

# Capacity KPIs and visualisations

## Annexes

Deliverable	3.1, 3.2, 3.3 : capacity KPIs and visualisations - Annexes
Date	08.03.2024
Version	4-01

# Annexes

1. Assumptions
2. Permeability
3. Capacity consumption rates
4. Calendar and process stability
5. Bottlenecks

# Diverse assumptions

- In all this study, the precision of the times (TCRs, trains) is maximum 6 seconds, and is given by the data and the data importation process (detailed in deliverables 1 and 2),
- All the maps represent a network splitted into sections : this split is the result of the decomposition below, calculated on all the 2022 year :

Elementary sections are cut :

- When the set of trains changes : trains origins, destinations, trains going to or coming from another section,
- Or when the infrastructure changes : number of tracks, and on the single tracks lines : crossing stations.

# Chosen routes

- “alternative itineraries” in case of TCR are considered as shown in the [KPI n°4] slides, these assumptions are the result of the collect and analysis of some data from the TCR planning rules in FR, BE, LU as well as from the TCR international planning rules,
- These assumptions are used in the various KPIs calculations, except for the residual capacity KPIs, for which the results of KPI [9] stability on itineraries, are added (paths are inserted in the timetable on the basis of the “real” used itineraries in 2022).

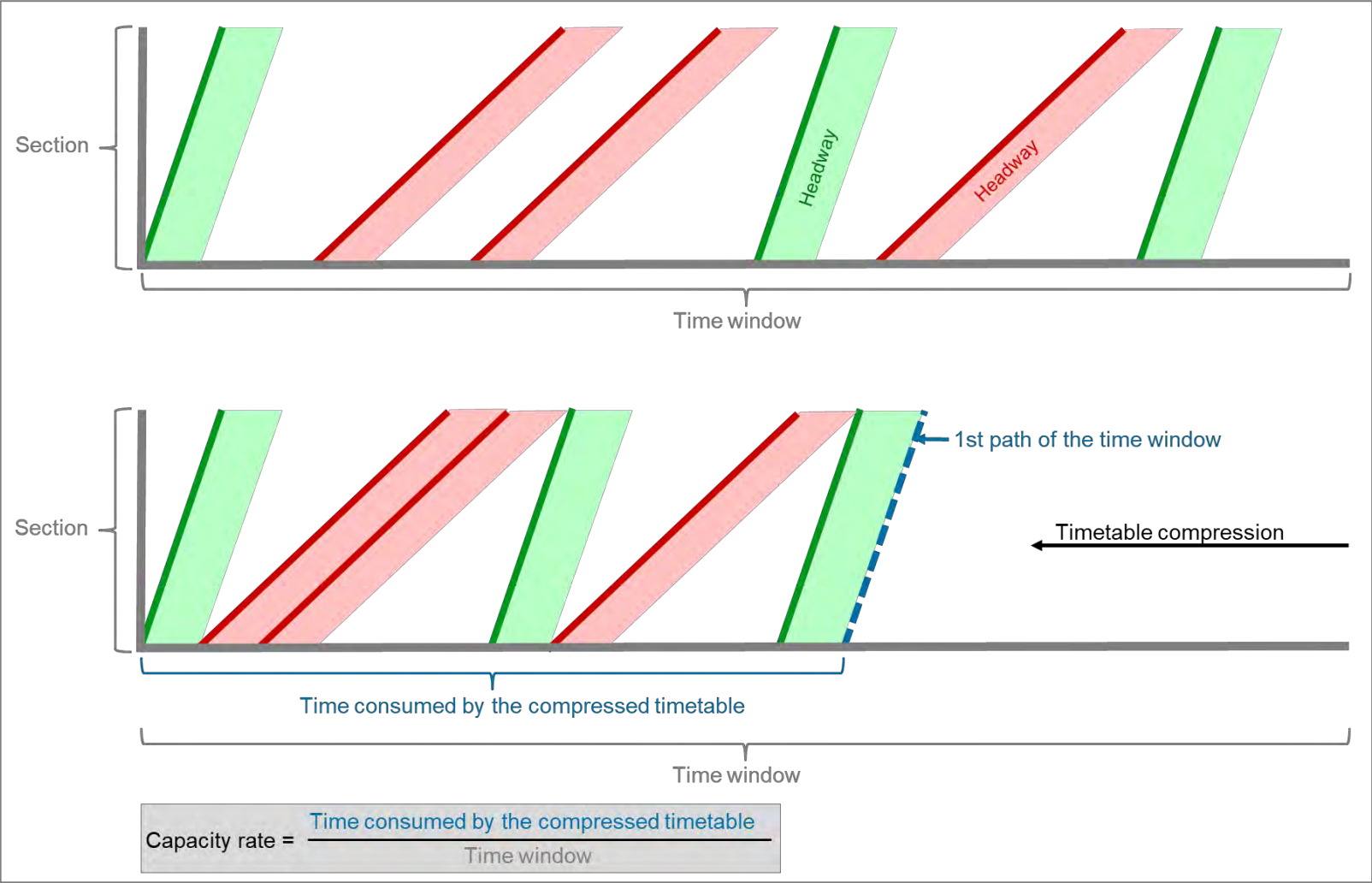
# Capacity consumption rate

The separation times considered are detailed in the deliverables 1 & 2.

- For Belgium, separation times come from the working group,
- For Luxembourg, separation times come from the working group,
- For France, separation times come from the “normes de tracé” : there is a difference, for some sections, stations, and junctions, between the official separation times which are given by the microscopic SIPH tool and the separation times considered here. This difference is considered non significant here at a macroscopic level,
- Junctions : in France, as junctions were not modelled in the provided infrastructure model, the value 4' is considered.

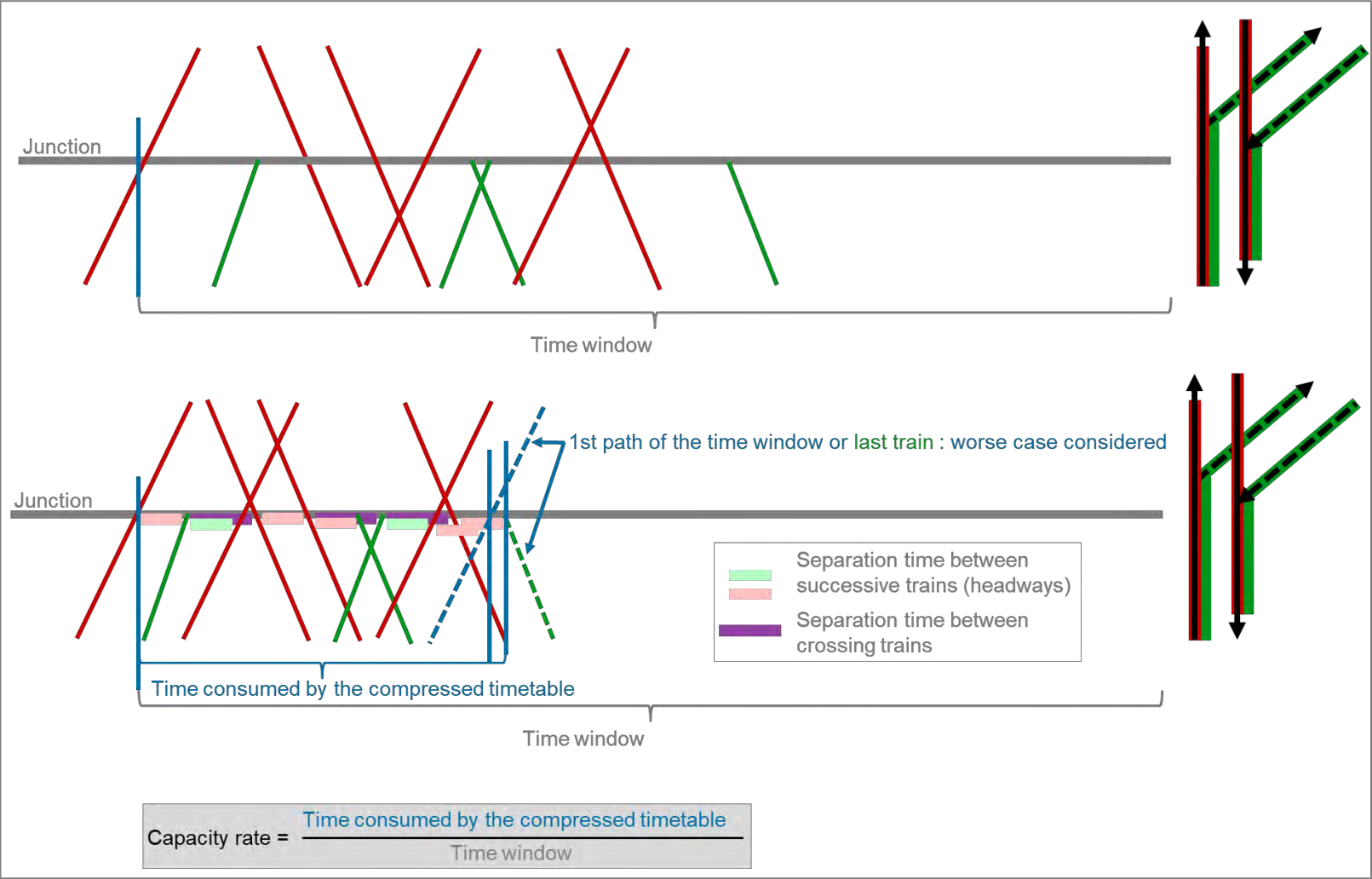
# Capacity consumption rate

Sections (2 tracks)



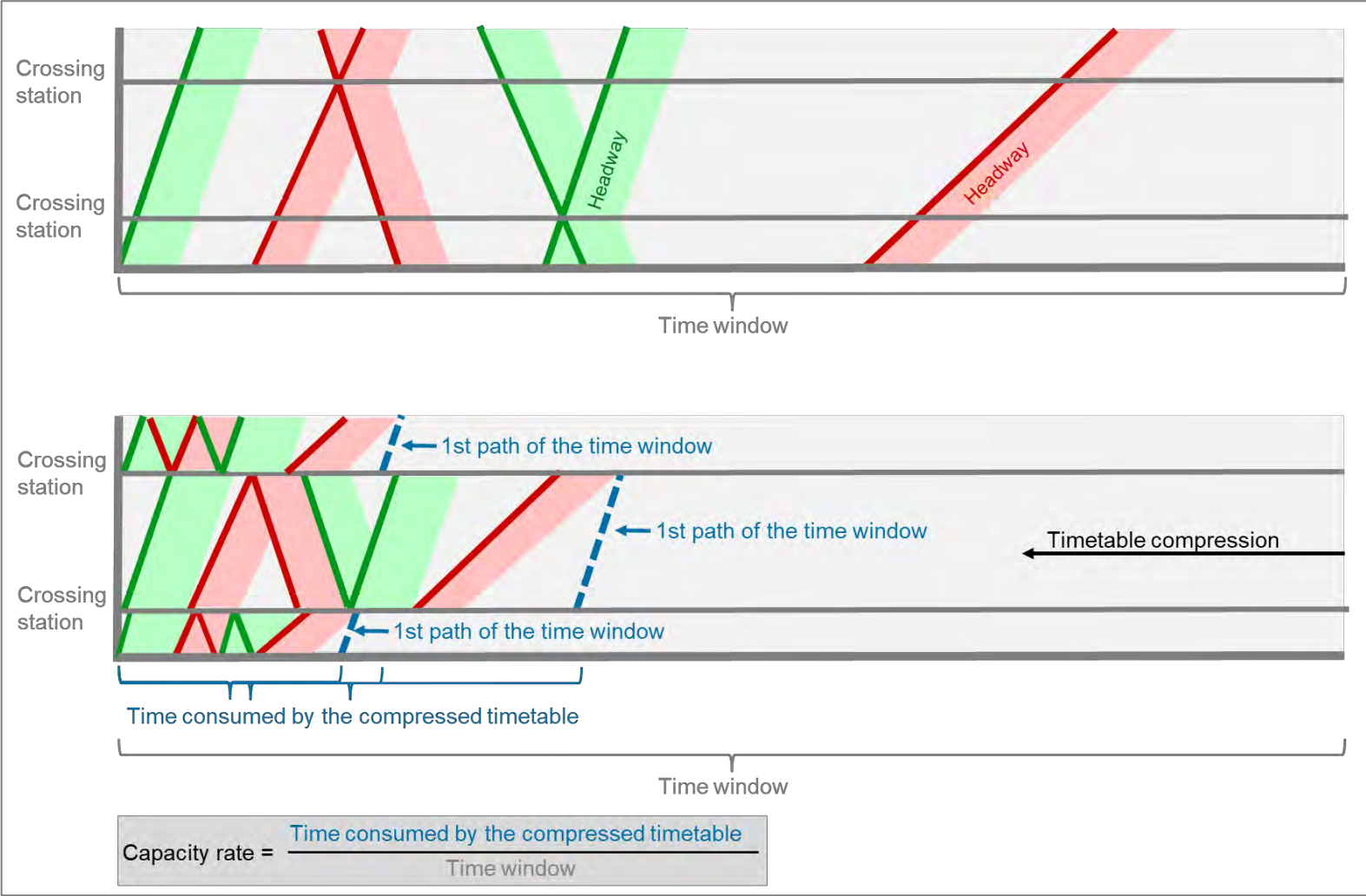
# Capacity consumption rate

## Junctions



# Capacity consumption rate

Sections (1 track)





# Capacity consumption rate

Sections with more than 2 tracks :

- If the trains can be, in real time, changed from a track to another, capacity rate considers all trains and divides by the number of tracks,
  - If the trains stay in their planned tracks in real time, capacity rate is calculated on the different track groups as if they were different sections
- The choice is done manually for every case in the perimeter

# Capacity consumption rate

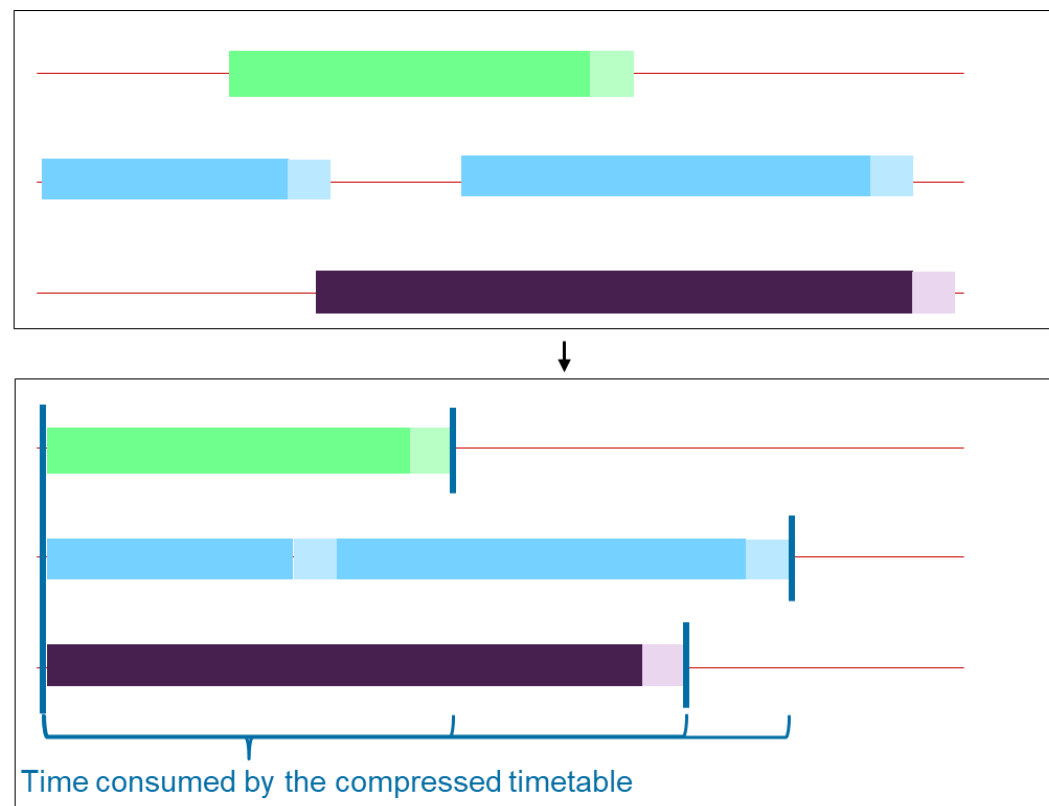
- The planned TCRs are considered, except in stations (see Deliverable “database constitution”),
- The planned time penalties for speed restrictions are not considered because not imported (see Deliverable “database constitution”),
- For the 1track/2 closures, we planned to manually identify them but on 4 years it's not possible, so it's considered no trains can run

# Capacity consumption rate in stations

Automatic method in Viriato

Capacity consumption rate in stations can be calculated by track if the track occupation plan is done, by considering for each track the stop times and separation times of the trains.

If not, it can be calculated for the entire station by adding the stop times and separation times of all trains and dividing by the number of tracks.



# Capacity consumption rate in stations

Manual method derived from UIC406

Capacity consumption rate : UIC 406 method for chosen stations.

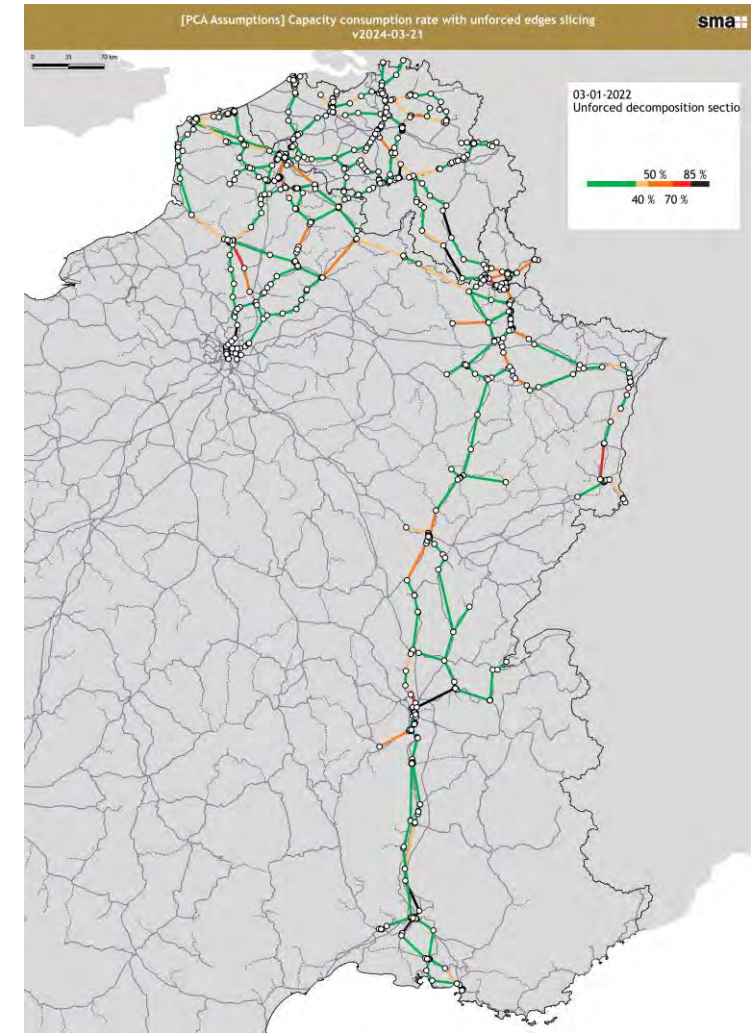
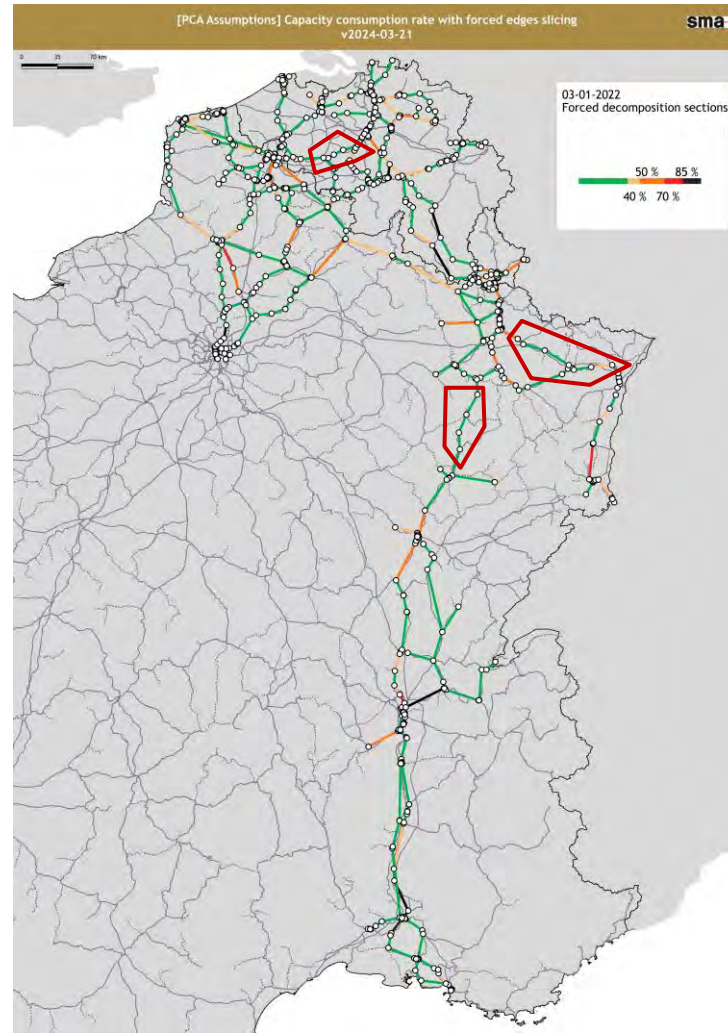
Interpretation of UIC 406 used in this capacity KPIs calculation work.

- Here headways margins are not known, so planning headways are considered and no other margin are added,
- A 1<sup>st</sup> step is added (except when real track occupation plans were given, in LUX, and Belgian stations) : optimisation of the track occupation plan if possible,
- The only considered interactions are those between non compatible itineraries,
- Except for the last train (copy of the 1<sup>st</sup> one), if the result value is < the value of the most longest incompatible trains sequency, this higher value is indicated in (),
- Stations tracks are not considered in the calculations for switches areas.

# Capacity consumption rate

Sensitivity testing of the assumption “always use the same network decomposition”.

→ Compression results on sections are not very sensitive to the decomposition considering all the trains in the year or only the trains of 1 day.

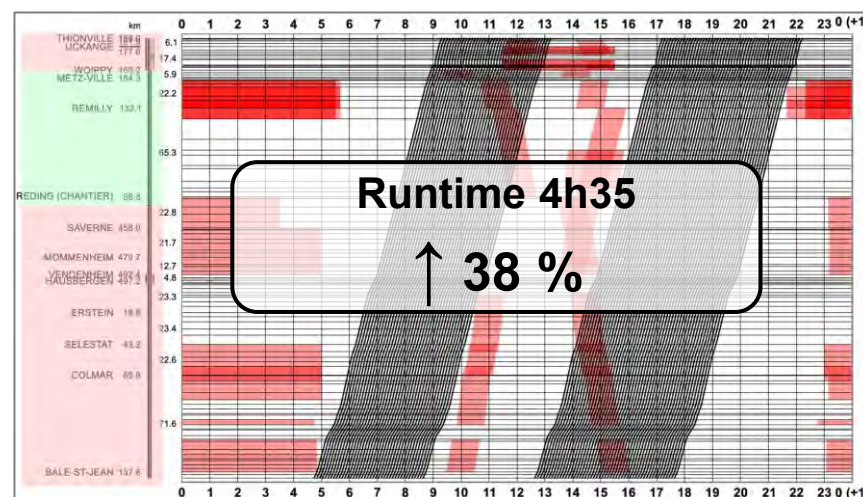
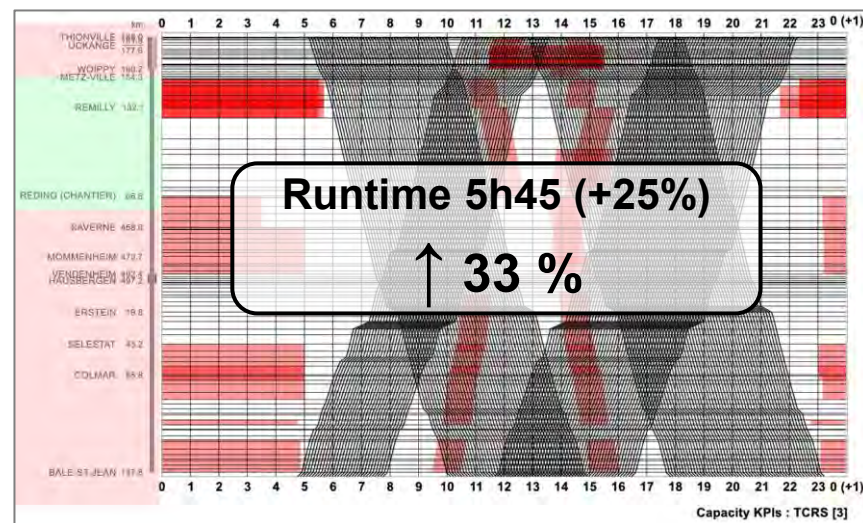




# Permeability

Sensitivity testing of the assumption “runtime on Thionville - Basel” (15.03.22).

Calculated % : usable capacity / total capacity, for 1 path, no path deformation possible (no added runtime), in a graphical timetable with only TCRs.



- With a longer runtime, permeability KPI is lower,
- The permeability KPI is not very sensitive to runtime variations,

→ This KPI has to be calculated  
 → On a given day  
 → On at least 1 given itinerary  
 → With a runtime / itinerary

# Choice of the analysed days

- Holidays were extracted of the data (FR, LUX, and BE),
- Some analyses were conducted on 365 days (sections compressions for 2022 for example),
- Other analyses were conducted for chosen days (real time, saturation, junctions, optimisation level)
- The chosen days are Tuesdays, Wednesdays or Thursdays, not on holidays, and not with too high or too low values,
- For the analyses on 5 days : 01.06, 17.06, 27.09, 06.10, 21.11,
- For the analyses on 10 days : 19.01, 28.01, 17.03, 22.03, 16.05, 01.06, 17.06, 27.09, 06.10, 21.11,
- For the analyses on 20 days : 19, 20, 21, 22, 23.09 ; 10, 11, 12, 13, 14.10, 17, 18, 19, 20, 21.10 ; 24, 25, 26, 27, 28.10
- For the analyses on 1 day : date is written directly on the page.

# Choice of the analysed stations

In France, the calculation is done on 2025+ data, because other data doesn't contain track occupation plans on chosen stations.

Some stations have been chosen by the IMs partners of the study to be studied manually, with the UIC 406 method.



# Assumptions for TCRs KPIs

- TCRs « fenêtres de surveillance » « blancs-travaux » are excluded for the TCR statistical analyses, but not for compressions and path search,
- For permeability, if there is a TCRs “1 track / 2” with possibility of opposite direction circulation, the 2 directions trains are placed in batteries of 1/2h.
- For [4] alternatives routes, only > 3h TCRs are considered, and 1 track/2 TCRs are not considered

# Planning method in stations

- Technical movements : for trains storage, for trains maintenance, for refuel, etc. are often not modelled, although it consumes capacity. As it seems not modelled for all the 3 countries, it's not considered here, but this assumption could lead to optimistic results,
- The “empty runs” modelled are by default considered, but for some KPIs the calculation are done with and without empty runs, or completely without empty runs, if applicable, it's notified.

# Train types (categorisation)

Colours represent how paths are displayed in the graphic timetables.

Trains are imported with their « train type », and the following categories are built by grouping some train types. If the train types are not modelled, wrongly modelled, or not well imported, it could lead to errors.

