / country (histogram) Delays at departure / arrival (map)	Used length / planned length (rate) Used duration / planned duration (rate) Used TCRs / planned TCRs (rate)

Main assumptions for this specific KPI

– Choice of the analysed days : dates without major delays at the borders

– Section cutting was done for the entire project. Here, more uniform lengths (runtimes) would have been better

– Segments less than 1 km long have been ignored

– For delay at first departure and at last arrival : we look also at every train starting (resp. ending) point and the entry (resp.) exit points of the area

Hurdles

– Availability of the data throughout the perimeter
→ the choice of days analysed may create a bias

– The main limit is the quality of the data :

→ Rounding of the measured and planned times

→ Number of measure points (different in the countries)

→ Unknown accuracy of measurements (effective or calculated stopping, starting or passing time)

Method
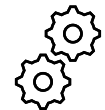
– The 1st step is to format the data to obtain for each measure point and each train, planned and measured time

– For each train and defined section, calculate : planned travel time, measured travel time, delay evolution

– For each section, calculate : amount of trains and mean value of the delay evolution pondered by section length

– Calculate for each entry and exit point of the area, mean delay of trains entering and leaving the section

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Real TCRs data analysis

|	Paths & TCRs	Paths	TCRs
Capacity consumption & residual capacity	Capacity consumption rates on sections (map) Capacity consumption rates on junctions (map) Capacity consumption rates on stations (map) Residual capacity (map & graphic timetable) Residual capacity (histogram)	-	-
Capacity consumption analysis	Signalling performance (map) Share TCR & paths / type (maps & histogram)	Paths volumes (maps) Runtimes heterogeneity (map and histograms) Timetable optimisation : sections, junctions (maps) Timetable optimisation : sections, junctions (histograms) Timetable optimisation : wasted capacity (nb)	TCRs volume (map)
General structure	Graphic timetable (graphic timetable) Number of trains / type + TCRs (24h histogram)		Nominal TCR structure (map)
Permeability	-	-	Rate of available capacity for a given path (rate on 1 or more itineraries)
Alternative routes	-	-	Days/nights with TCRs on all itineraries (histogram)
TCRs & Paths statistics	-	Runtimes, speeds, lengths (histograms & maps) Number of paths : year / weekdays (histograms) Number of paths (maps) Share of freight paths (map)	Planned capacity (maps & histograms) Typology of works day/night (pie chart) Typology of closure complete/partial (pie chart) Length, duration capacity planned (histograms)
Calendar stability	Possible unique paths for a 365 days train (nb), or comparison between 1 day / 365 days compressions, level of graphic timetable transparency (%)	Nb of versions / days of circulation (histogram) Changed paths from a year to another (nb) Level of graphic timetable transparency (%) Variability of runtime for a route (histogram) Variability of itinerary for a route (map)	Days with the same planned TCR (nb) Level of graphic timetable transparency (%)
Process stability	-	Stable planned paths across steps (rate)	Stable planned TCRs across steps (rate)
Real-data analysis	-	Delay increase per section (map) Nb of planned paths / real trains (map) Delays across the year / country (histogram) Delays at departure / arrival (map)	Used length / planned length (rate) Used duration / planned duration (rate) Used TCRs / planned TCRs (rate)

Main assumptions for this specific KPI

– Thresholds used to consider that a TCR is used (in distance and time)

– Considered step in the planning and allocation process where data is extracted ("planned" TCRs)

Hurdles

– Differences of "capacity language" between countries can lead to differences in representations and interpretations

– Data availability

– Method underlying the data collection (ex : measure of the track protections requests is less accurate than measure of the number of sleepers replaced)

Method
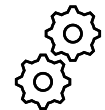
– For each day of each planned TCR, compare with planned situation :

  – Number of really used TCRs (according to assumptions, and considering the method used to collect the data)

  – Length really used

  – Duration really used, per track

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