**High speed trains** : TGV, GV, THAL, EURST, FRz, ICE

**Freight** : MA, ME, HKM4, HKM5, MV160, Gz

**Regional passenger trains** : IC, ICT, IZY, TER, L, P, INT, Rz

**Others** : TT, TN, HLP, Lz, Bauzug, HPM, HPV

**Empty runs** : HLP, Bauzug, HPM, HPV

# Diverse assumptions

- Trains and TCRs are considered in the perimeter if they run / are planned on at least one section of the perimeter,
- Trains (train numbers) are sometimes cut into 2 parts in Belgium, with the 2<sup>nd</sup> part appearing as a version (variant),
- When the tool switches paths (optimisation level), paths are switches with each other on a 30 min basis,
- For the capacity sharing histograms ([7]), a 1<sup>st</sup> approximation is used : 3 timetable compression are realised, with TCRs and freight trains, without TCRs and freight trains, with freight trains but no TCRs, and the difference of sections compression rates is used to calculate the shares. Another interesting method would be to estimate the capacity consumptions for freight / passenger trains and TCRs using, for the trains, the **runtime difference with the average runtime for the section (this method was shown in the previous PoC).**

ASSUMPTION :  
CHOICE OF  
MACROSCOPIC  
APPROACH

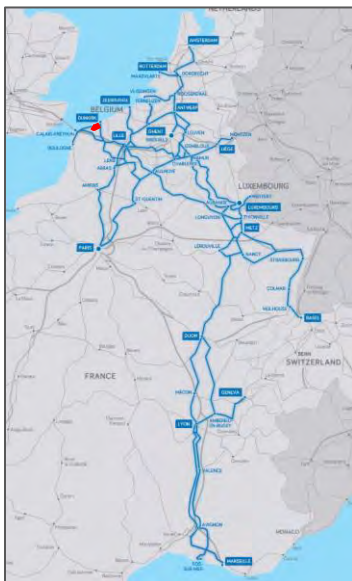
# Macro/micro comparison

## Dunkerque – Gravelines / Micro (SIPH)

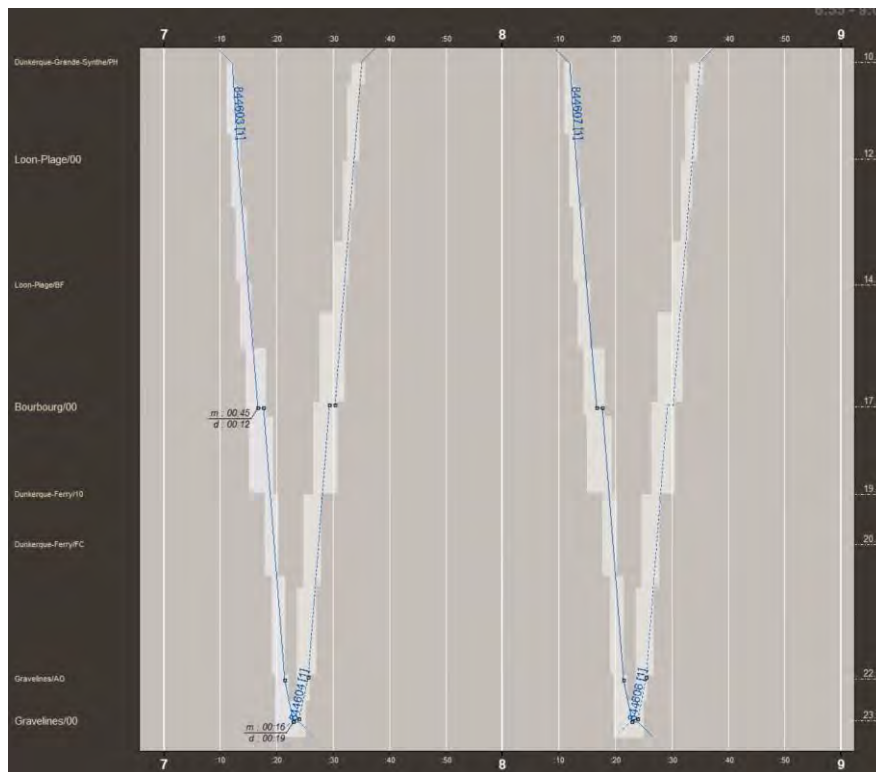
Elementary section  
Dunkerque/PH-  
Gravelines  
(France, 304 000)

7am-9am

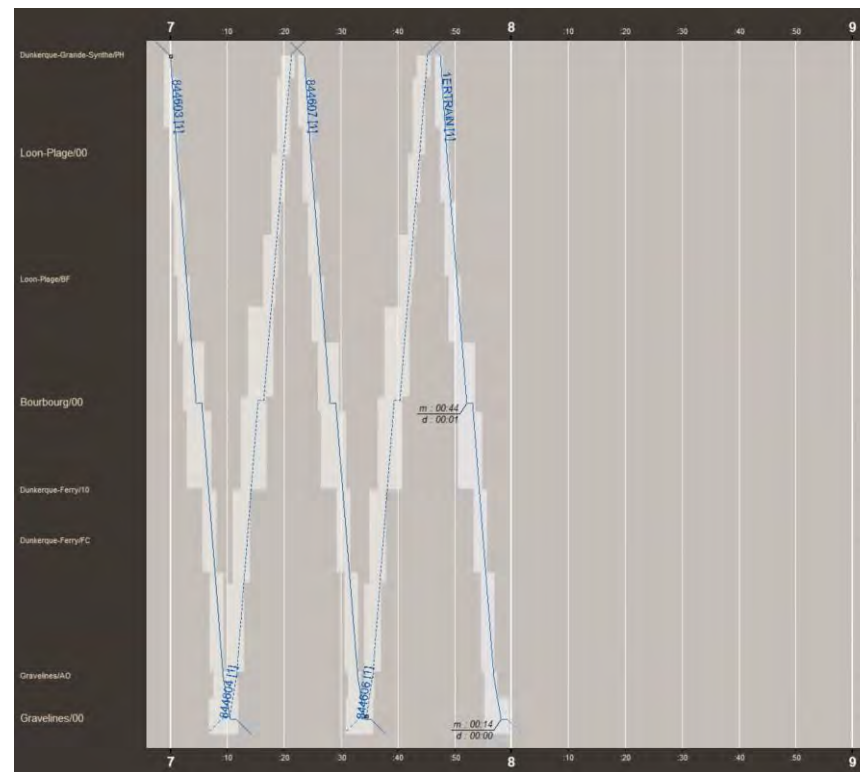
Compression result  
: **40%** of capacity  
used (micro)



Nominal timetable (25/04/2023) :



Compression result (25/04/2023) :



ASSUMPTION :  
CHOICE OF  
MACROSCOPIC  
APPROACH

# Macro/micro comparison

## Dunkerque – Gravelines / Macro (Viriato)

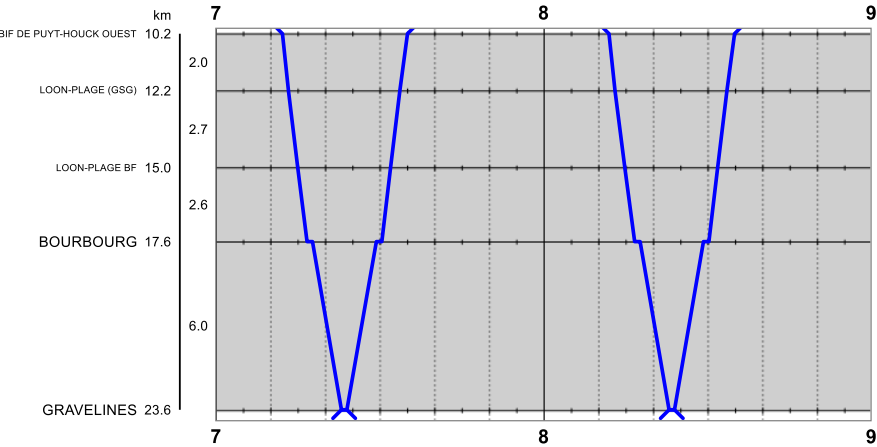
Elementary section  
Dunkerque/PH-  
Gravelines  
(France, 304 000)

7am-9am

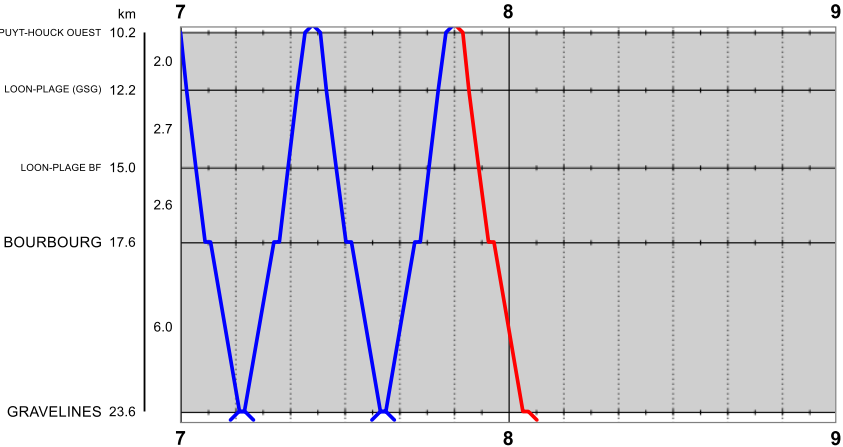
Compression result  
: **43%** of capacity  
used (macro)



Nominal timetable (25/04/2023) :



Compression result (25/04/2023) :



Separation times used (published by SNCF Réseau) : 1 min in Gravelines, 2.5 min in Puyt-Houck Ouest junction, more pessimistic than what SIPH allows.



ASSUMPTION :  
CHOICE OF  
MACROSCOPIC  
APPROACH

# Macro/micro comparison

Don-Sainghin – bif. de Sallaumines (Lens) / Micro (SIPH)

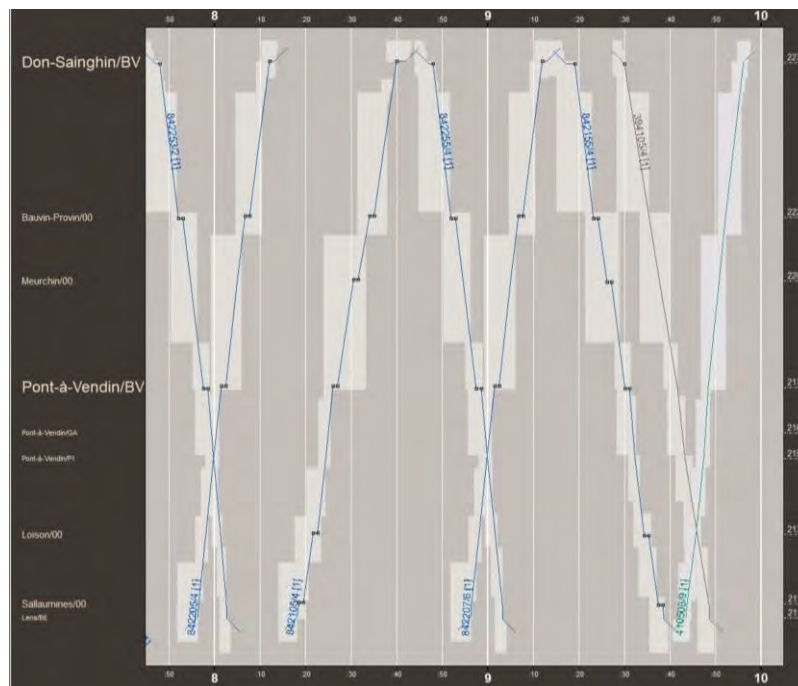
Elementary section  
Don-Sainghin-bif.  
de Sallaumines  
(France, 286 000)

7:45am-9:45am

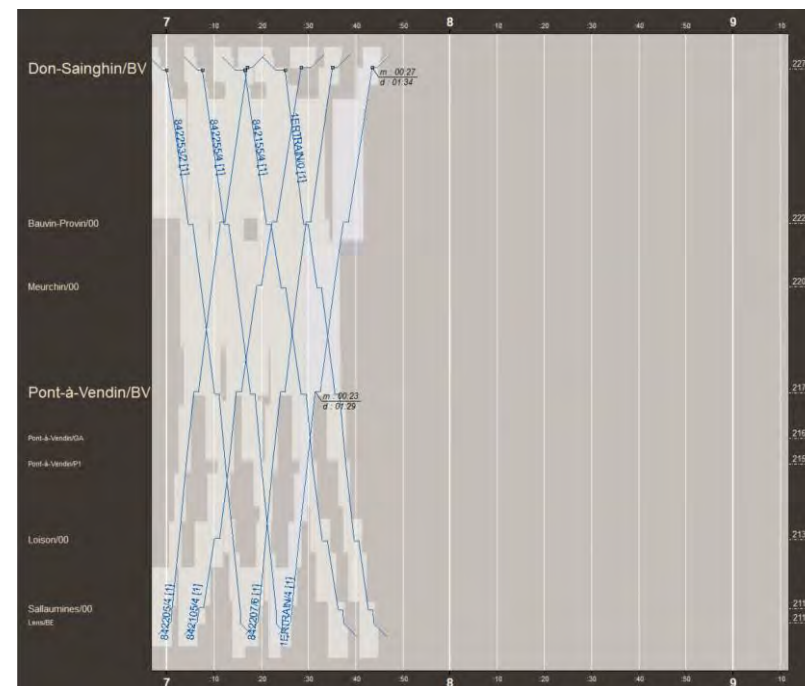
Compression result  
: up = down = **21%**  
of capacity used



Nominal timetable (11/04/2023) :



Compression result (11/04/2023) :



ASSUMPTION :  
CHOICE OF  
MACROSCOPIC  
APPROACH

# Macro/micro comparison

Don-Sainghin – bif. de Sallaumines (Lens) / Macro (SIPH)

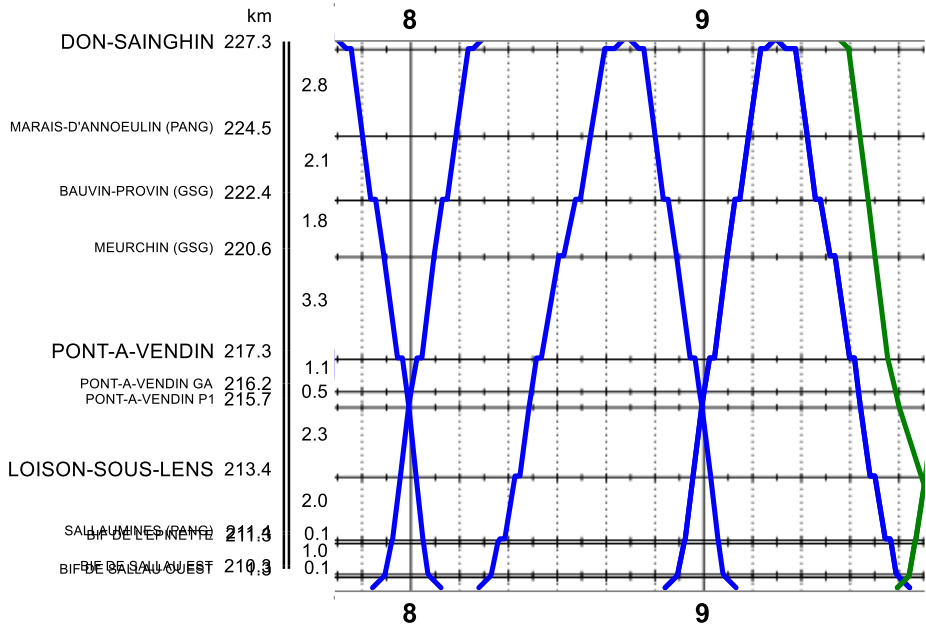
Elementary section  
Don-Sainghin-bif.  
de Sallaumines  
(France, 286 000)

7:45am-9:45am

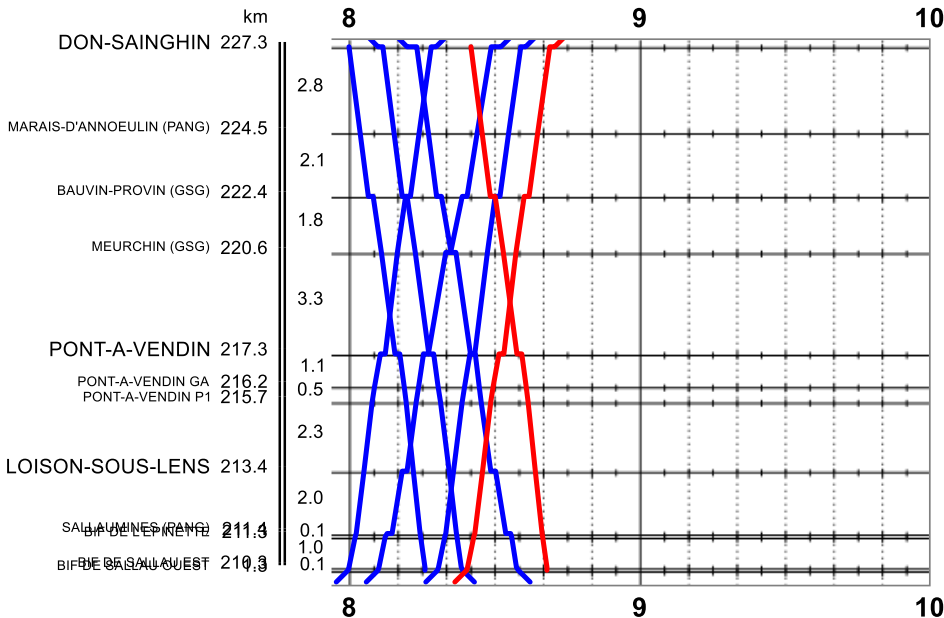
Compression result  
: up = down = **21%**  
of capacity used



Nominal timetable (11/04/2023) :



Compression result (11/04/2023) :



Headway (slow passenger train) : 6 min

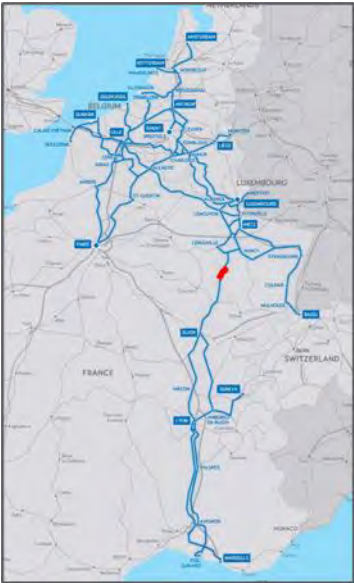


ASSUMPTION :  
CHOICE OF  
MACROSCOPIC  
APPROACH

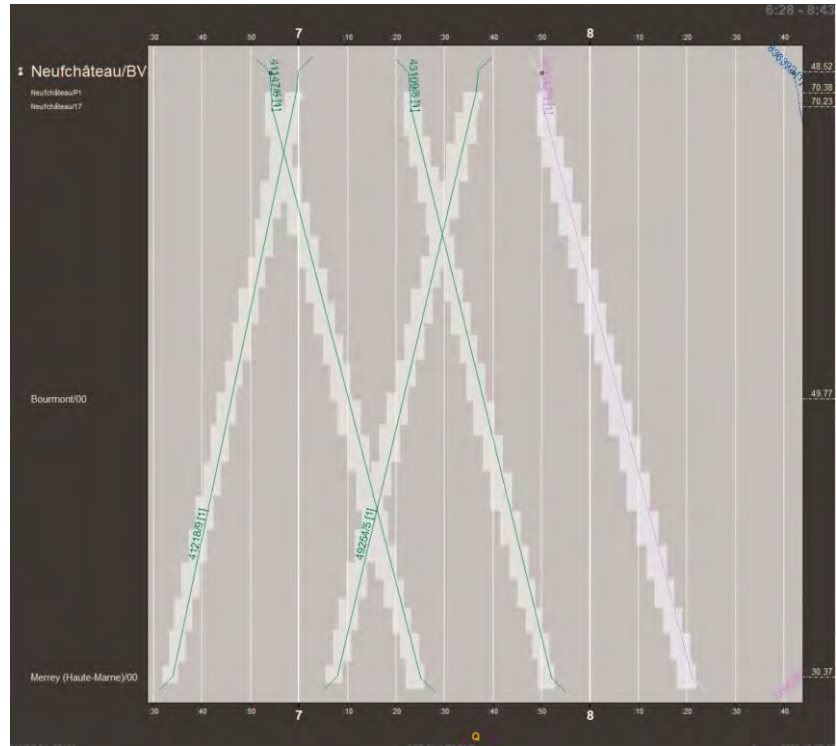
# Macro/micro comparison

## Neufchâteau – Merrey / Micro (SIPH)

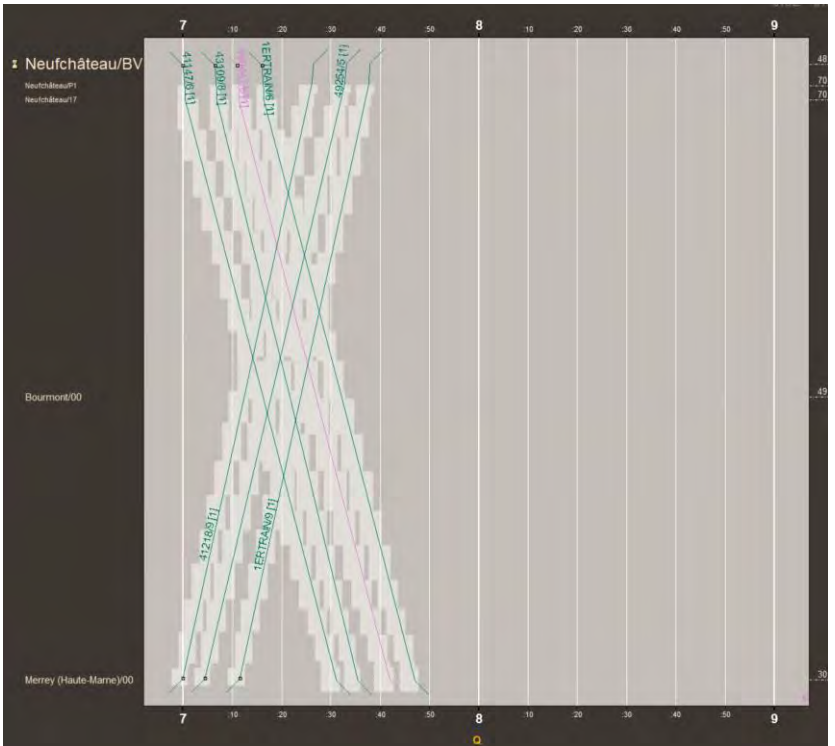
Elementary section  
Neufchâteau –  
Merrey (France,  
032 000)  
6:30am-8:30am  
Compression result :  
up **10%**, down **14%**  
of capacity used



Nominal timetable (11/04/2023) :



Compression result (11/04/2023) :



ASSUMPTION :  
CHOICE OF  
MACROSCOPIC  
APPROACH

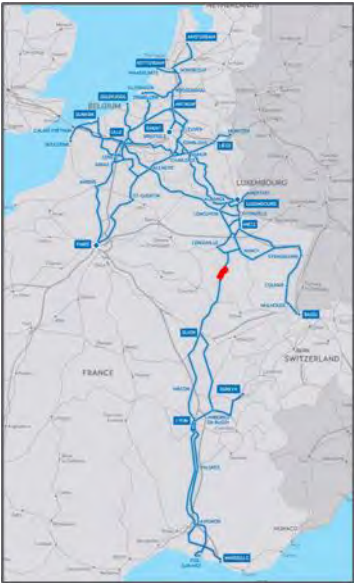
# Macro/micro comparison

## Neufchâteau – Merrey / Macro (SIPH)

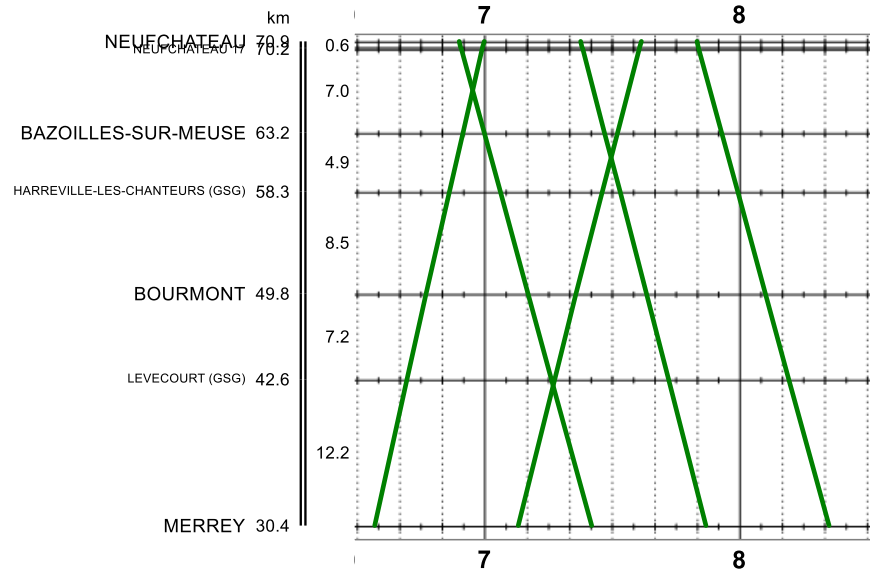
Elementary section  
Neufchâteau –  
Merrey (France,  
032 000)

6:30am-8:30am

Compression result :  
up **11%**, down **14%**  
of capacity used

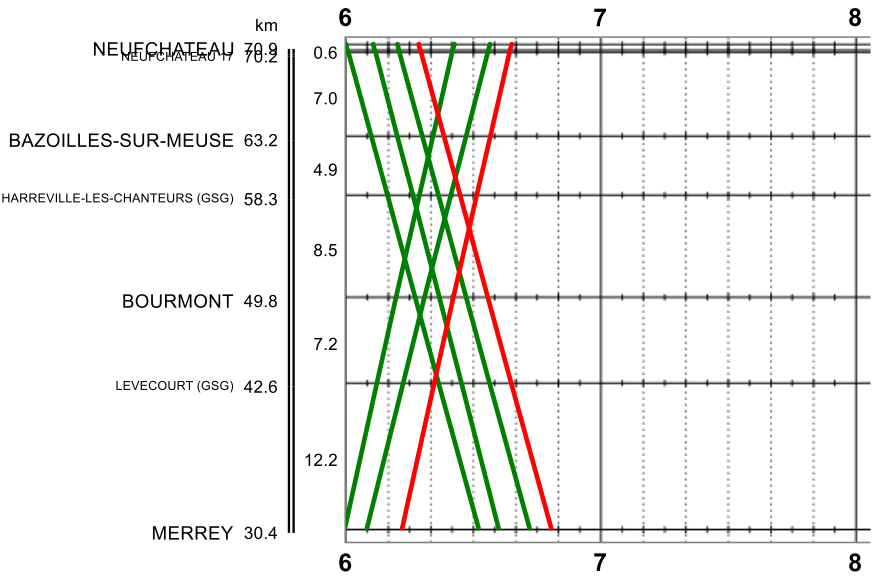


Nominal timetable (11/04/2023) :



Headway (freight) : 5 min

Compression result (11/04/2023) :

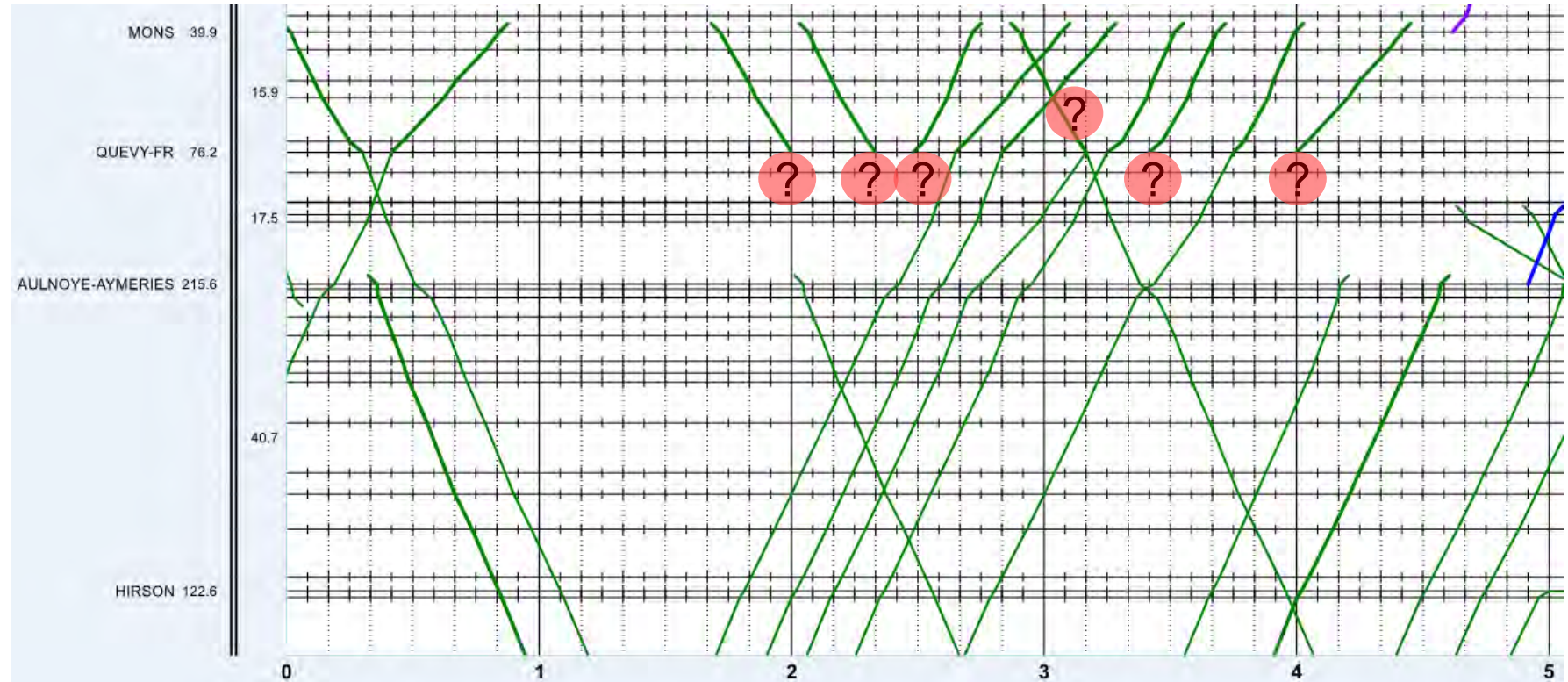


# Planned trains at frontiers

29.09.2022

Example of non-matching planned trains at the French/Belgium frontier of Quévy.

- Sometimes trains do not match at frontiers (possibly extracted before the IMs coordination)
- These trains are still considered here in the analyses



# Annexes

1. Assumptions
2. **Permeability**
3. Capacity consumption rates
4. Calendar and process stability
5. Bottlenecks



AVAILABLE  
CAPACITY AT A  
GIVEN MOMENT  
(2022)

On the chosen  
itinerary for each  
chosen route.

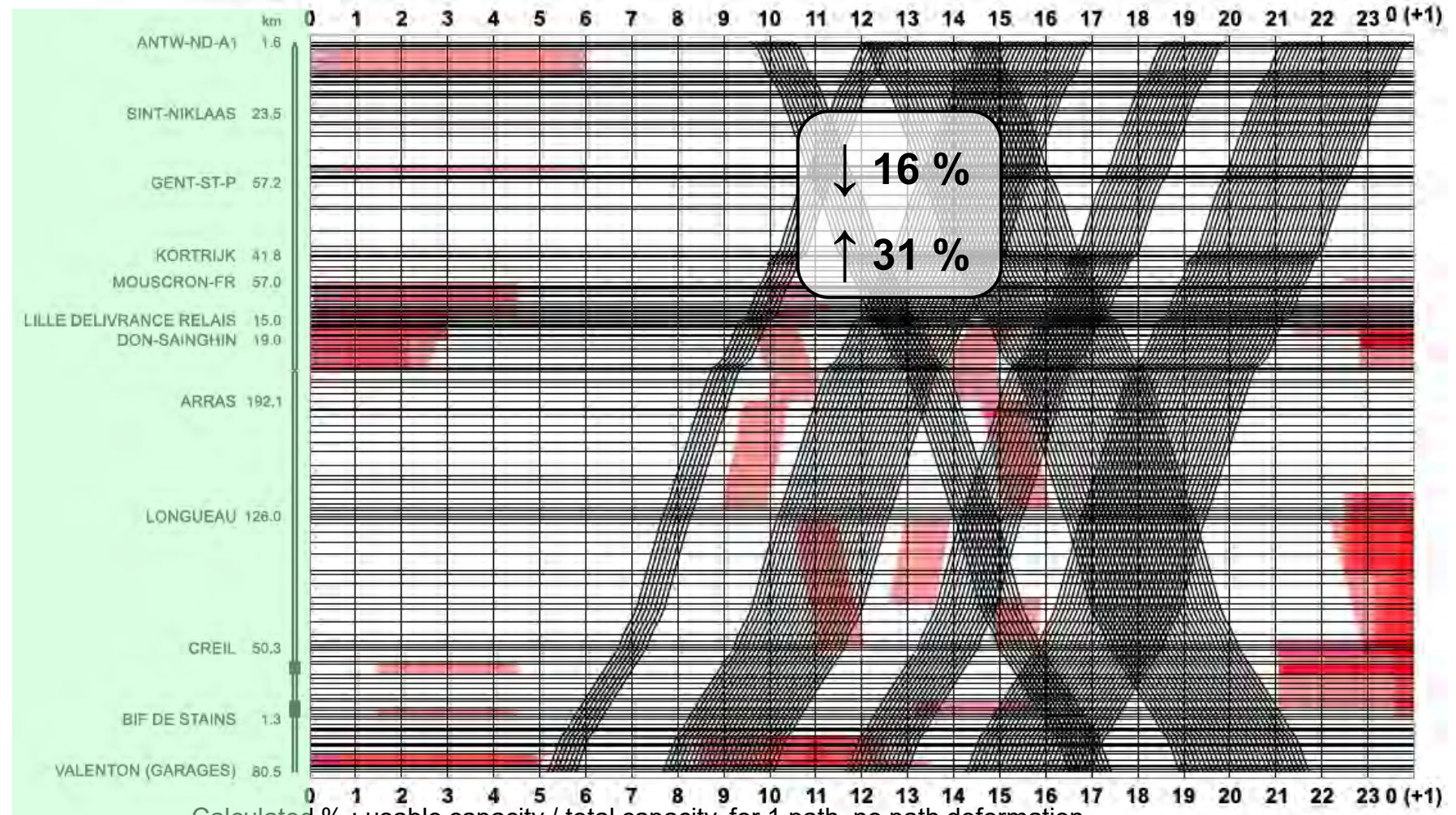
On a date which is  
near to the median  
hours x km of the  
year.

Anvers – Paris for  
the 20.06.22.

⚠ non alignments  
can be linked to  
other traffics or  
other constraints.

⚠ Operational  
choices of the RU  
can have an impact  
on the “raw”  
runtime used here.

## [3] Permeability of the TCRs structure → are the planned TCRs aligned for freight routes ?



Calculated % : usable capacity / total capacity, for 1 path, no path deformation  
possible (no added runtime), in a graphical timetable with only TCRs



AVAILABLE  
CAPACITY AT A  
GIVEN MOMENT  
(2022)

### [3] Permeability of the TCRs structure → are the planned TCRs aligned for freight routes ?

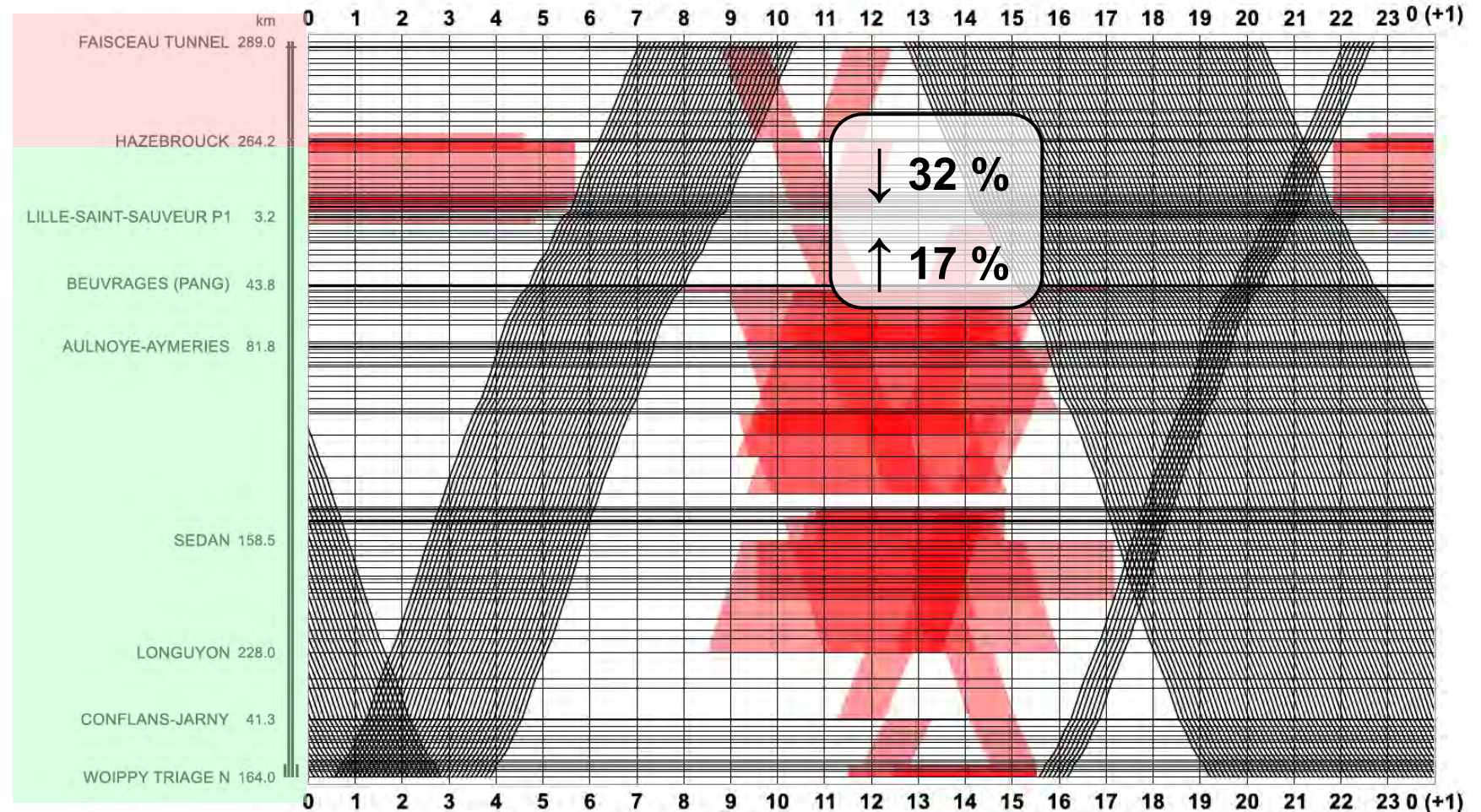
On the chosen  
itinerary for each  
chosen route.

On a date which is  
near to the median  
hours x km of the  
year.

Calais – Woippy for  
the 12.04.22.

⚠ non alignments  
can be linked to  
other traffics or  
other constraints.

⚠ Operational  
choices of the RU  
can have an impact  
on the “raw”  
runtime used here.



Calculated % : usable capacity / total capacity, for 1 path, no path deformation  
possible (no added runtime), in a graphical timetable with only TCRs

Capacity KPIs : TCRs [3]



AVAILABLE  
CAPACITY AT A  
GIVEN MOMENT  
(2022)

### [3] Permeability of the TCRs structure → are the planned TCRs aligned for freight routes ?

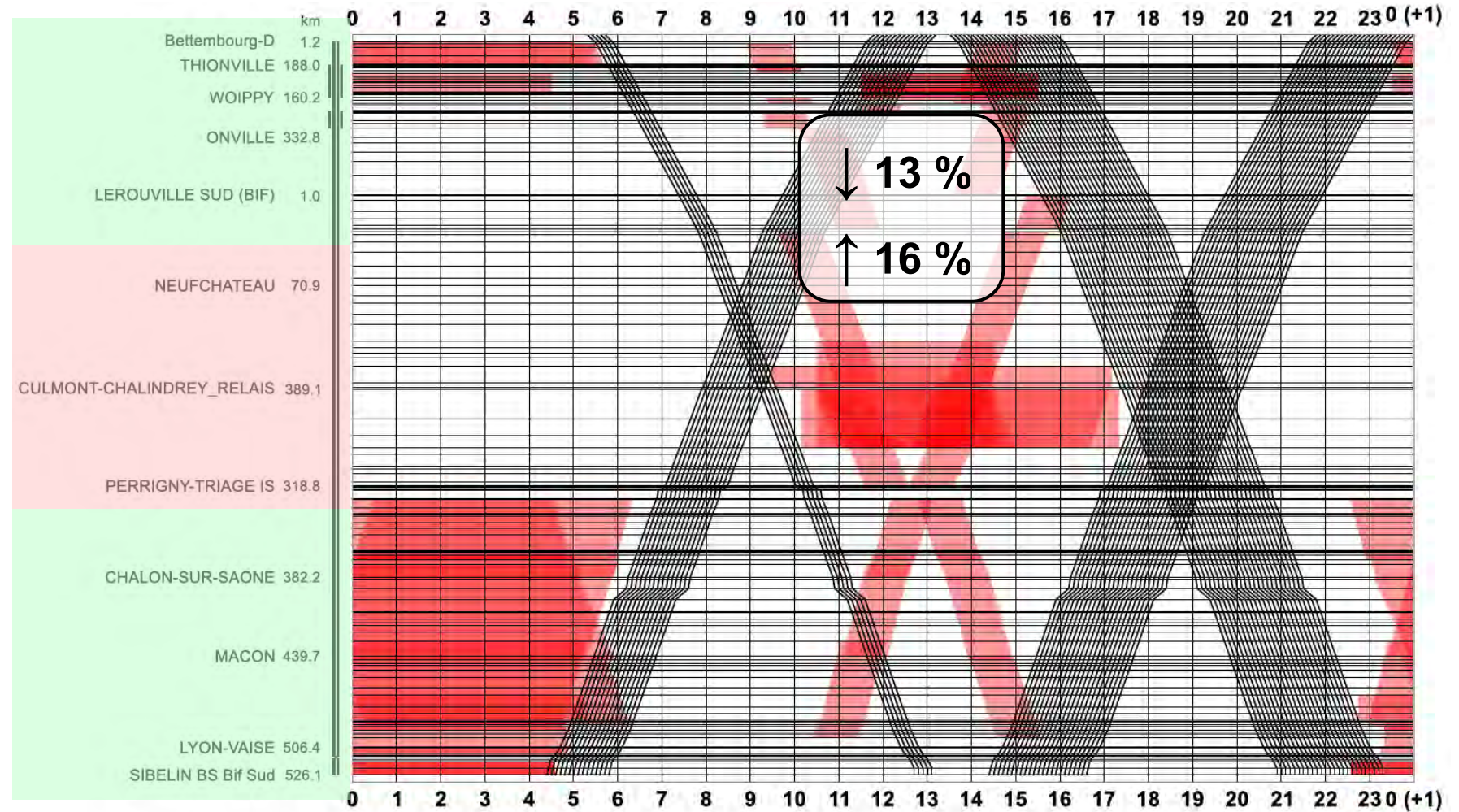
On the chosen  
itinerary for each  
chosen route.

On a date which is  
near to the median  
hours x km of the  
year.

Bettembourg –  
Lyon for the  
30.03.22.

⚠ non alignments  
can be linked to  
other traffics or  
other constraints.

⚠ Operational  
choices of the RU  
can have an impact  
on the “raw”  
runtime used here.



Calculated % : usable capacity / total capacity, for 1 path, no path deformation  
possible (no added runtime), in a graphical timetable with only TCRs

Capacity KPIs : TCRS [3]



AVAILABLE  
CAPACITY AT A  
GIVEN MOMENT  
(2022)

On the chosen  
itinerary for each  
chosen route.

On a date which is  
near to the median  
hours x km of the  
year.

Bettembourg –  
Lyon for the  
**30.03.22** without  
the TCR Toul –  
Culmont.

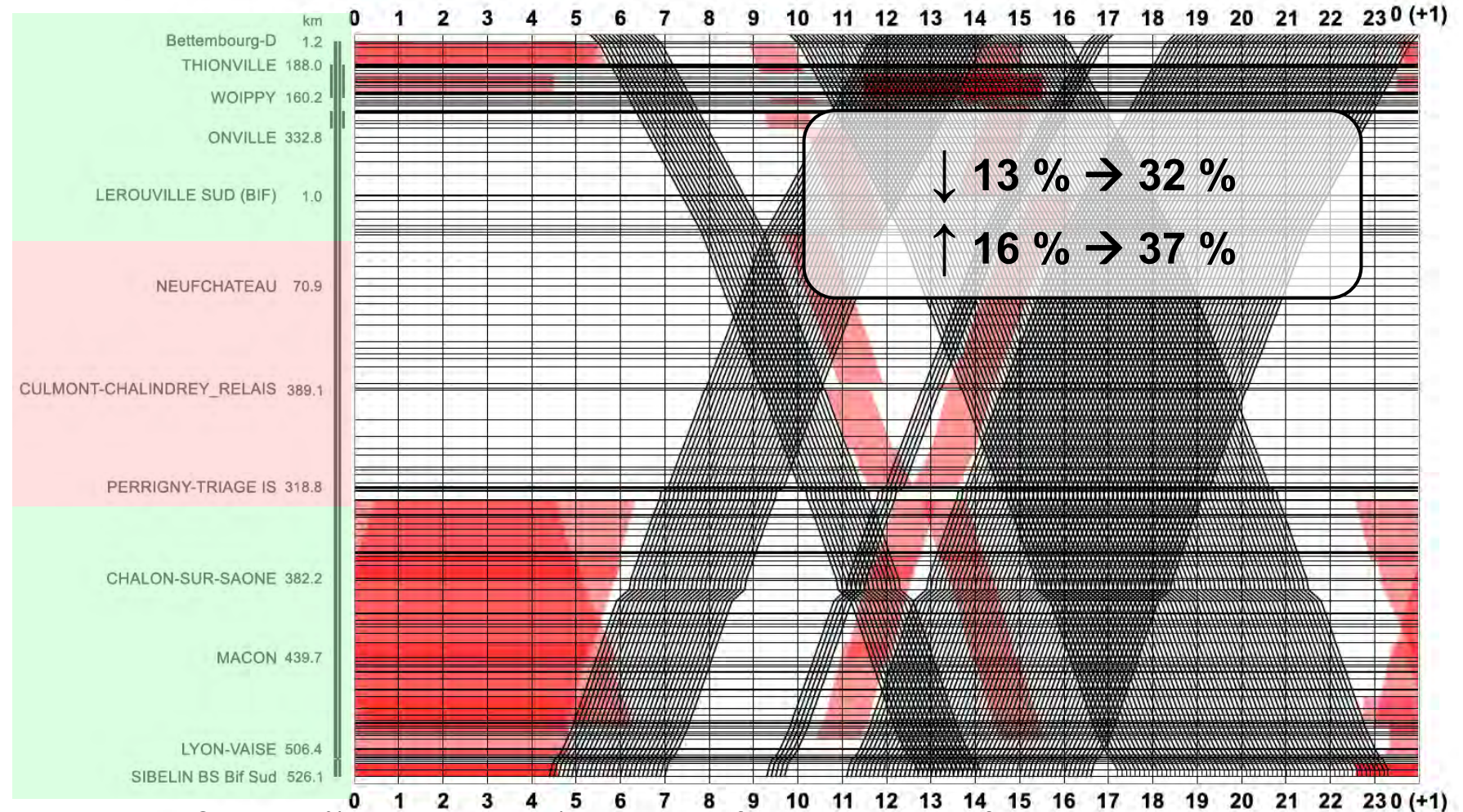
⚠ non alignments  
can be linked to  
other traffics or  
other constraints.

⚠ Operational  
choices of the RU  
can have an impact  
on the “raw”  
runtime used here.

### [3] Permeability of the TCRs structure

→ are the planned TCRs aligned for freight routes ?

→ easy measure of a new TCR impact on available capacity



Calculated % : usable capacity / total capacity, for 1 path, no path deformation  
possible (no added runtime), in a graphical timetable with only TCRs

Capacity KPIs : TCRs [3]

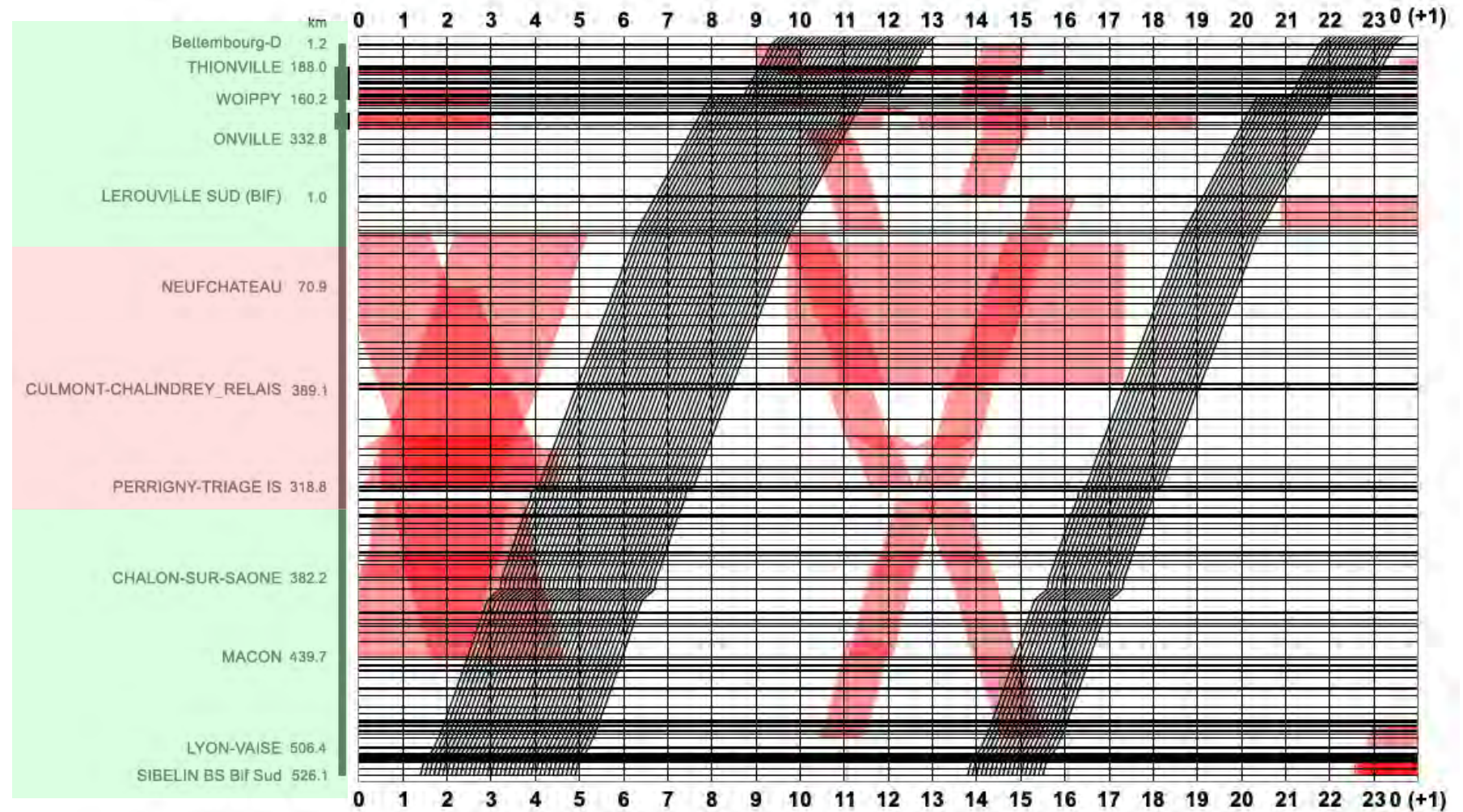


AVAILABLE  
CAPACITY AT A  
GIVEN MOMENT  
(2022)

Bettembourg –  
Lyon for the  
07.02.22.

⚠ Operational  
choices of the RU  
can have an impact  
on the “raw”  
runtime used here  
→ example here  
with a stop at  
Woippy

## [3] Permeability of the TCRs structure → are the planned TCRs aligned for freight routes ?



Calculated % : usable capacity / total capacity, for 1 path, no path deformation possible (no added runtime), in a graphical timetable with only TCRs

Capacity KPIs : TCRS [3]



AVAILABLE  
CAPACITY AT A  
GIVEN MOMENT  
(2022)

On the chosen  
itinerary for each  
chosen route.

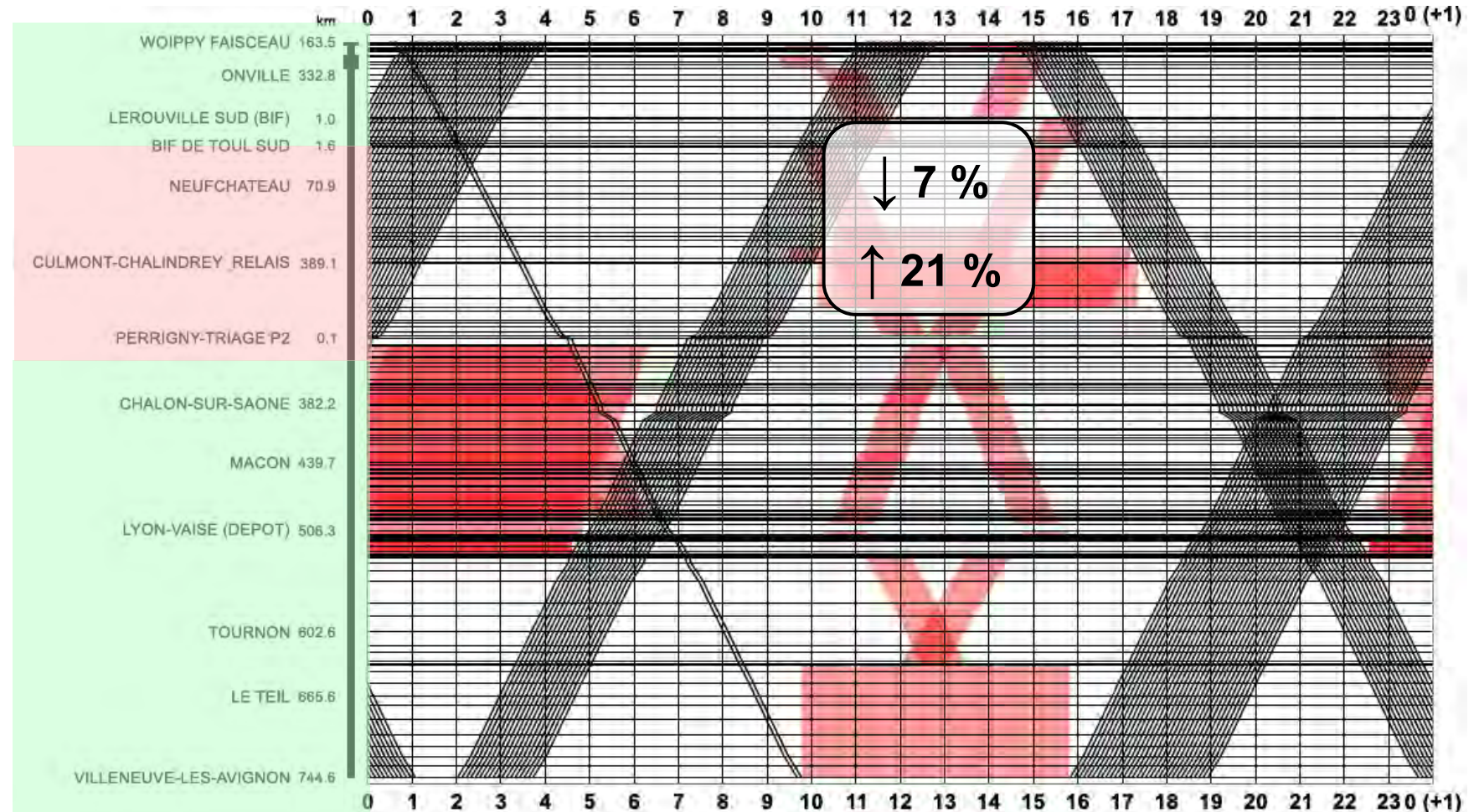
On a date which is  
near to the median  
hours x km of the  
year.

Anvers – Paris for  
the 29.03.22.

⚠ non alignments  
can be linked to  
other traffics or  
other constraints.

⚠ Operational  
choices of the RU  
can have an impact  
on the “raw”  
runtime used here.

### [3] Permeability of the TCRs structure → are the planned TCRs aligned for freight routes ?



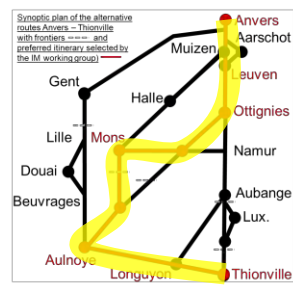
Calculated % : usable capacity / total capacity, for 1 path, no path deformation  
possible (no added runtime), in a graphical timetable with only TCRs

Capacity KPIs : TCRS [3]



AVAILABLE  
CAPACITY AT A  
GIVEN MOMENT  
(2022)

### [3] Permeability of the TCRs structure → are the planned TCRs aligned for freight routes ?



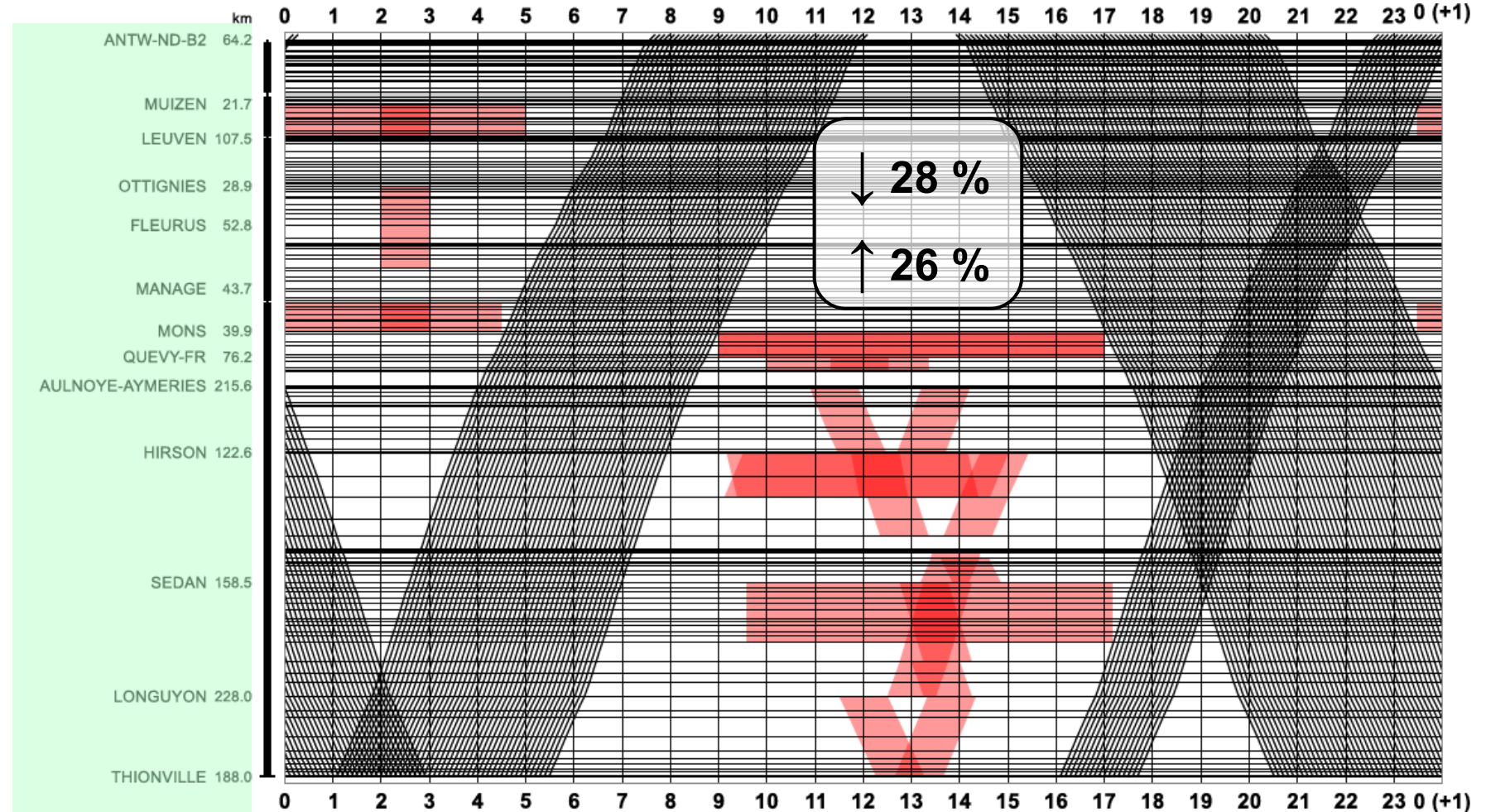
On all alternative itineraries for this route.

On a date which is near to the median hours x km of the year.

Anvers – Thionville for the 08.06.22.

⚠ non alignments can be linked to other traffics or other constraints.

⚠ Operational choices of the RU can have an impact on the “raw” runtime used here.



Calculated % : usable capacity / total capacity, for 1 path, no path deformation possible (no added runtime), in a graphical timetable with only TCRs

Capacity KPIs : TCRS [3]

# Annexes

1. Assumptions
2. Permeability
3. Capacity consumption rates
4. Calendar and process stability
5. Bottlenecks

AVAILABLE  
CAPACITY AT A  
GIVEN MOMENT  
(2022)

## [6] Capacity consumption rates

Sections – average compression rates

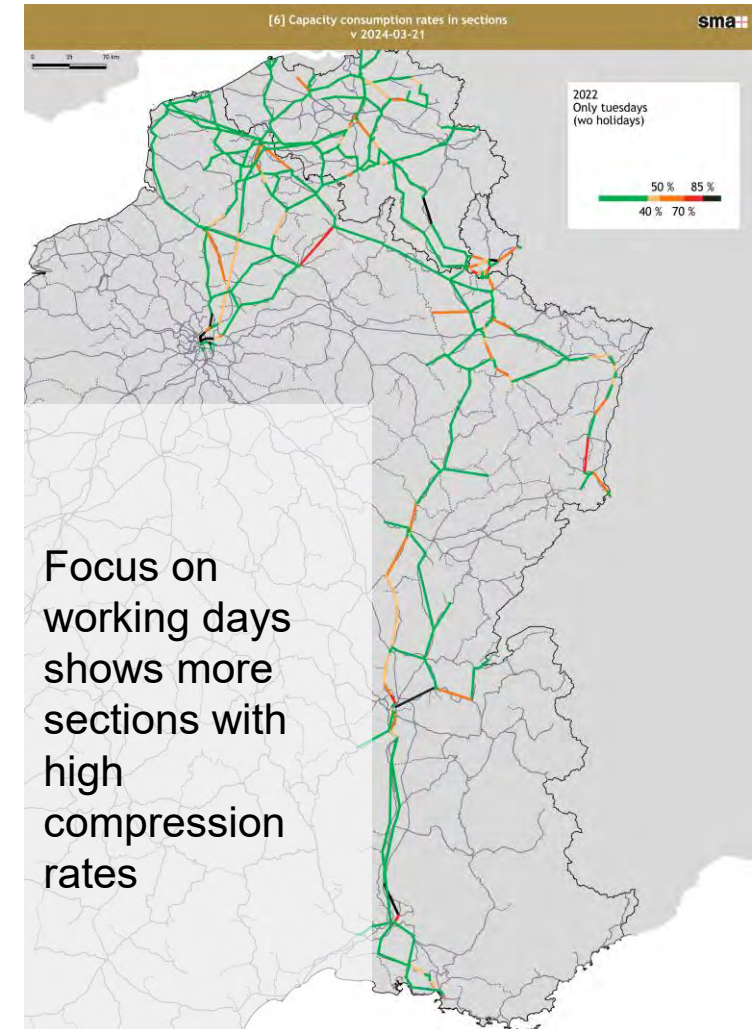
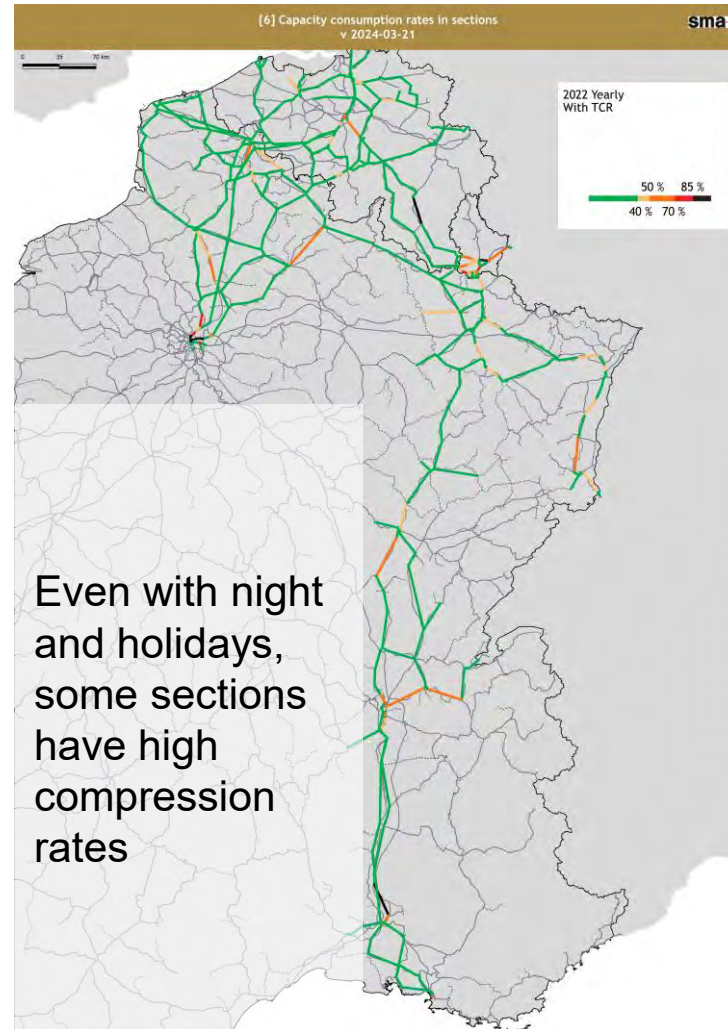
Left : compression  
all days all hours

Right :  
compression for  
Tuesdays (no  
holidays) all hours

No empty runs

With TCRs

All year 2022





AVAILABLE  
CAPACITY AT A  
GIVEN MOMENT  
(2022)

[6] Capacity consumption rates

Stations - Example of Thionville

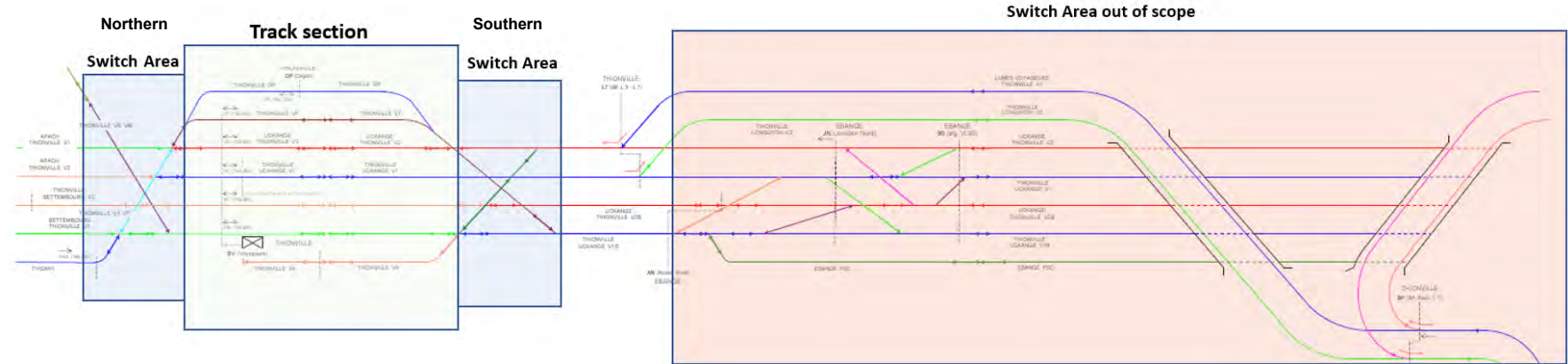
Layout and scope  
of the study in  
Thionville station.

All trains (passenger and freight) between 8am and 10am of the  
“maquette 24h” 2025 PER are considered.

The station is  
divided into 3  
studied areas :  
tracks section, and  
2 switch areas.

Other switch areas  
are out of scope,  
as well as  
junctions.

Definition of  
possible routes



South direction routes			North Direction Routes		
p1	Lux - Metz	V1bet - VB - V1	p0	Metz - Lux	V2bis - VD - V2bet
p3	Lux - Metz	V1bet - VB - V1bis	p2	Metz - Lux	V2bis - VE - V2bet
p5	Lux-Nancy	V1bet - VB - V1bis	p4	Nancy-Lux	V2bis - VD - V2bet
p7	Lux-Nancy	V1bet - VC - V1bis	p6	Nancy-Lux	V2bis - VE - V2bet
p9	BET - WPY	V1bet - VB - V1bis	p8	WPY - BET	V2bis - VE - V2bet
p11	Lux -Paris	V1bet - VC - V1bis	p10	Paris - Lux	V2bis - VD - V2bet
p13	Lux - Stras	V1bet - VC - V1bis	p12	Stras - Lux	V2bis - VC - V2bet
p15	SBH - THL	V2ap -1M	p14	THL - SBH	2M - V1ap
p17	AP - WPY	V2ap - VB - V1B	p16	WPY - AP	V2bis - V2M - V1ap
p19	TRZ-MZ	V2ap-VE-V1	p18	MZ -TRZ	V2bis - V2M -V1ap
p21	THL - LGN	1M - V1	p20	LGN - THL	V1 - V2M
p23	Lux - THL	V1BET-VC	p22	THL-Lux	VD - V2bet
p25	THL -WPY	1M - 1bis	p24	WPY - THL	V2bis - 2M

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# [6] Capacity consumption rates

## Stations - Example of Thionville

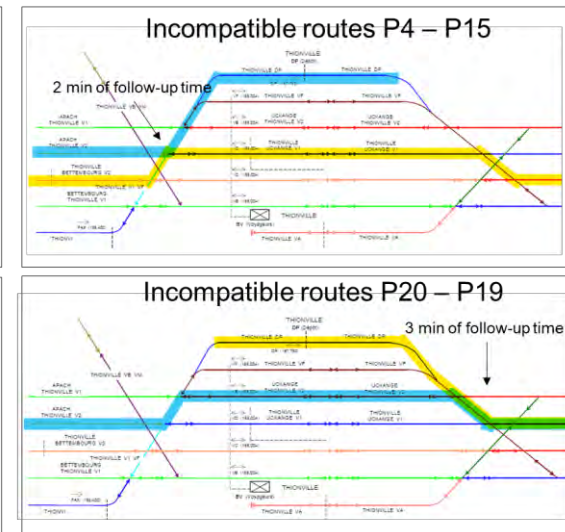
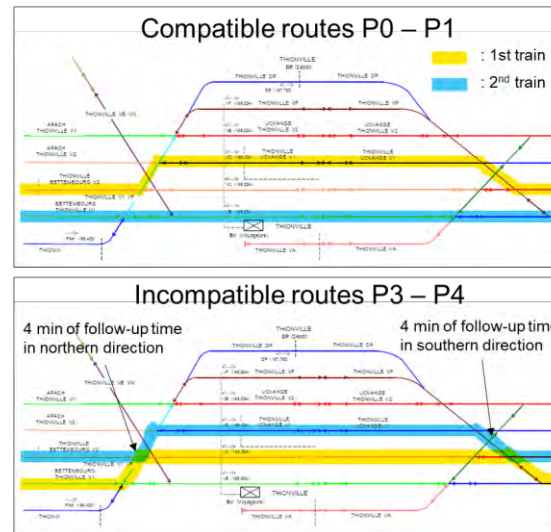
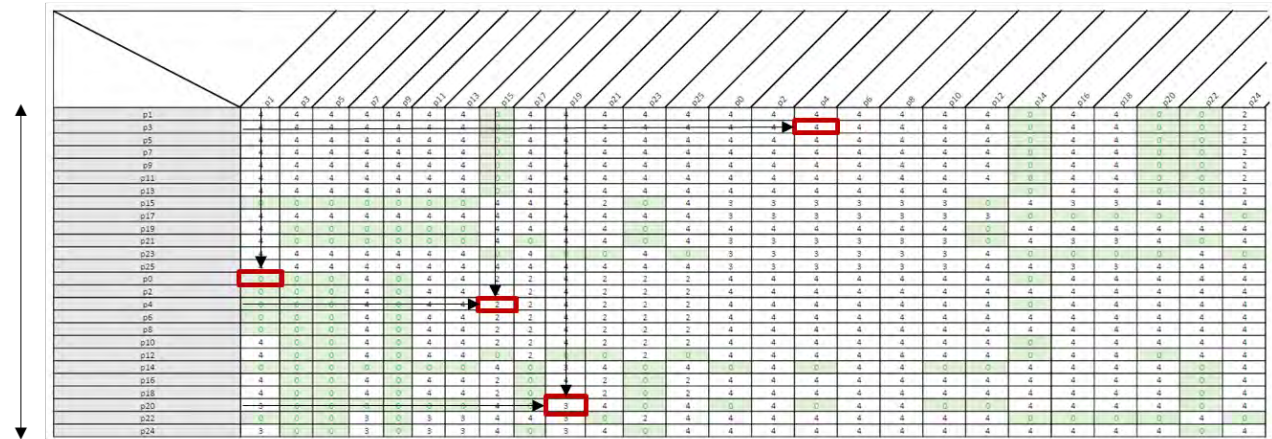
Minimum separation times between the possible routes of one of the 2 switch areas.

According to “norme de tracé” SNCF Réseau :

- 4 minutes between two successive routes
- 4 minutes for two intersecting or diverging/converging routes
- 3 minutes for a route to a garage before a direct track train
- 2 minutes for a route to a garage after a direct track train

First train route

Second train route



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## [6] Capacity consumption rates

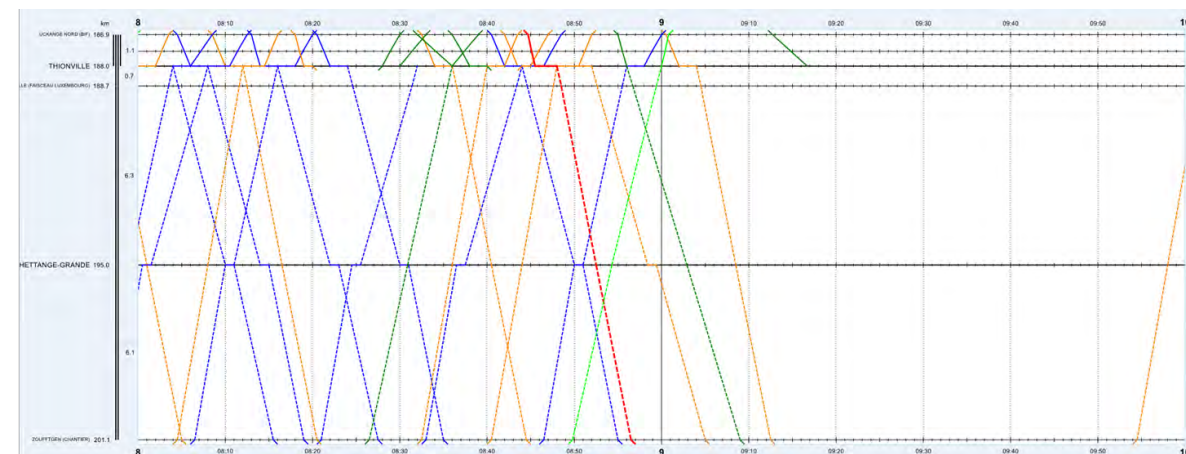
## Stations - Example of Thionville

## Automatic station compression of Northern switch area in Excel.

Manual station compression of northern switch area in Viriato.

Route	n° route	Beginning of occupation	p1	p2	p3	p4	p5	p6	p7	p8	p9	p10	p11	p12	p13	p14	p15	p16	p17	p18	p19	p20	p21	p22	p23	p24
LuN-Lux	p27	0	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	0	0	2	
THL-Lux	p20	0	0	0	0	3	0	0	3	3	4	4	4	4	3	0	2	4	4	4	4	4	4	0	0	4
LuN-MZ	p1	4	8	6	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	4	4	8	
MZ-Lux	p26	8	0	0	0	12	0	0	12	12	12	10	10	10	10	12	12	12	12	12	12	12	0	12	12	
Lux-MZ	p1	8	12	12	12	12	12	12	12	10	10	10	10	12	12	12	12	12	12	12	12	12	0	12	12	
NY-Lux	p9	12	0	0	0	16	0	0	16	16	16	14	14	16	14	14	16	16	16	16	16	16	16	16	16	
LuN-Lux	p5	12	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	
MZ-Lux	p5	16	0	0	0	20	0	0	20	20	20	18	18	20	18	18	20	20	20	20	20	20	20	20	20	
LuN-Lux	p20	16	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	
MZ-TRV	p18	20	24	0	0	24	0	0	24	24	24	22	0	24	22	0	22	24	24	24	24	24	24	24	24	
MZ-Lux	p2	24	0	0	0	28	0	0	28	28	26	26	26	28	26	26	28	28	28	28	28	28	28	28	28	
AP-WFY	p17	26	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	
Lux-THL	p23	30	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	
LuN-Lux	p3	30	37	37	37	37	37	37	37	35	35	35	35	37	35	35	35	37	37	37	37	37	37	37	37	
BEM-WFY	p9	34	38	38	38	38	38	38	38	38	38	38	38	38	38	38	38	38	38	38	38	38	38	38	38	
LuN-NY	p7	38	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	
WFY-AP	p16	42	46	0	0	46	0	0	46	46	46	44	0	46	44	0	46	46	46	46	46	46	46	46	46	
TRV-MZ	p19	46	50	0	0	50	0	0	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	
SBM-THL	p15	50	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	
MZ-Lux	p20	50	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	
Lux-MZ	p2	50	0	0	0	57	0	0	57	57	55	55	55	57	55	55	55	57	57	57	57	57	57	57	57	
LuN-MZ	p1	50	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	
NY-Lux	p4	57	0	0	0	61	0	0	61	61	61	59	59	61	59	59	61	61	61	61	61	61	61	61	61	
PE-Lux	p10	54	65	0	0	65	0	0	65	65	65	63	63	65	63	63	65	65	65	65	65	65	65	65	65	
LuN-Lux	p11	57	58	58	58	58	58	58	58	58	58	58	58	58	58	58	58	58	58	58	58	58	58	58	58	
WFY-BET	p3	58	62	62	62	62	62	62	62	62	62	62	62	62	62	62	62	62	62	62	62	62	62	62	62	
LuN-MZ	p3	58	62	62	62	62	62	62	62	62	62	62	62	62	62	62	62	62	62	62	62	62	62	62	62	
NY-Lux	p4	59	0	0	0	63	0	0	63	63	63	61	61	63	61	61	63	63	63	63	63	63	63	63	63	
BET-WFY	p9	62	66	66	66	66	66	66	66	66	66	66	66	66	66	66	66	66	66	66	66	66	66	66	66	
LuN-Lux	p1	62	71	71	71	71	71	71	71	71	71	71	71	71	71	71	71	71	71	71	71	71	71	71	71	
THL-Lux	p22	72	0	0	0	76	0	0	76	76	76	77	77	76	0	75	77	77	77	77	77	77	77	77	77	

2 last trains (copy of the 2 first trains involved in northern switch with random order because of same depart slot)





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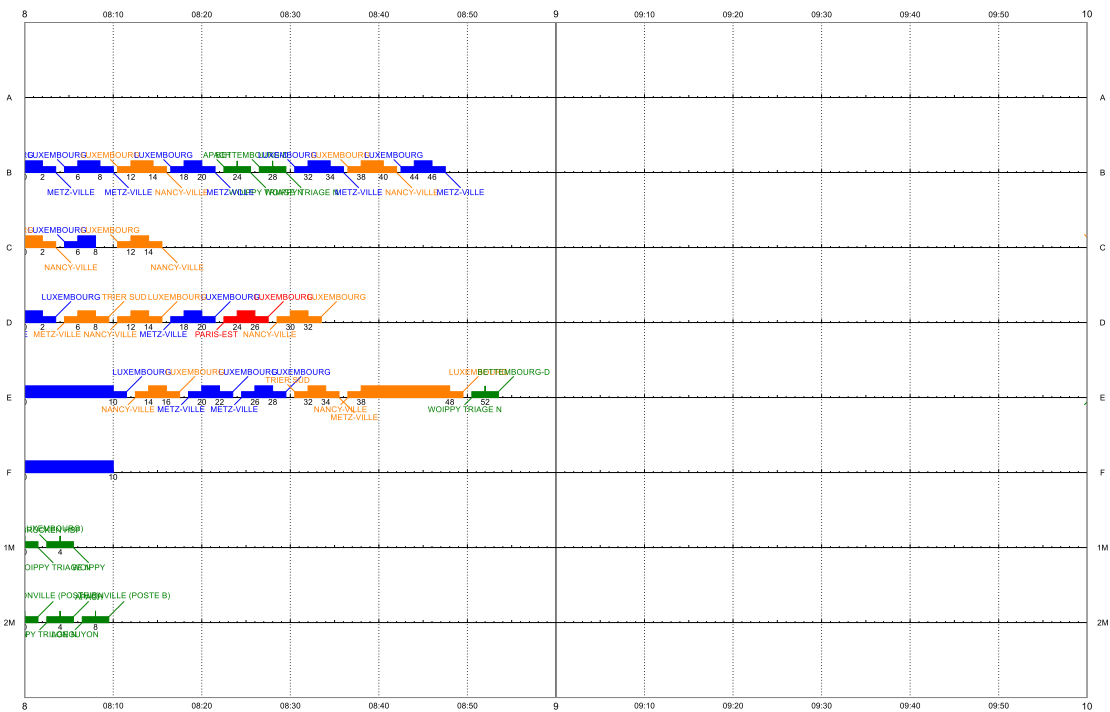
# [6] Capacity consumption rates

Stations - Example of Thionville

Automatic station (tracks) compression in Excel.

Route	Parking time	Track	1M	2M	Vf	VE	VD	VC	VB	VA
Lux-NY	2	VC	0	0	0	0	0	6	0	0
THL - Lux	10	VE	0	0	0	14	0	0	0	0
Lux-MZ	2	VB	0	0	0	0	0	0	6	0
MZ-Lux	2	VD	0	0	0	0	6	0	0	0
NY-Lux	2	VE	0	0	0	6	0	0	0	0
Lux - MZ	2	VB	0	0	0	0	0	0	6	0
THL - WPY	0	1M	4	0	0	0	0	0	0	0
MZ-Lux	2	VE	0	0	0	6	0	0	0	0
Lux-NY	2	VB	0	0	0	0	0	0	6	0
LGN-THL	0	2M	0	4	0	0	0	0	0	0
MZ-TRZ	2	VD	0	0	0	0	6	0	0	0
Lux-MZ	2	VB	0	0	0	0	0	0	6	0
MZ-Lux	2	VE	0	0	0	6	0	0	0	0
AP - WPY	0	VB	0	0	0	0	0	0	4	0
Lux - THL	2	VC	0	0	0	0	0	6	0	0
NY - Lux	2	VD	0	0	0	0	6	0	0	0
BET-WPY	0	VB	0	0	0	0	0	0	4	0
Lux-NY	2	VC	0	0	0	0	0	6	0	0
WPY - AP	0	2M	0	4	0	0	0	0	0	0
TRZ -MZ	2	VE	0	0	0	6	0	0	0	0
SBH - THL	0	1M	4	0	0	0	0	0	0	0
MZ - Lux	2	VD	0	0	0	0	6	0	0	0
LGN - THL	0	2M	0	4	0	0	0	0	0	0
Metz - Lux	0	VE	0	0	0	4	0	0	0	0
NY - Lux	10	VE	0	0	0	14	0	0	0	0
Lux - MZ	2	VB	0	0	0	0	0	0	6	0
PE-Lux	2	VD	0	0	0	0	6	0	0	0
Lux - NY	2	VB	0	0	0	0	0	0	6	0
Lux - MZ	2	VB	0	0	0	0	0	0	6	0
NY-Lux	2	VD	0	0	0	0	6	0	0	0
LGN-THL	10	VF	0	0	14	0	0	0	0	0
TOTAL			8	12	14	56	36	18	50	0

Manual station compression of tracks in Viriato.



## [6] Capacity consumption rates

Stations - Example of Thionville

### Conclusion

- **OTR values of switch areas are within UIC recommended rates** (60-80%), but note that values are calculated with planning separation times, including margins, so that no other margins are added in the calculation (see assumption chapter),
- **OTR values of track areas are below UIC recommended rates** (40-50%) (same point of attention), except for tracks B and D in PEE 2030.
- In PER 2025, before the improvements in Thionville, junctions are the biggest limiting factor of the station. In PEE 2030, after the improvements, platform capacity is the biggest limiting factor of the station.
- Station tracks usage vary greatly within the station,
- Track Occupation Diagram has been designed in order to optimise the use of capacity.

# [6] Capacity consumption rates

Stations - Example of Hazebrouck

OTR in Hazebrouck station track section.

Track	OTR (Occupancy Time Rate)
J1	$OTR = \frac{4}{120} * 100 = \mathbf{0.5\%}$
VA	$OTR = \frac{20}{120} * 100 = \mathbf{17\%}$
V8	$OTR = \frac{34}{120} * 100 = \mathbf{30\%}$
V6	$OTR = \frac{55}{120} * 100 = \mathbf{46\%}$
V4	$OTR = \frac{12}{120} * 100 = \mathbf{10\%}$
V2	$OTR = \frac{18}{120} * 100 = \mathbf{15\%}$
V1	$OTR = \frac{20}{120} * 100 = \mathbf{17\%}$

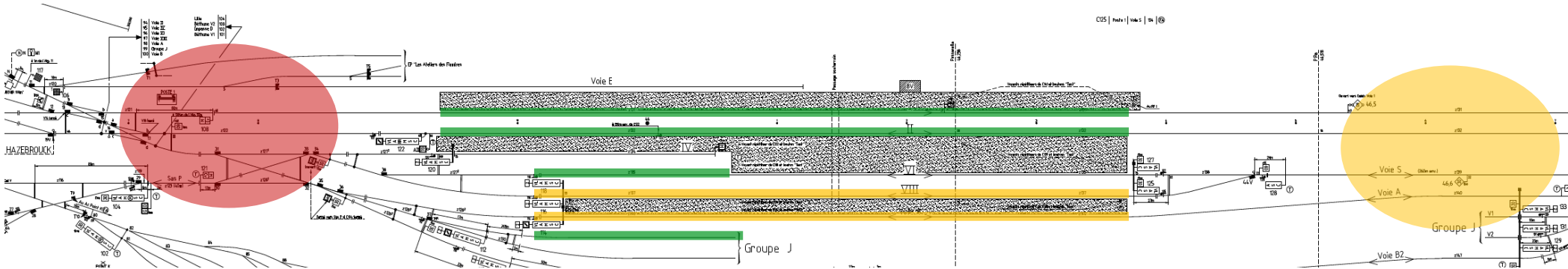
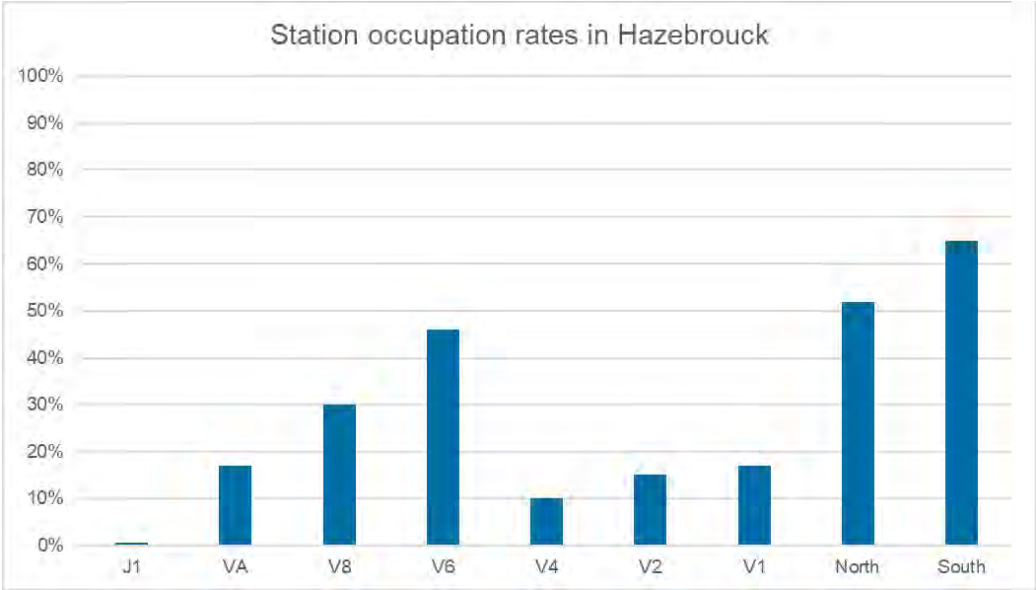
Result : switches areas.

Switch Area	OTR (Occupancy Time Rate)
North	$OTR = \frac{63}{120} * 100 = \mathbf{52\%}$
South	$OTR = \frac{78}{120} * 100 = \mathbf{65\%}$

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# [6] Capacity consumption rates

Stations - Example of Hazebrouck



## [6] Capacity consumption rates

Stations - Example of Hazebrouck

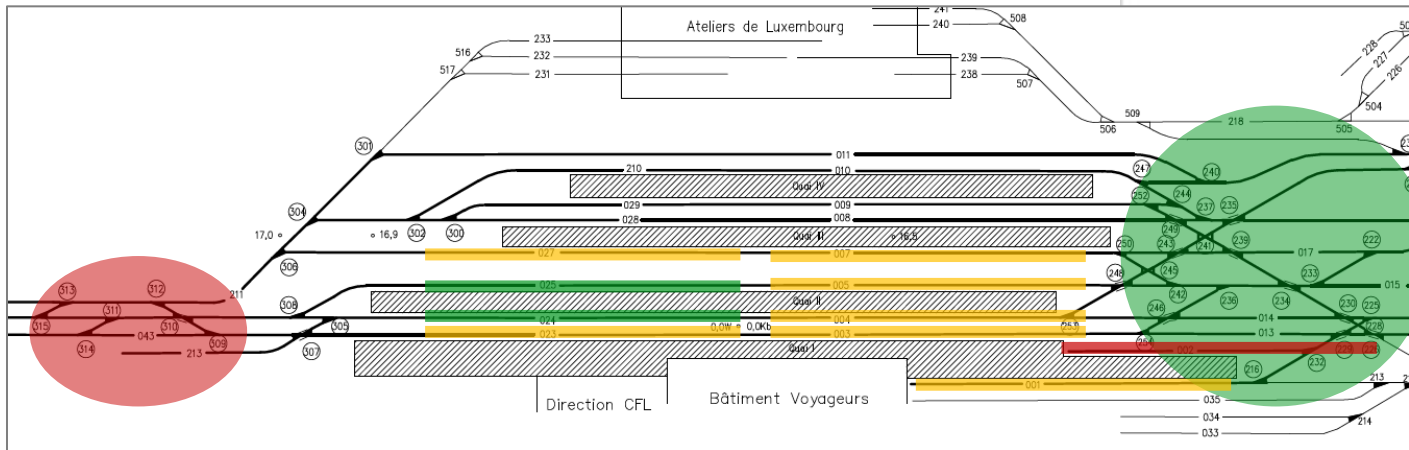
### Conclusion

- **OTR values of switch areas are within UIC recommended rates** (60-80%), but note that values are calculated with planning separation times, including margins, so that no other margins are added in the calculation (see assumption chapter),
- **OTR values of track areas are below UIC recommended rates** (40-50%) (same point of attention),
- The capacity in this station is not saturated,
- Track Occupation Diagram has been designed in order to optimise the use of capacity.

## [6] Capacity consumption rates

### Stations - Example of Luxembourg

Vehicle Type	Occupation Rate (%)
V1	50%
V2	65%
V3-AB	48%
V3-CD	42%
V4-AB	42%
V4-CD	1%
V5-AB	62%
V5-CD	0%
V7-AB	60%
V7-CD	70%
switches (North)	95%
switches (South)	15%



## [6] Capacity consumption rates

### Stations - Example of Luxembourg

- **OTR values of switch areas are NOT within UIC recommended rates** (60-80%), but note that values are calculated with planning separation times, including margins, so that no other margins are added in the calculation (see assumption chapter), are not balanced between south and north,
- **OTR values of track areas are ABOVE UIC recommended rates** (40-50%) (same point of attention), 6 tracks are saturated.
- Switches areas are sizing the capacity in this station,
- Some station tracks are not used,
- Track Occupation Diagram is the one in use today, has not been designed to optimise the use of capacity.

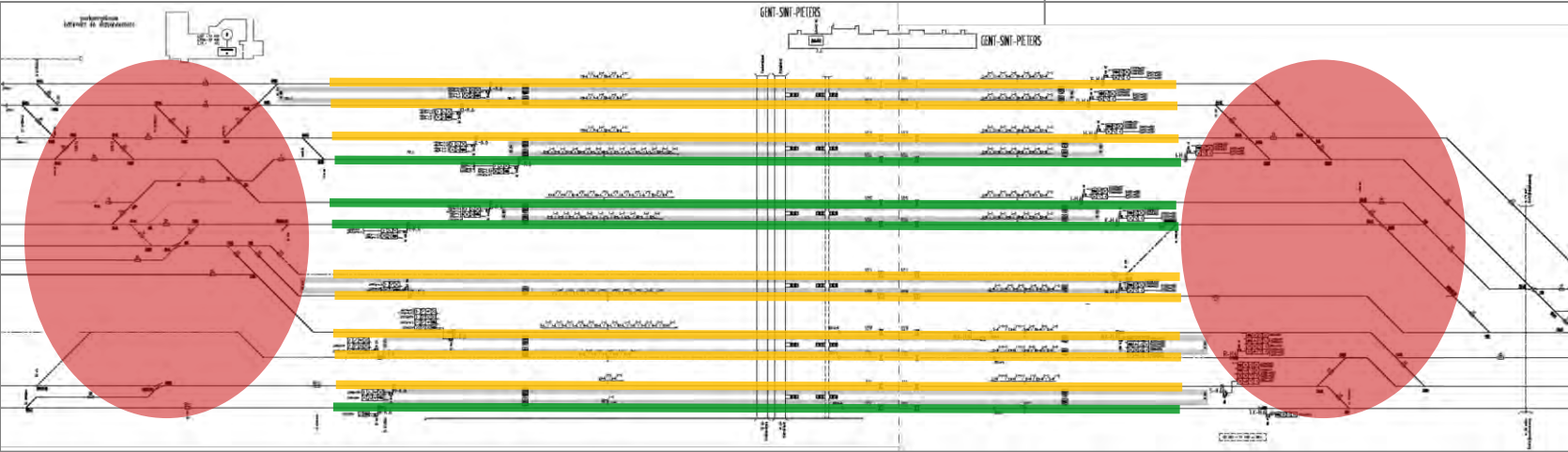
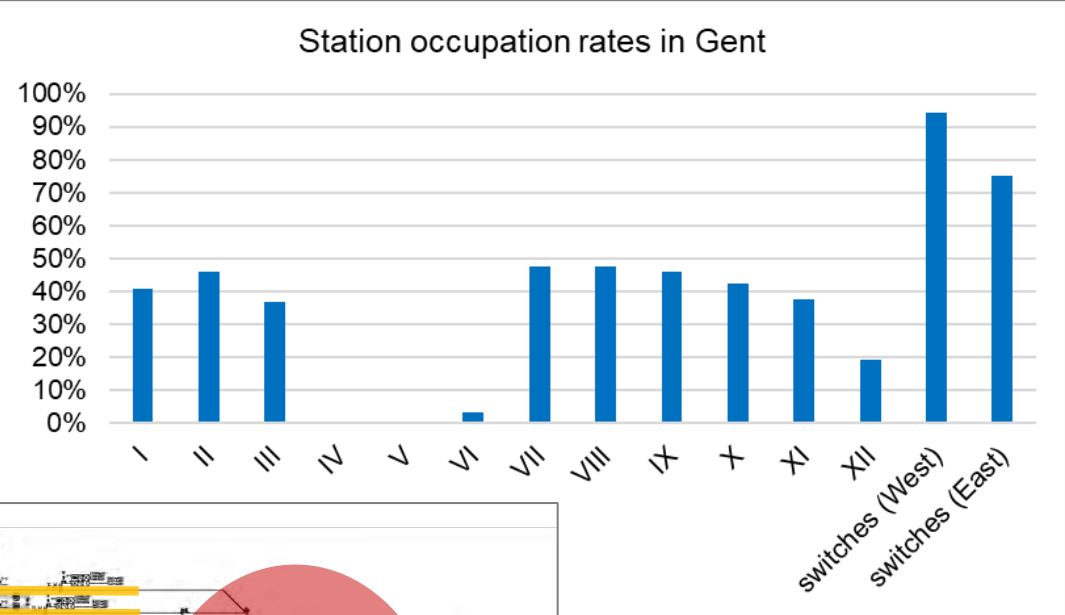


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(2022)

# [6] Capacity consumption rates

Stations - Example of Gent

Station track section and switches areas  
(Tuesdays & Thursdays 2023)



## [6] Capacity consumption rates

### Stations - Example of Gent

- **OTR values of switch areas are NOT within UIC recommended rates** (60-80%) but note that values are calculated with planning separation times, including margins, so that no other margins are added in the calculation (see assumption chapter). The western switch zone is more saturated than the eastern one
- **OTR values of track areas are within UIC recommended rates** (40-50%) (same point of attention)
- The saturation of the switch zone might be linked to technical movements between platforms and Bundle L/M
- Switches areas are sizing the capacity in this station
- Track Occupation Diagram is the one in use today, has not been designed to optimise the use of capacity. It takes into account technical movements
- Some tracks (IV and V) could not be used due to construction work in the station

# [6] Capacity consumption rates

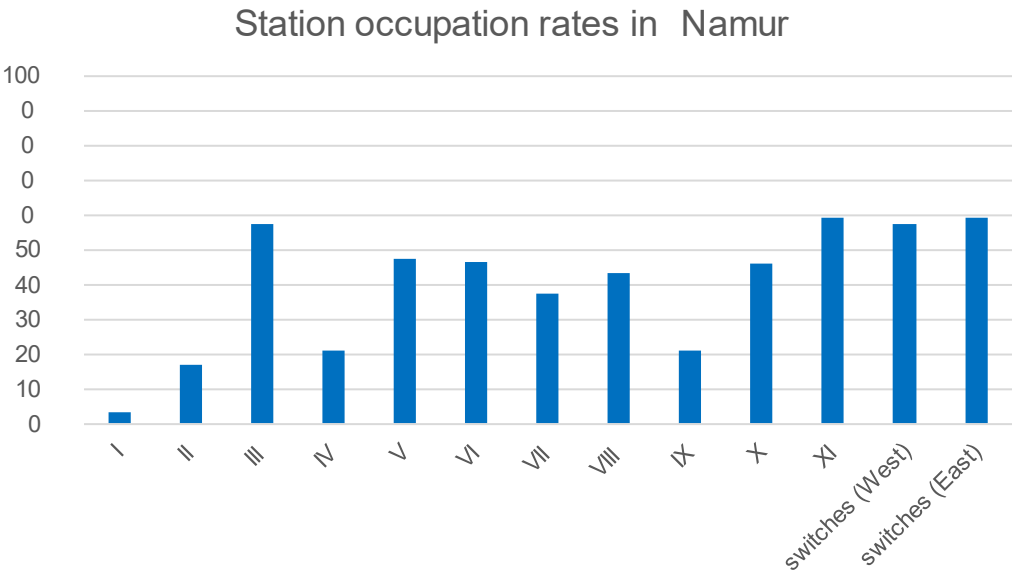
Stations - Example of Namur

Station track section (Tuesdays & Thursdays 2023)

Track	OTR (Occupancy Time Rate)
I	$OTR = \frac{4}{120} * 100 = 3\%$
II	$OTR = \frac{20}{120} * 100 = 17\%$
III	$OTR = \frac{69}{120} * 100 = 58\%$
IV	$OTR = \frac{25}{120} * 100 = 21\%$
V	$OTR = \frac{57}{120} * 100 = 48\%$
VI	$OTR = \frac{56}{120} * 100 = 47\%$
VII	$OTR = \frac{45}{120} * 100 = 38\%$
VIII	$OTR = \frac{52}{120} * 100 = 43\%$
IX	$OTR = \frac{25}{120} * 100 = 21\%$
X	$OTR = \frac{55}{120} * 100 = 46\%$
XI	$OTR = \frac{71}{120} * 100 = 59\%$

Switches areas (Tuesdays & Thursdays 2023)

Switch Area	OTR (Occupancy Time Rate)
North	$OTR = \frac{69}{120} * 100 = 58\%$
South	$OTR = \frac{71}{120} * 100 = 59\%$

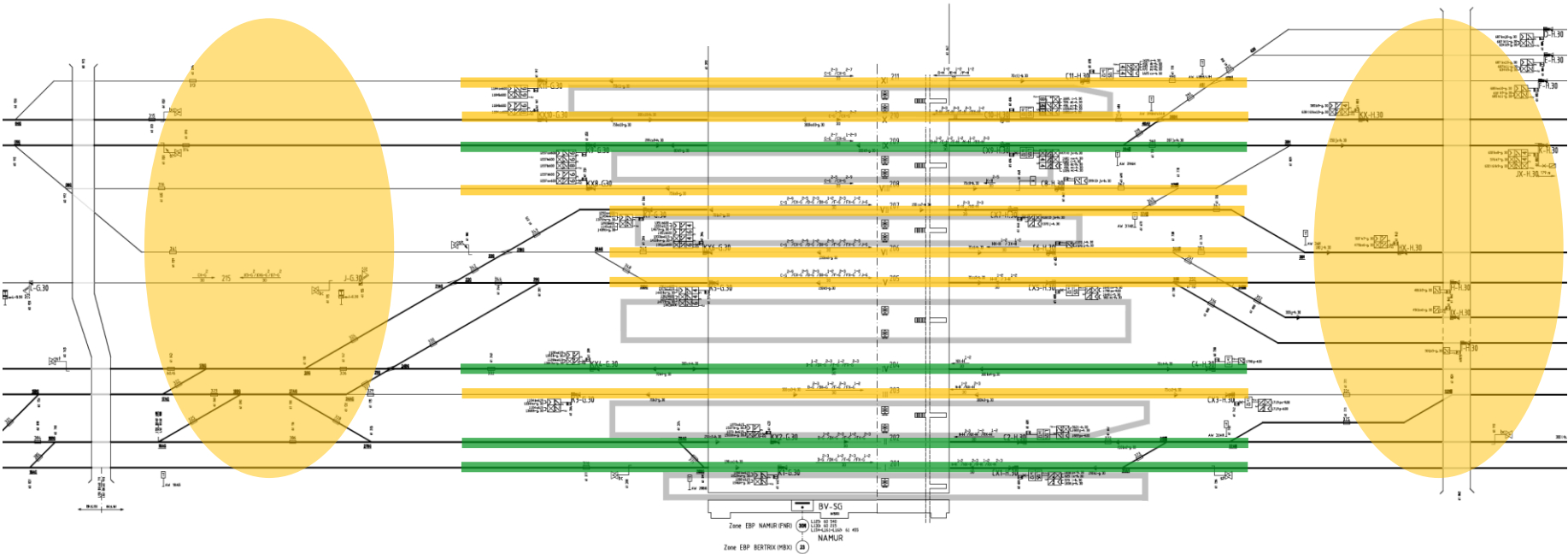
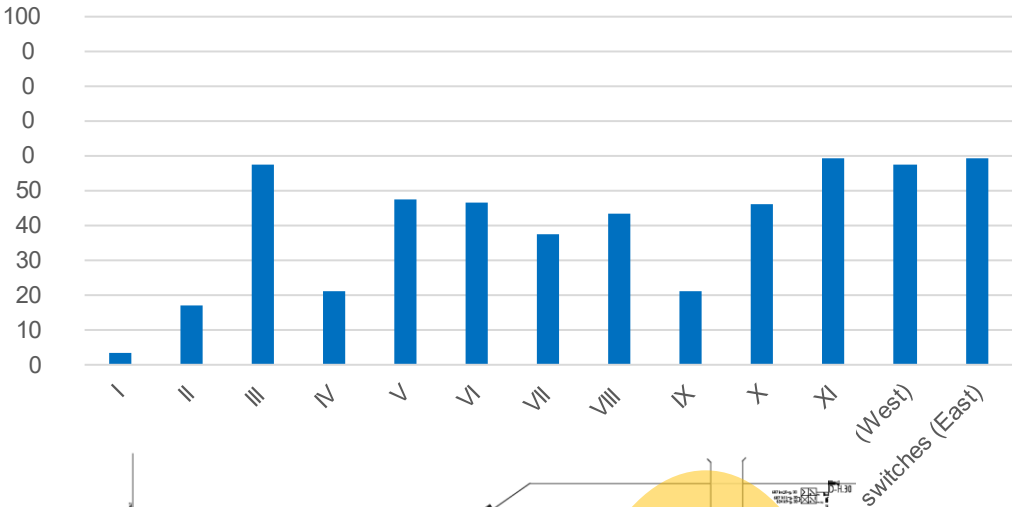


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GIVEN MOMENT  
(2022)

# [6] Capacity consumption rates

Stations - Example of Namur

Station occupation rates in Namur



## [6] Capacity consumption rates

### Stations - Example of Namur

- **OTR values of switch areas are within UIC recommended rates** (60-80%) but note that values are calculated with planning separation times, including margins, so that no other margins are added in the calculation (see assumption chapter).
- **OTR values of track areas are ABOVE UIC recommended rates** (40-50%) (same point of attention), 2 tracks are saturated.
- Some station tracks are saturated, when others have a low usage
- Track Occupation Diagram is the one in use today, has not been designed to optimise the use of capacity. It takes into account technical movements

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(2022)

# [6] Capacity consumption rates

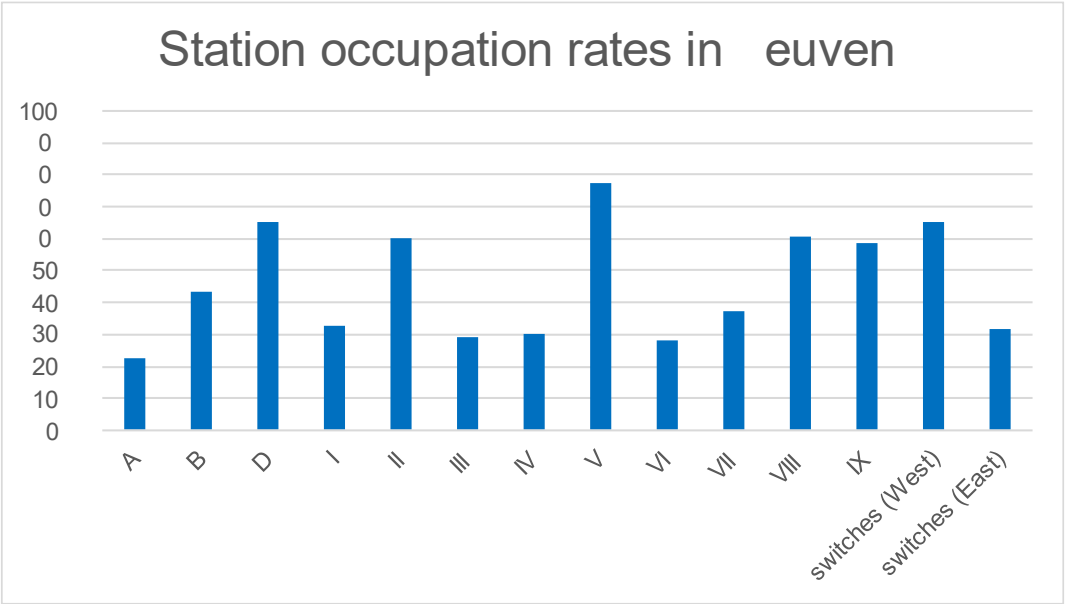
Stations - Example Leuven

Station track section (Tuesdays & Thursdays 2023)

Track	OTR (Occupancy Time Rate)
A	$OTR = \frac{27}{120} * 100 = 23\%$
B	$OTR = \frac{52}{120} * 100 = 43\%$
D	$OTR = \frac{78}{120} * 100 = 65\%$
I	$OTR = \frac{39}{120} * 100 = 33\%$
II	$OTR = \frac{72}{120} * 100 = 60\%$
III	$OTR = \frac{35}{120} * 100 = 29\%$
IV	$OTR = \frac{36}{120} * 100 = 30\%$
V	$OTR = \frac{93}{120} * 100 = 78\%$
VI	$OTR = \frac{34}{120} * 100 = 28\%$
VII	$OTR = \frac{45}{120} * 100 = 38\%$
VIII	$OTR = \frac{73}{120} * 100 = 61\%$
IX	$OTR = \frac{70}{120} * 100 = 58\%$

Switches areas (Tuesdays & Thursdays 2023)

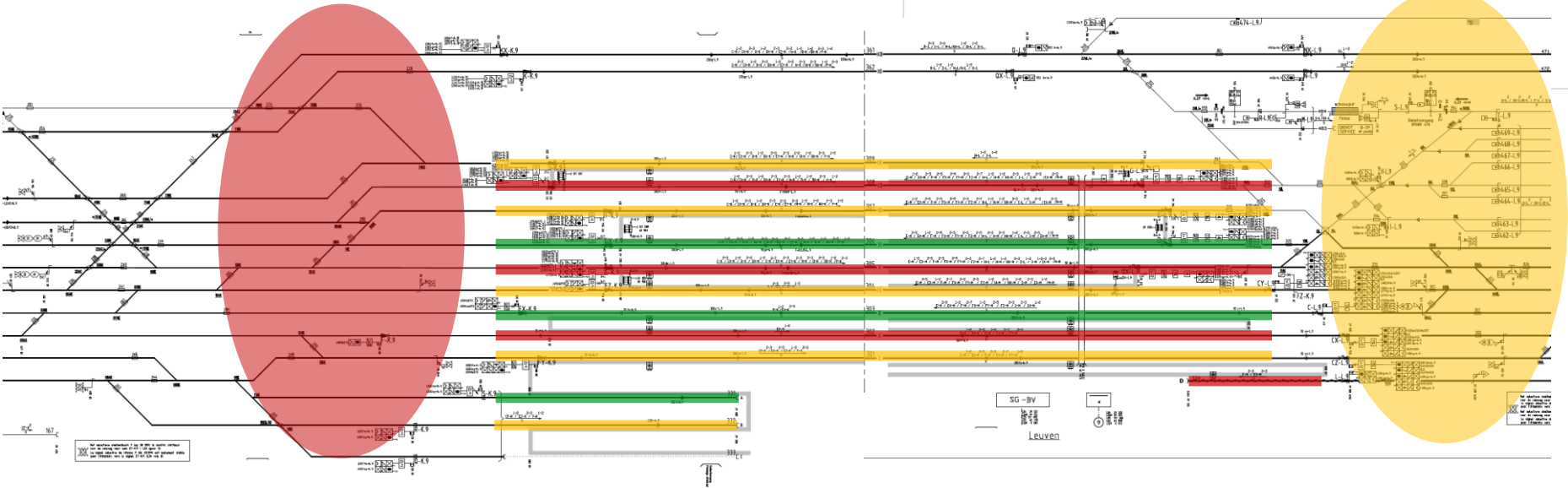
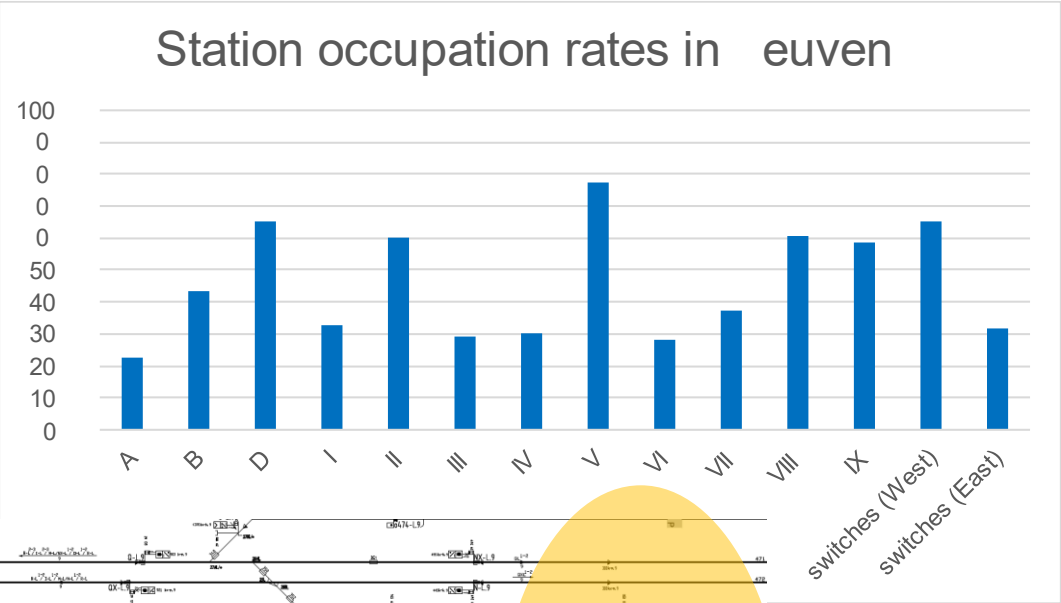
Switch Area	OTR (Occupancy Time Rate)
North	$OTR = \frac{78}{120} * 100 = 65\%$
South	$OTR = \frac{38}{120} * 100 = 32\%$



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CAPACITY AT A  
GIVEN MOMENT  
(2022)

# [6] Capacity consumption rates

Stations - Example Leuven





## [6] Capacity consumption rates

### Stations - Example of Leuven

- **OTR values of switch areas are within UIC recommended rates** (60-80%) but note that values are calculated with planning separation times, including margins, so that no other margins are added in the calculation (see assumption chapter).
- **OTR values of track areas are ABOVE UIC recommended rates** (40-50%) (same point of attention), 5 tracks are saturated.
- Platform occupation is the limiting factor in Leuven, but freight train are able to use some side passing tracks (361, 362) which still have capacities
- The high occupation rates on platform D, V and VIII are linked to long turnaround times (22, 34 or 38min)
- Track Occupation Diagram is the one in use today, has not been designed to optimise the use of capacity. It takes into account technical movements

# Annexes

1. Assumptions
2. Permeability
3. Capacity consumption rates
- 4. Calendar and process stability**
5. Bottlenecks

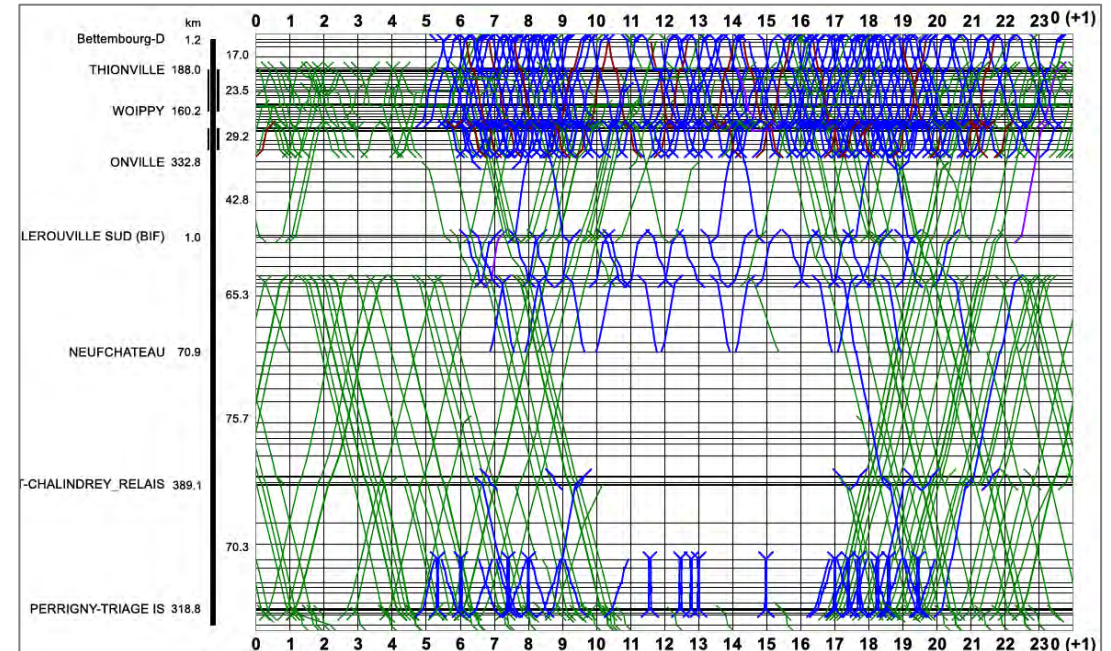
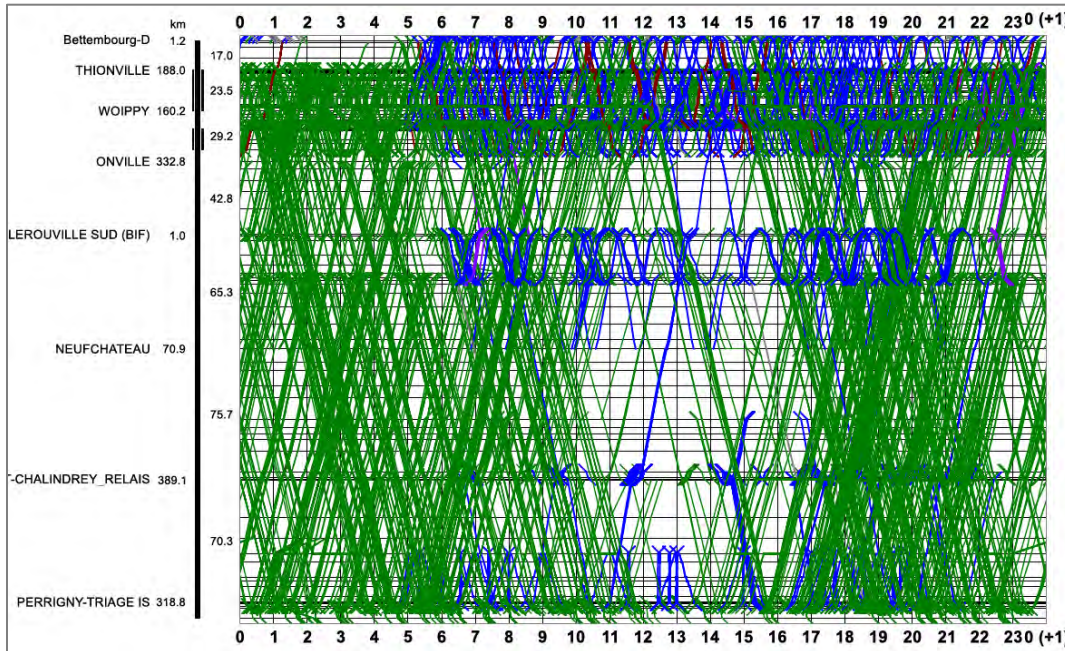
AVAILABLE  
CAPACITY AT A  
GIVEN MOMENT  
(2022)

## [9] Calendar and process stability

Stability (calendar stability during the year)

365 days planned for 2022  
(FR = construction, LUX = DEF)

1 day planned for 2022  
(FR = construction, LUX = DEF)



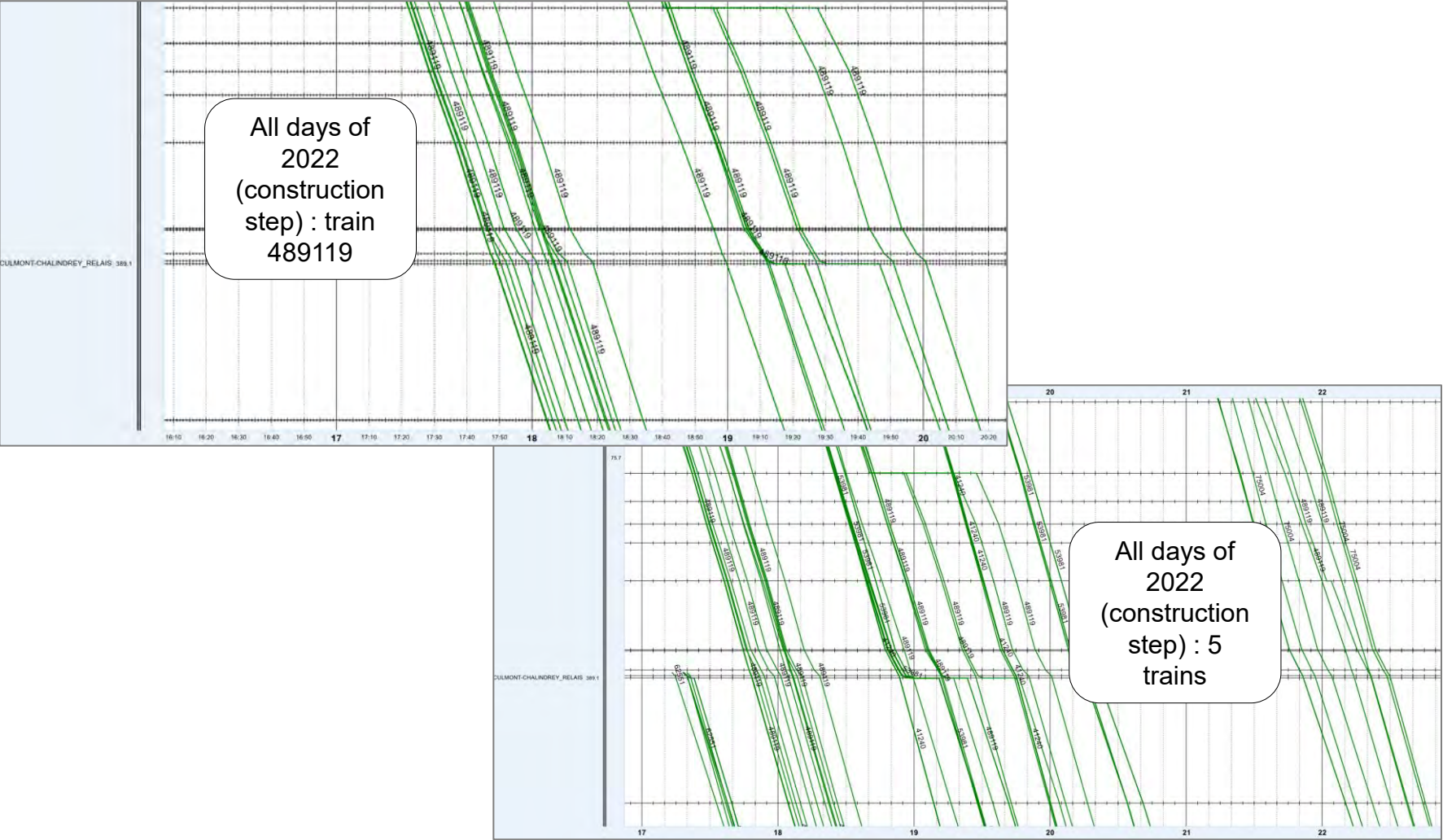


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GIVEN MOMENT  
(2022)

# [9] Calendar and process stability

Stability (calendar stability during the year)

Examples of trains  
with many  
versions,  
consuming a lot of  
calendar capacity.

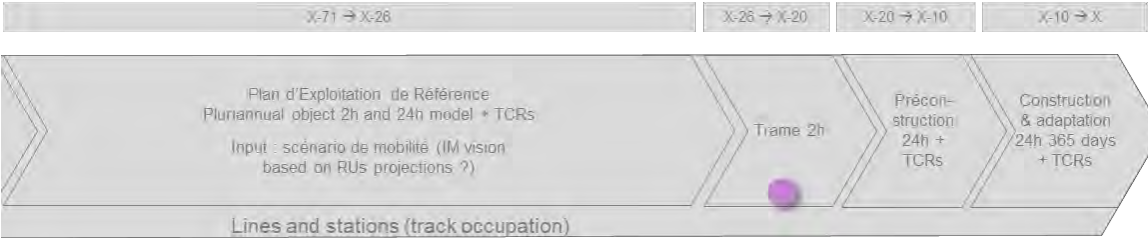
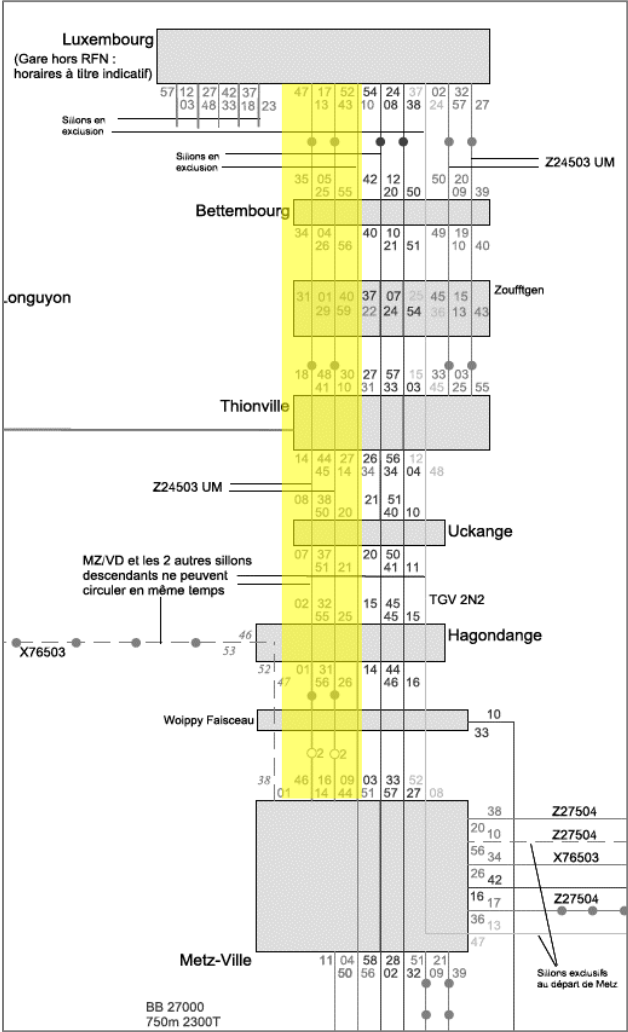




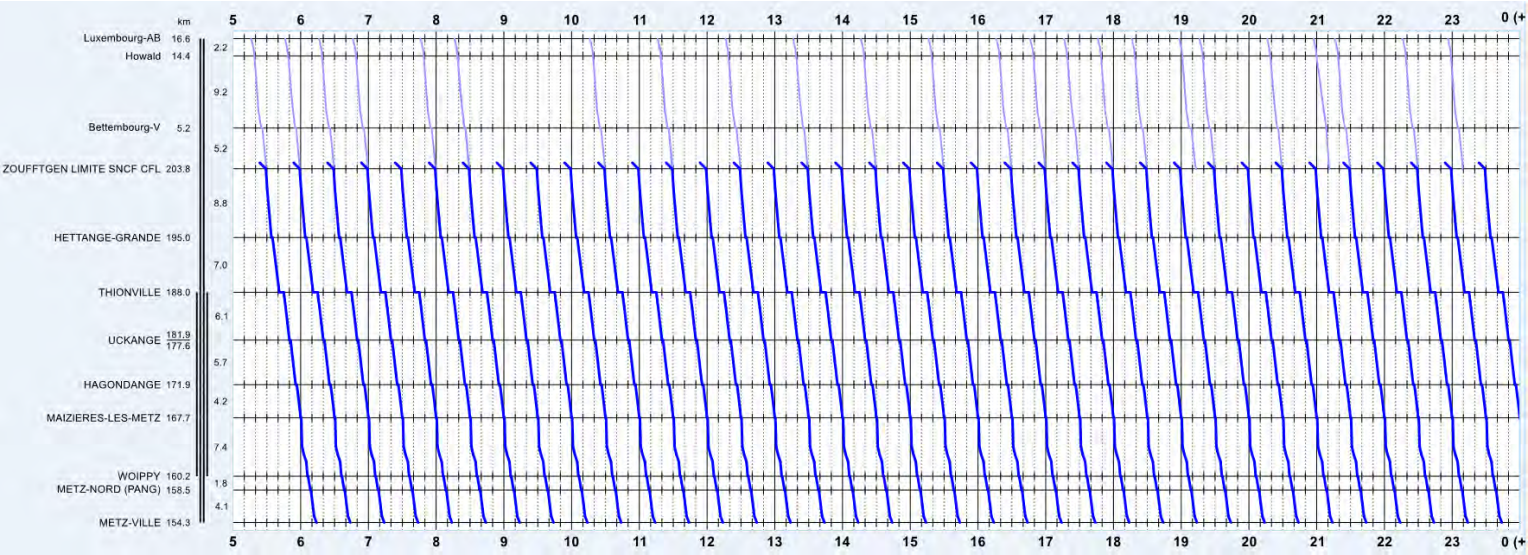
AVAILABLE  
CAPACITY AT A  
GIVEN MOMENT  
(2022)

# [9] Calendar and process stability

Stability (during the capacity process) : example regional LUX > Metz



In the French netgraph for 2022, in the direction studied here, departure at '13 and '43 (of any hour) from luxembourg, arrival at '14 and '44 (of any hour) at Metz, stops, travel time of 1'.



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(2022)

# [9] Calendar and process stability

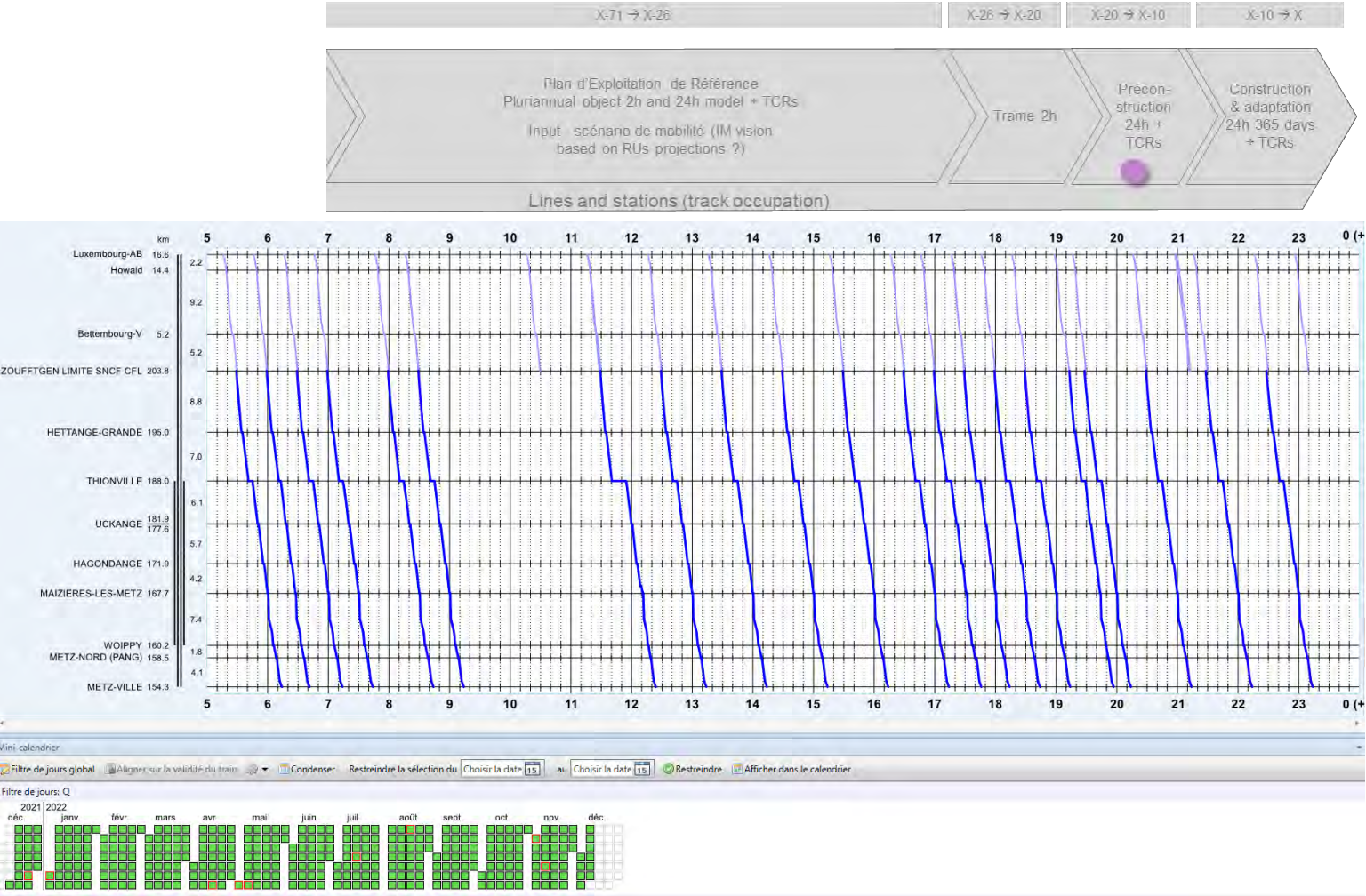
Stability (during the capacity process) : example regional LUX > Metz

Preconstruction  
(1 x 24h) of SA  
2022

At LUX, paths have  
-3'.

21 paths activated  
in the day.

7 trains (33%) have  
changed in  
comparison to the  
previous step,  
considering  
departure and  
arrival minutes.





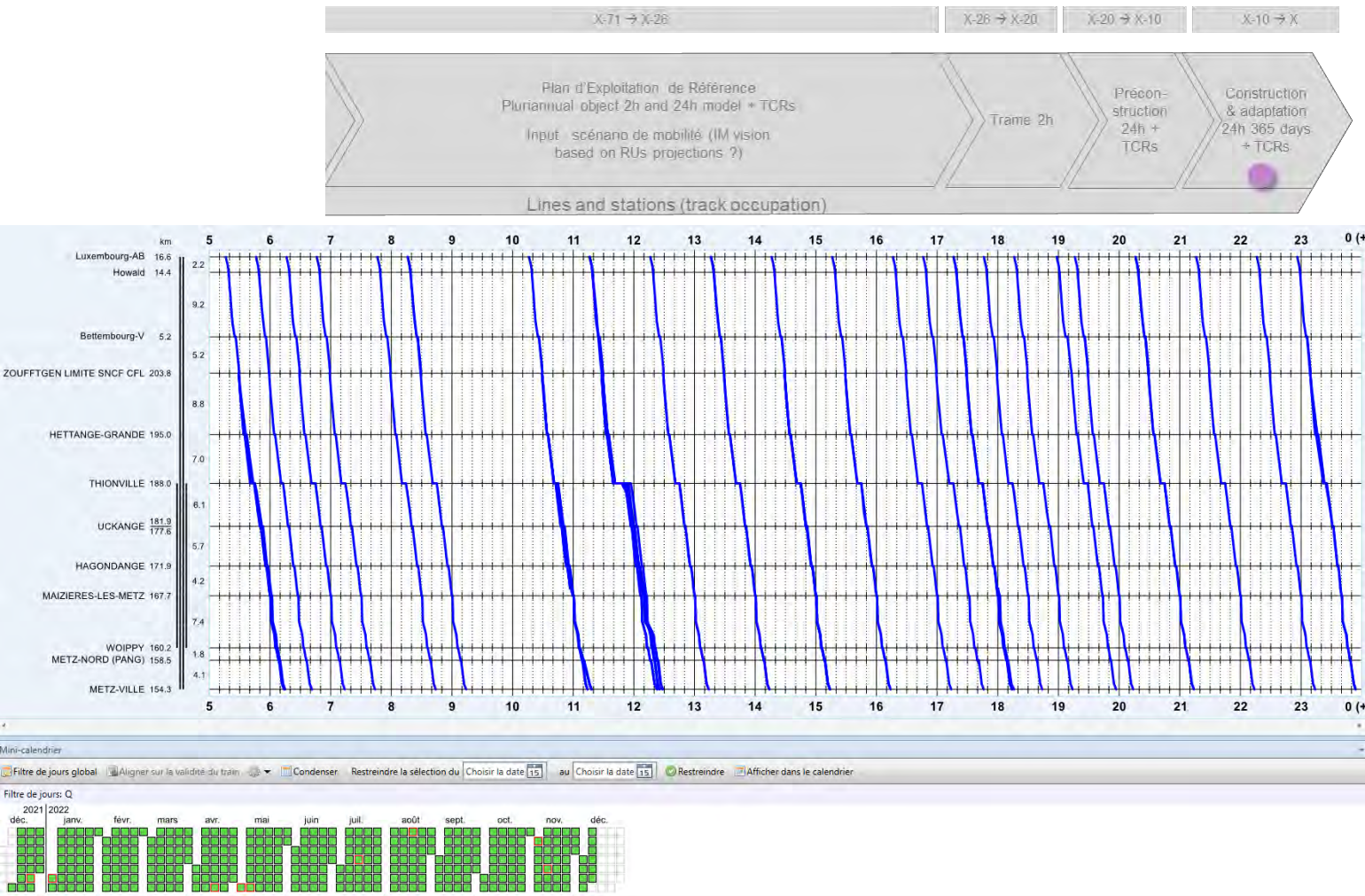
AVAILABLE  
CAPACITY AT A  
GIVEN MOMENT  
(2022)

# [9] Calendar and process stability

Stability (during the capacity process) : example regional LUX > Metz

Construction SA  
24h x 265 days)  
2022.

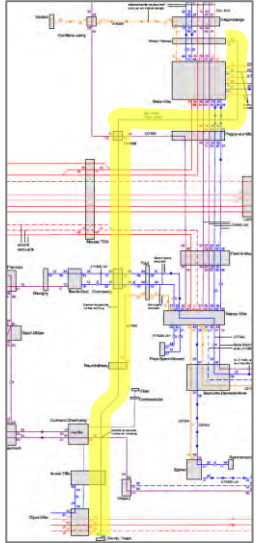
23 paths activated  
in the day : +2.  
5 trains (24%) have  
changed in  
comparison to the  
previous step,  
considering  
departure and  
arrival minutes.



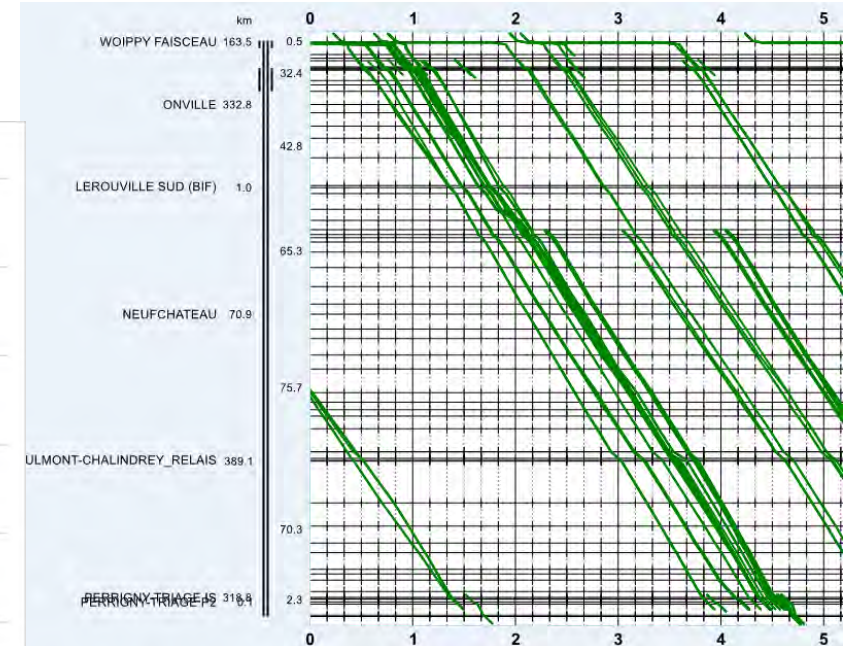
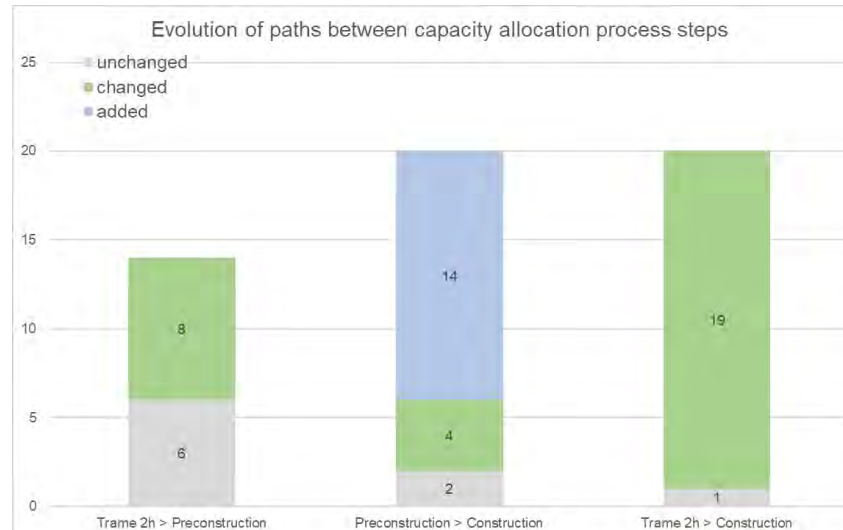
AVAILABLE  
CAPACITY AT A  
GIVEN MOMENT  
(2022)

## [9] Calendar and process stability

Stability (during the capacity process) : other examples



### Freight path Woippy > Gevrey



Lack of calendar stability on these freight train makes the calculation of the stability during process KPI difficult. The work done upstream on the insertion of this freight path in the 2h systematic timetable is partially deleted in the downstream phases on this path.

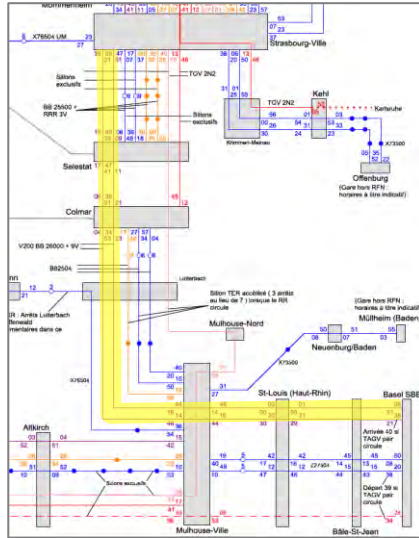
This leads to another question : are the freight paths planned upstream made for this usage of copying the exact path ? Or are they only planned to book capacity for the freight traffic ?



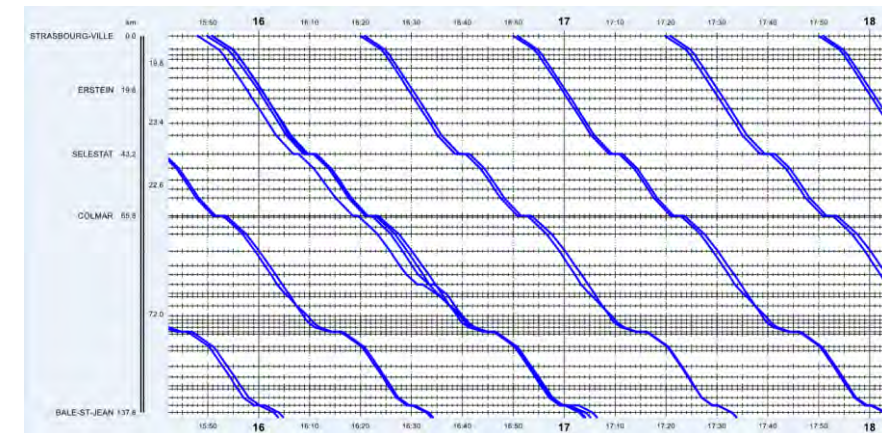
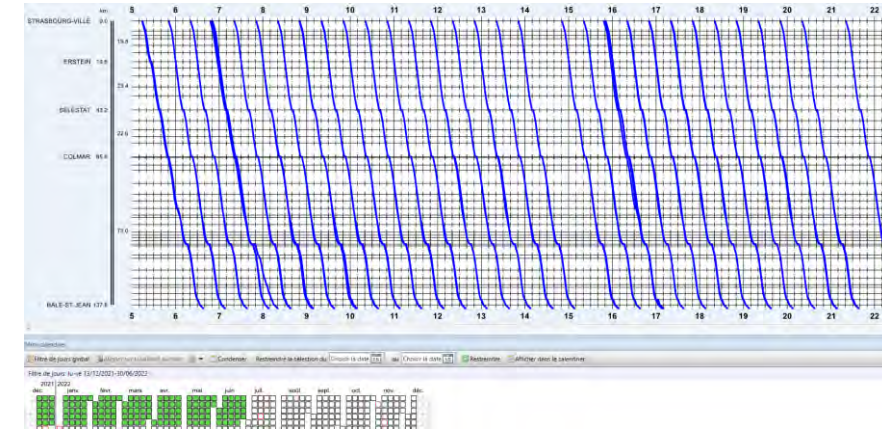
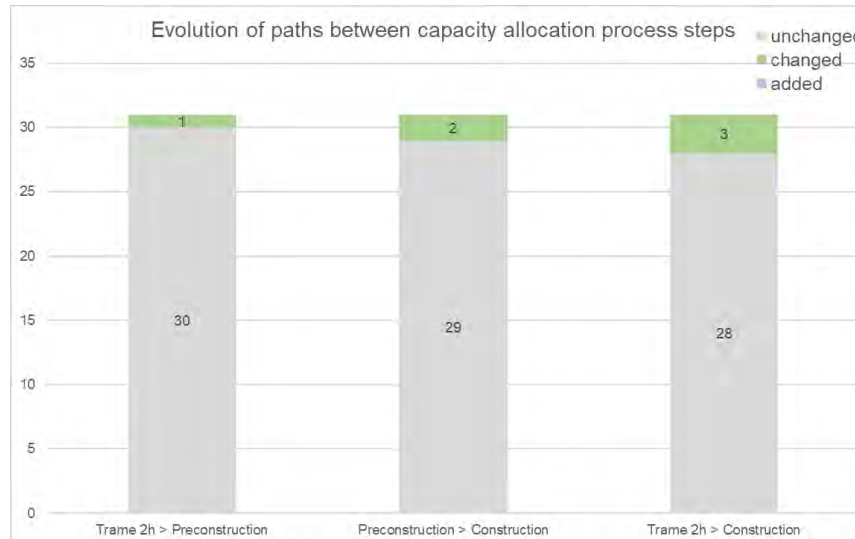
AVAILABLE  
CAPACITY AT A  
GIVEN MOMENT  
(2022)

# [9] Calendar and process stability

Stability (during the capacity process) : other examples



## TER 200 (passenger Strasbourg > Basel)



Much better than freight train, upstream work is not changed, but still some little variations (1 or 2 minutes), and some lack of calendar stability.

# [9] Calendar stability

Paths (calendar stability during the year)

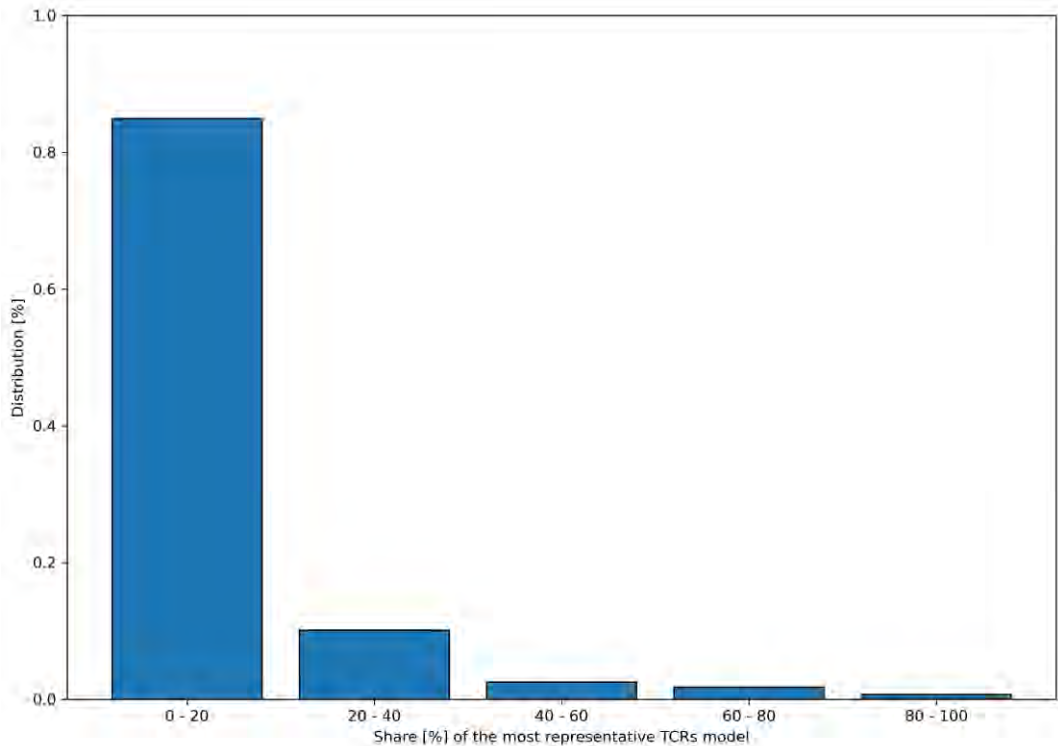
Stability of the TCRs planning (all year 2022)

This histogram shows the proportion of the most often planned TCR, among all the planned TCRs.

For each section (% distribution), the days with 0 TCRs are excluded.

Among the days with TCRs, the one which is the most encountered is identified and considered as “model”.

The share is calculated =  $\frac{\text{\# days matching model}}{\text{\# days with TCRs}}$



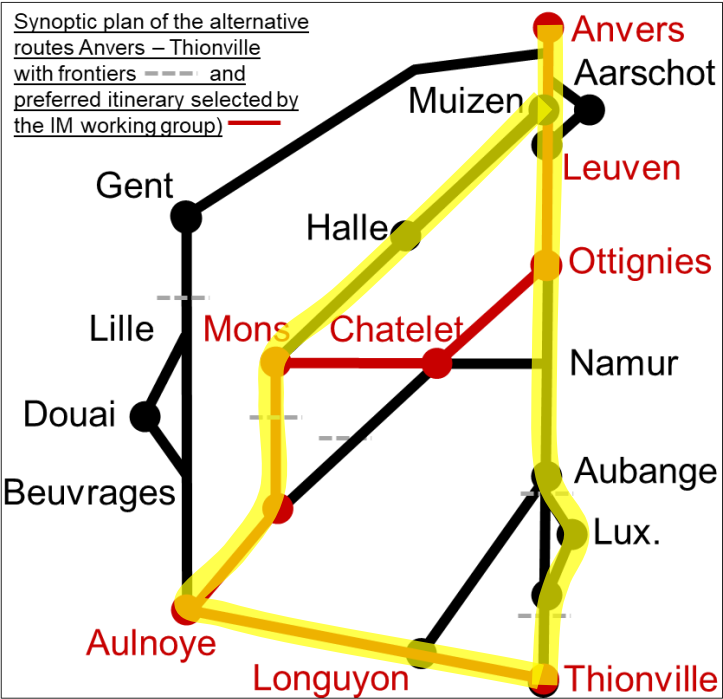
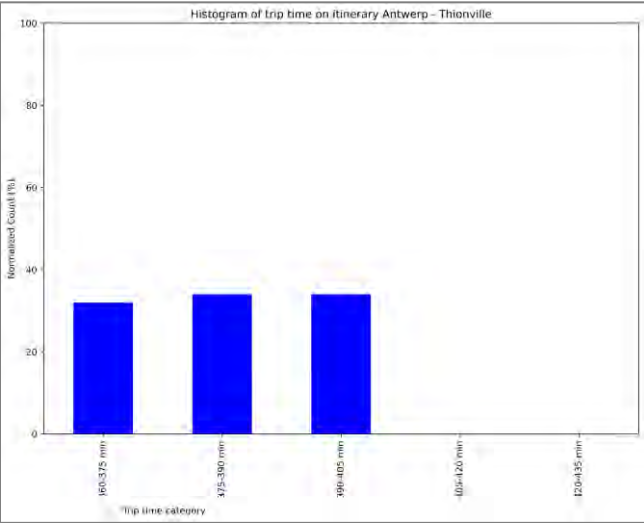
AVAILABLE  
CAPACITY AT A  
GIVEN MOMENT  
(2022)

# [9] Calendar stability

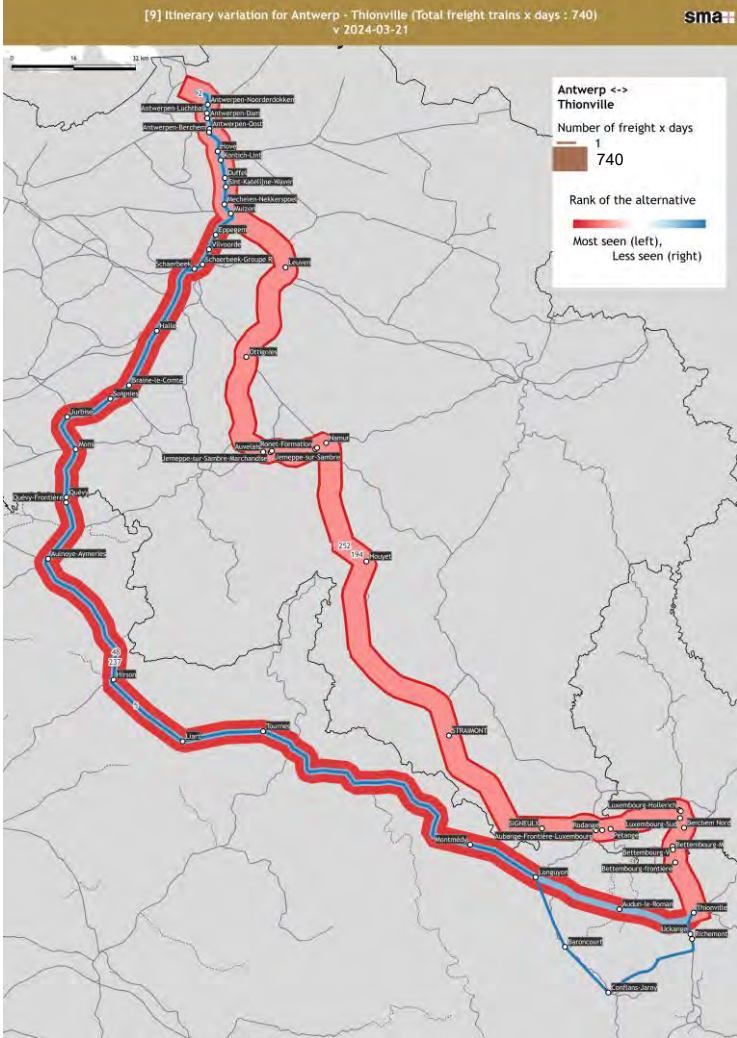
Stability (calendar stability during the year) : itineraries

Trains running on Anvers – Thionville are planned via Bruxelles or Aubange, and sometimes with a deviation via Conflans.

All year 2022



No trains via Mont-St-Martin : on all 2022, 11 trains via Mont-St-Martin in Belgian data, but 0 in French data.





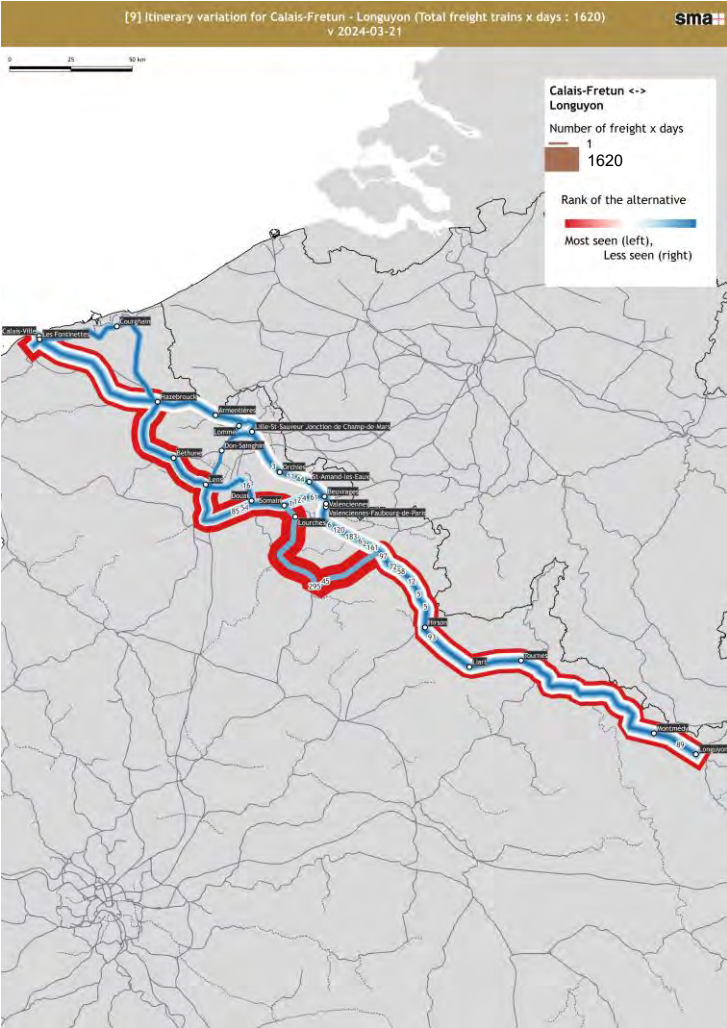
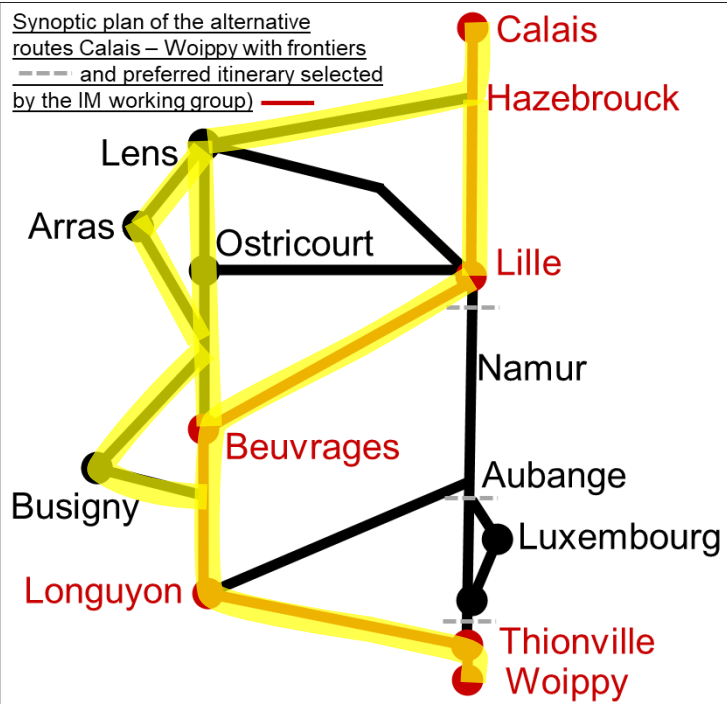
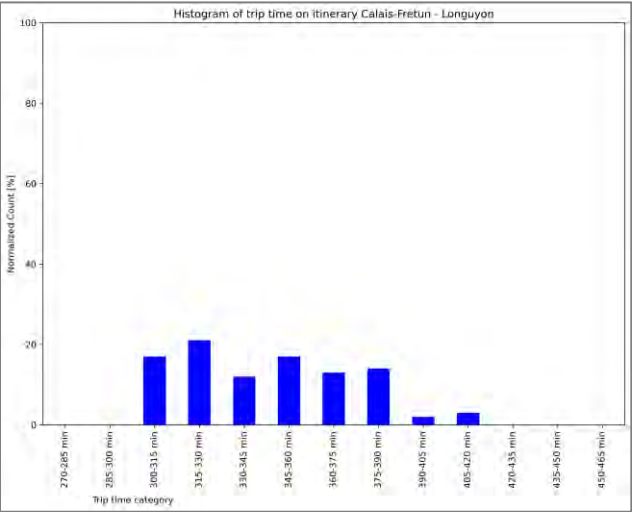
AVAILABLE  
CAPACITY AT A  
GIVEN MOMENT  
(2022)

# [9] Calendar stability

Stability (calendar stability during the year) : itineraries

Trains running on Calais - Woippy are planned via the preferred itinerary but also via the different possibilities in the Nord of France.

All year 2022





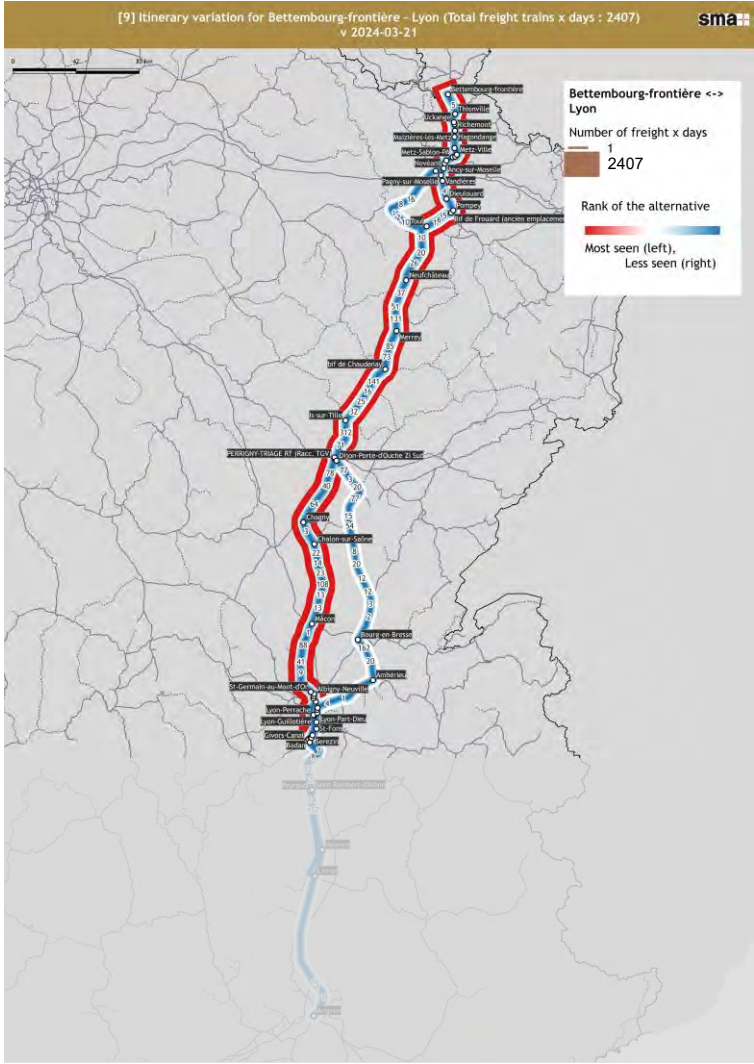
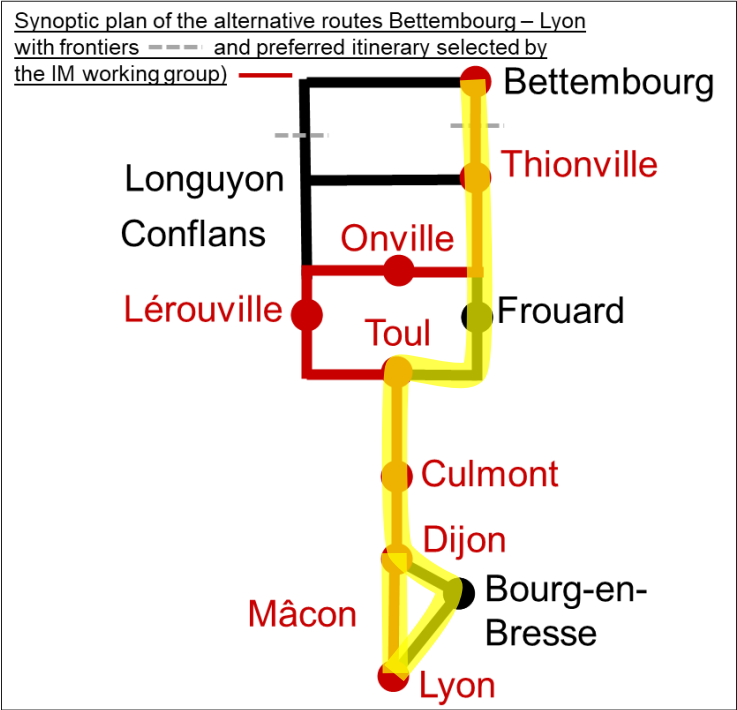
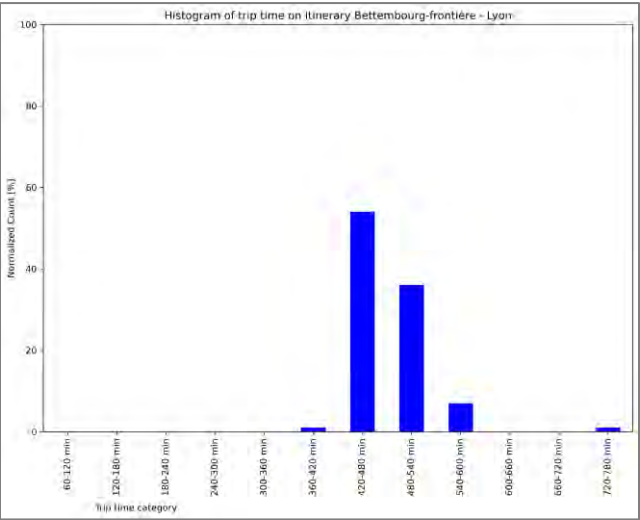
AVAILABLE  
CAPACITY AT A  
GIVEN MOMENT  
(2022)

# [9] Calendar stability

Stability (calendar stability during the year) : itineraries

Trains running on  
Bettembourg – Lyon are  
mostly planned via Frouard  
and Bourg-en-Bresse.

All year 2022

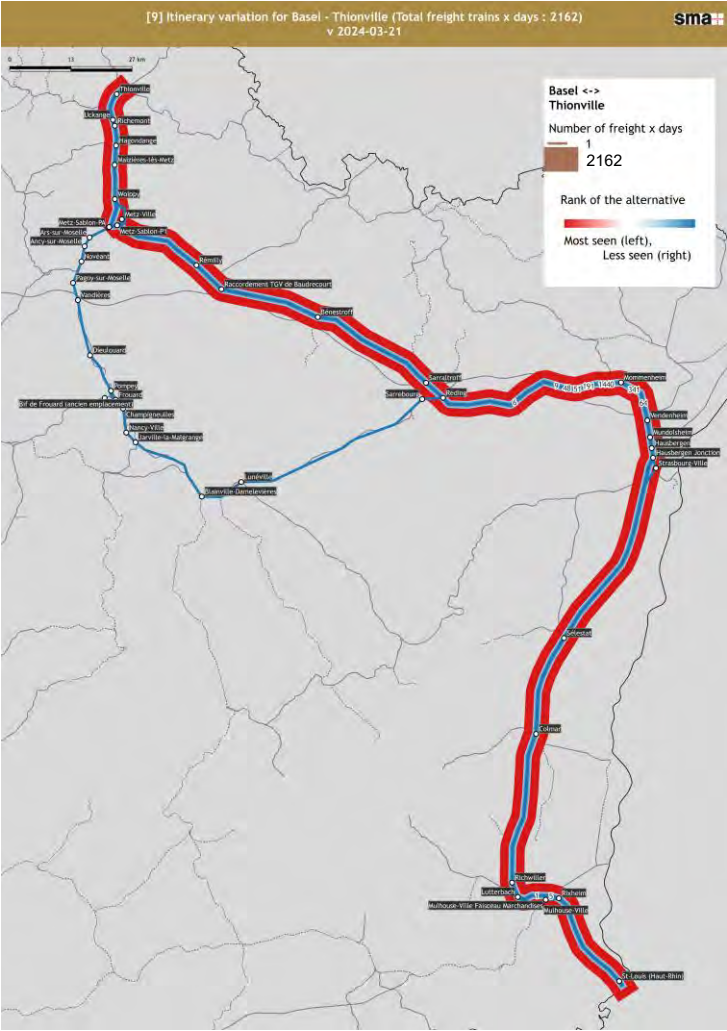
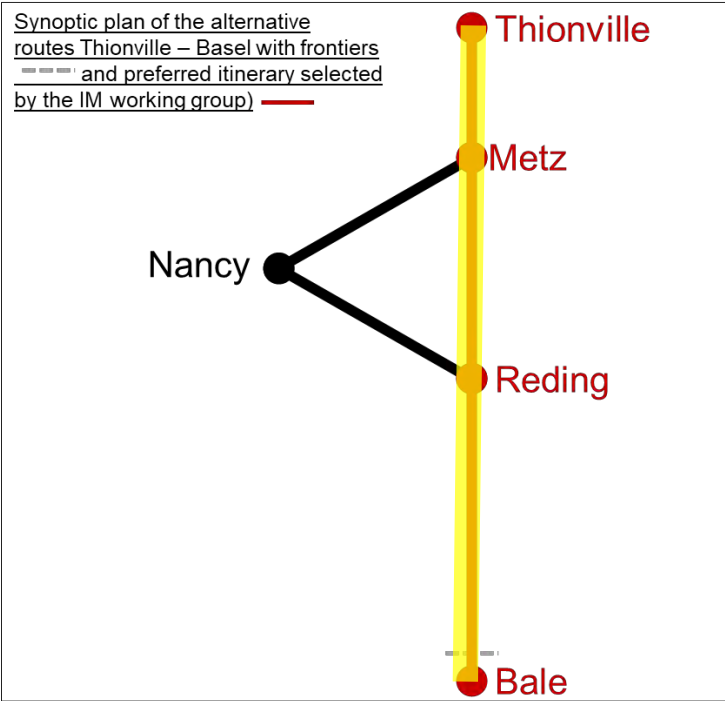
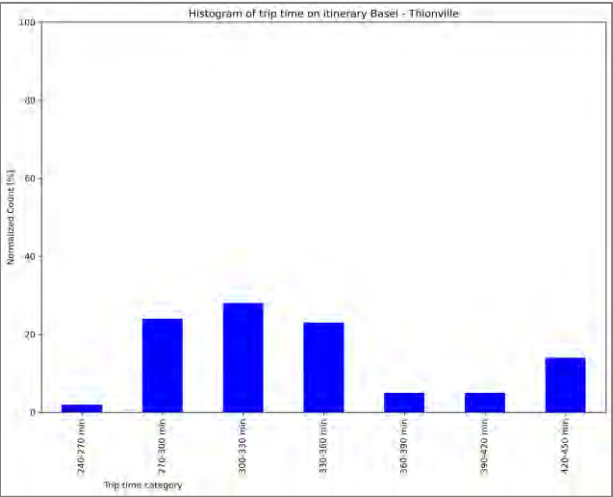


AVAILABLE  
CAPACITY AT A  
GIVEN MOMENT  
(2022)

# [9] Calendar stability

Stability (calendar stability during the year) : itineraries

Trains running on Thionville  
– Bale are mostly planned  
via the preferred itinerary,  
and sometimes via Nancy.  
All year 2022



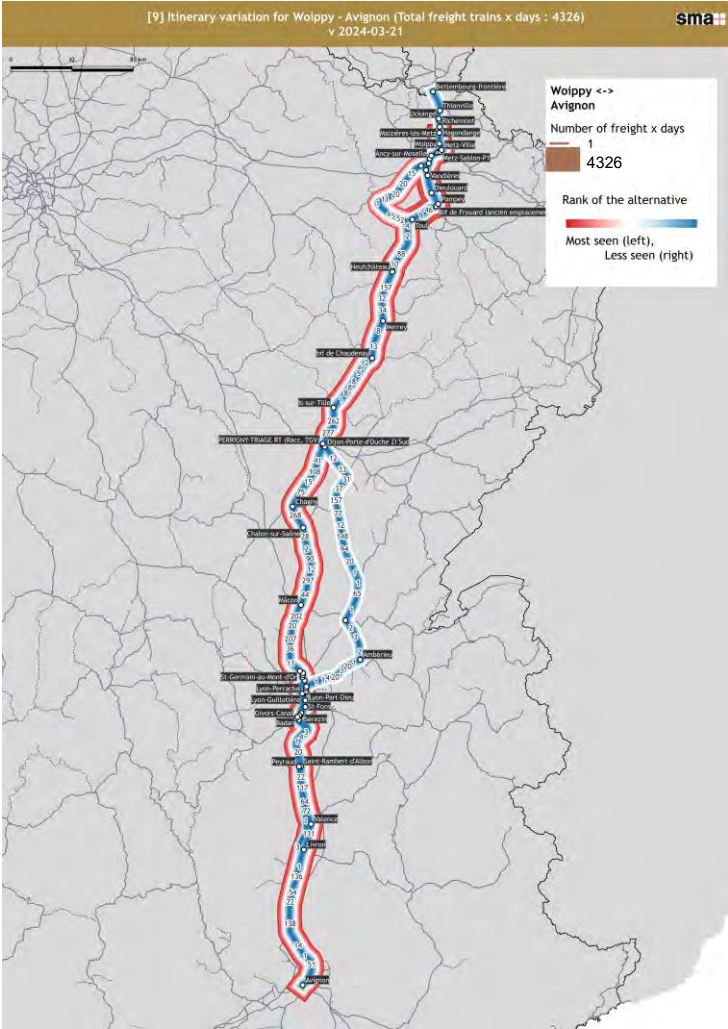
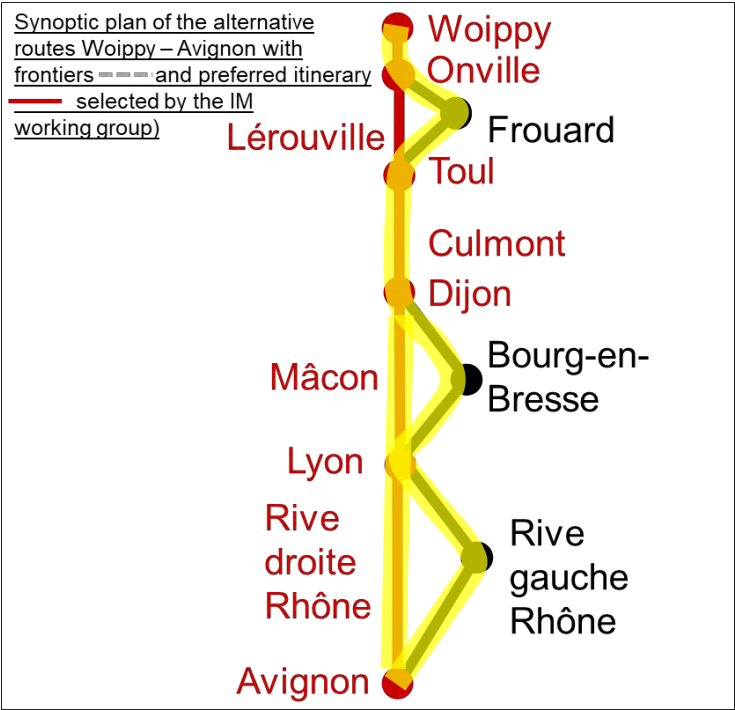
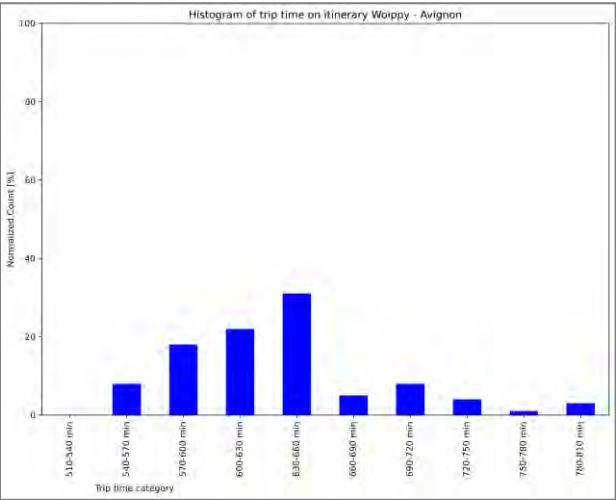
AVAILABLE  
CAPACITY AT A  
GIVEN MOMENT  
(2022)

# [9] Calendar stability

Stability (calendar stability during the year) : itineraries

Trains running on Woippy – Avignon are planned via a combination of the different alternative itineraries.

All year 2022








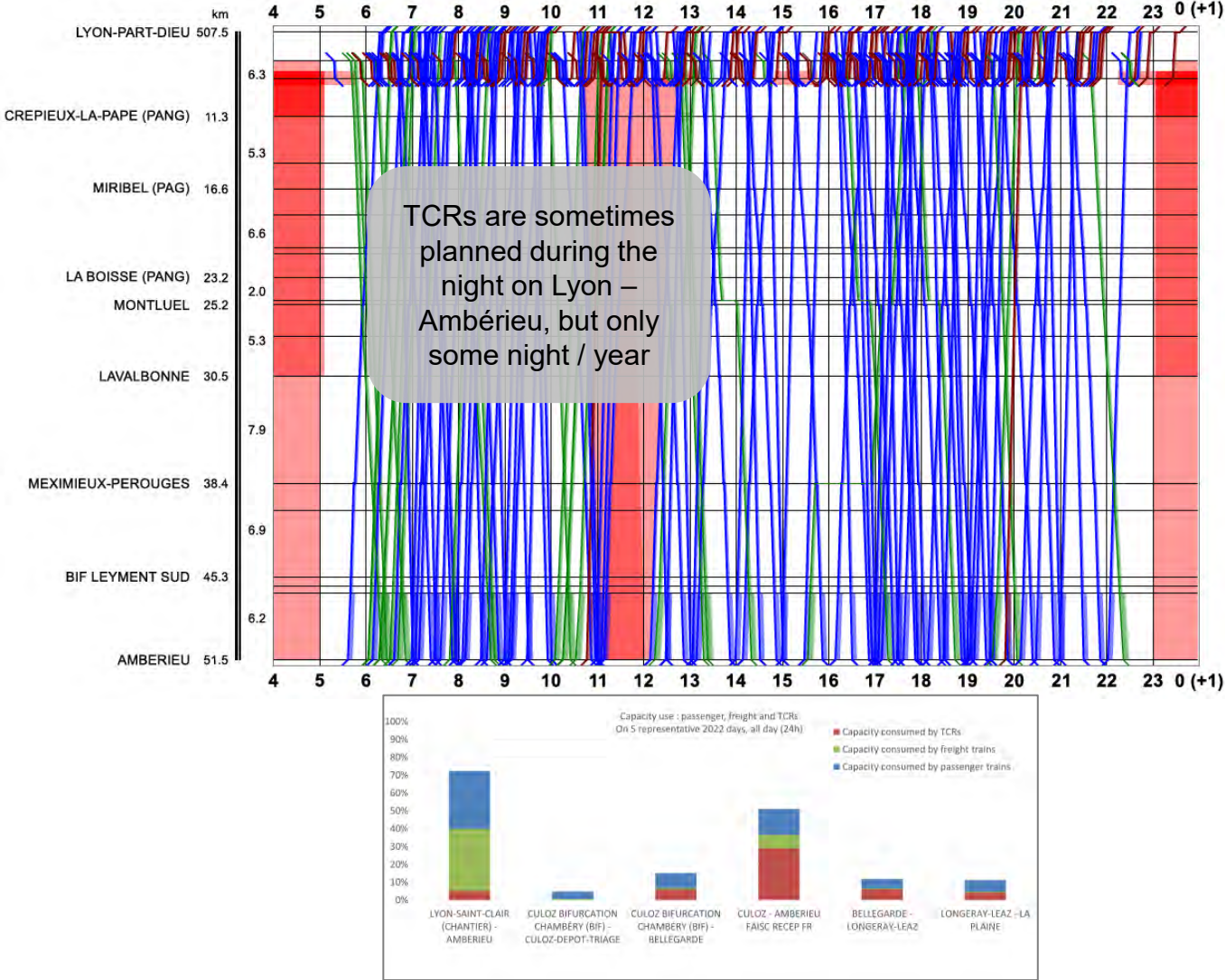
# Annexes

1. Assumptions
2. Permeability
3. Capacity consumption rates
4. Calendar and process stability
5. Bottlenecks



# Bottlenecks : zoom on Lyon – Ambérieu

▼ negative impacts on capacity		High heterogeneity of runtimes on the sections
		High volume of trains during all day : freight, regional and local trains with a difference on runtimes due to a lot of stops
		Average timetable optimisation due to commercial constraints
▲ positive impacts on capacity		Good signalling performance
		Some TCRs during the night (not a majority of the nights) + 1h during the day
Diverse significant observations		Under-decomposition of the network due to the tool specifications
		Low calendar instability of paths for passenger trains but high for freight trains

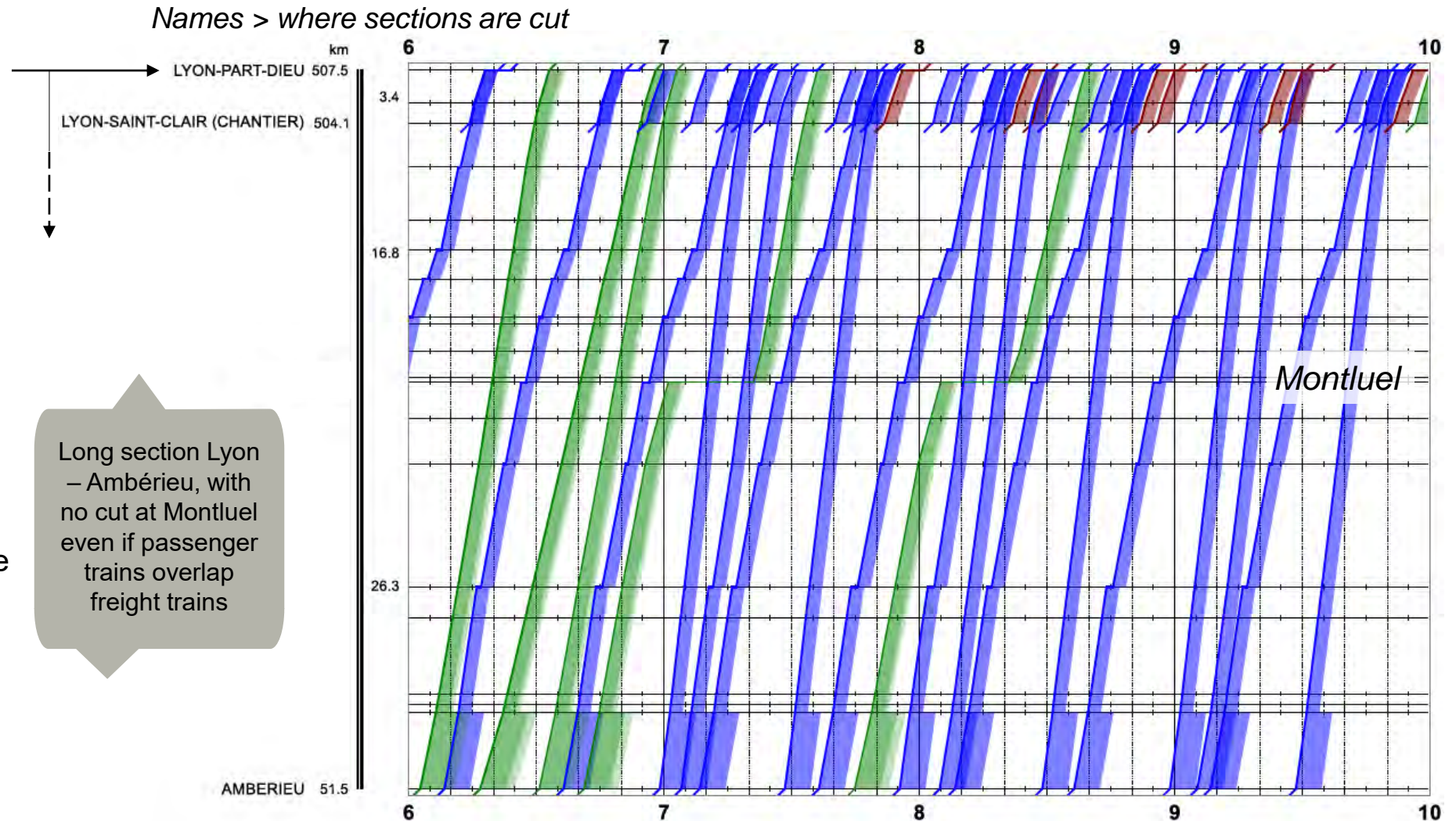


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(2022)

# Bottlenecks : zoom on Lyon – Ambérieu

Under-decomposition of the network (network is cut where name are displayed here), which leads to a overestimation of the consumed capacity.






Under-decomposition is linked to an interpretation of the rules into the tool.

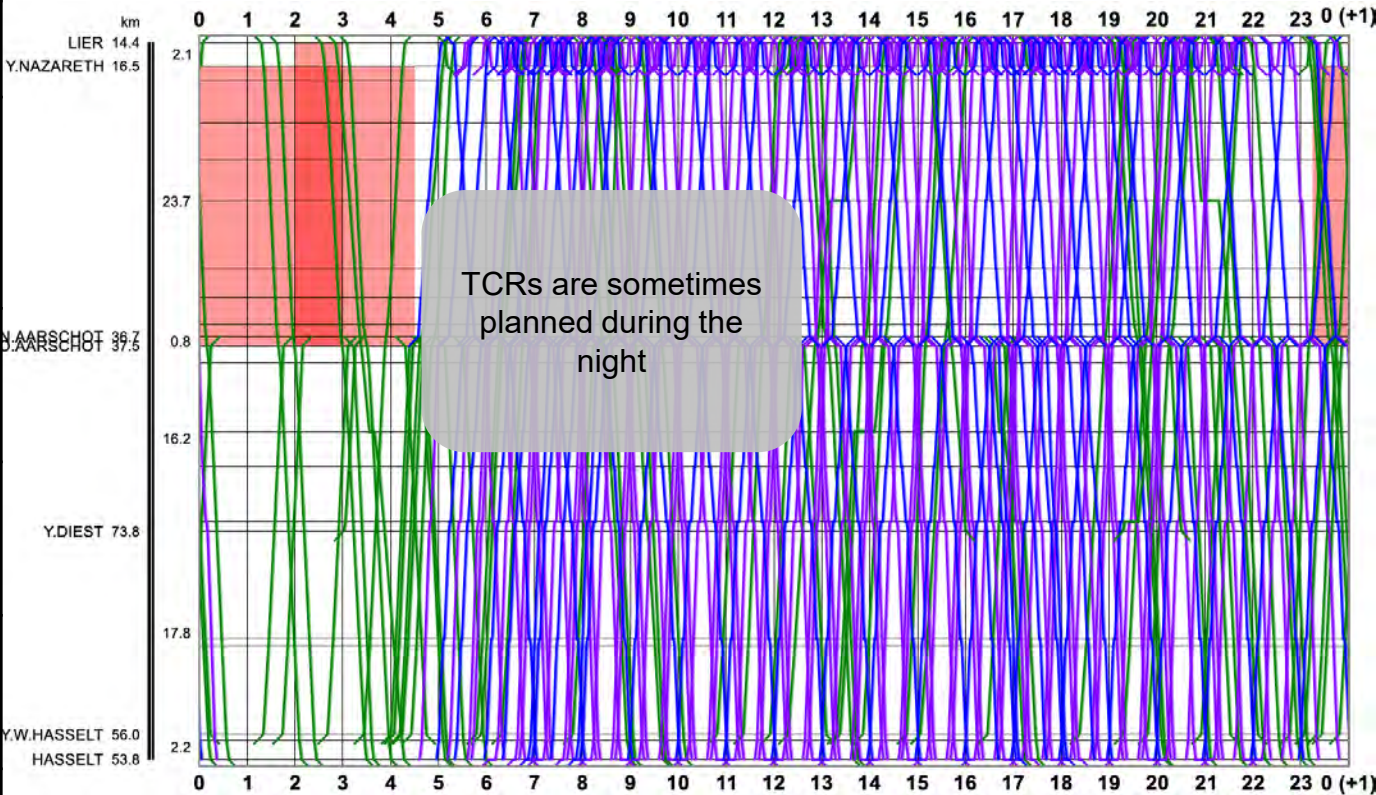




AVAILABLE  
CAPACITY AT A  
GIVEN MOMENT  
(2022)

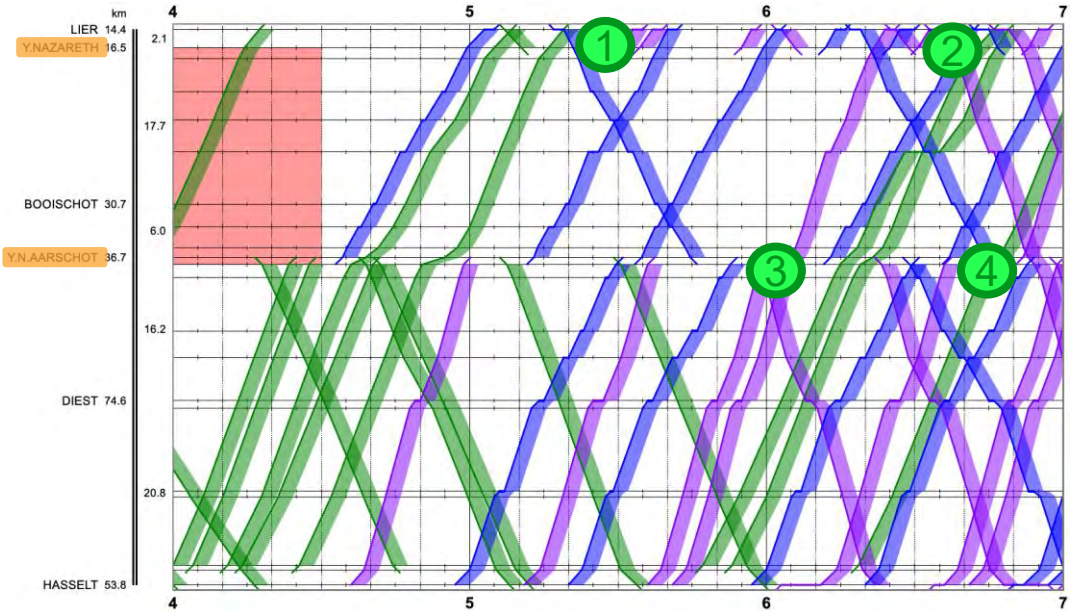
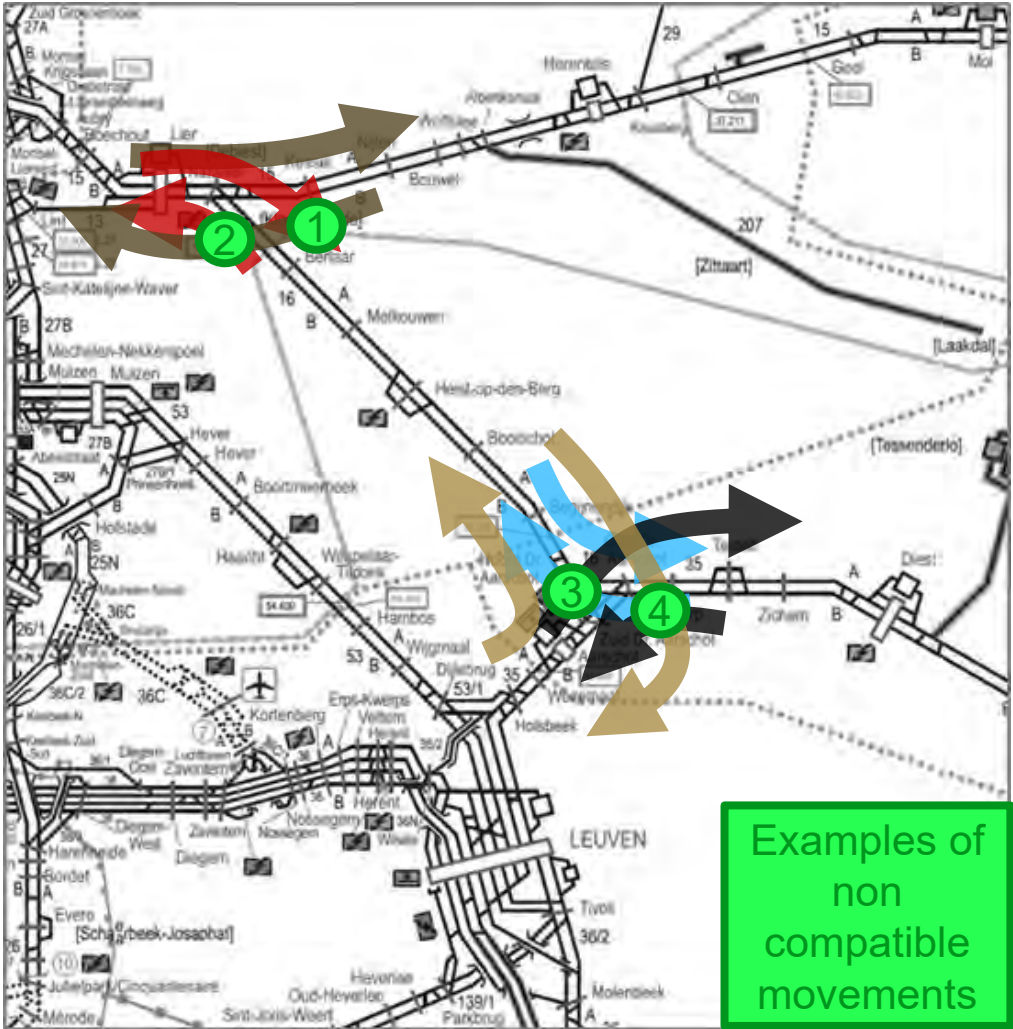
# Bottlenecks : zoom on Lier – Aarschot - Hasselt

▼ negative impacts on capacity		High heterogeneity of runtimes on the sections
		High volume of trains during all day : freight, regional and local trains with a difference on runtimes due to a lot of stops
▲ positive impacts on capacity		Good timetable optimisation
		Good signalling performance
		Some TCRs during the night (not a majority of the nights) + 1h during the day
Diverse significant observations		2 major junctions-zones which are bottlenecks : Nazareth, Aarschot
		Low calendar instability

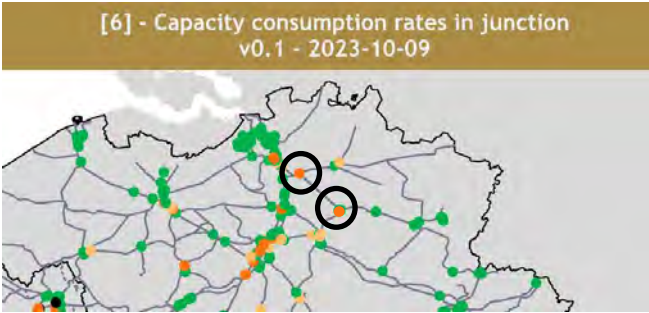


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# Bottlenecks : zoom on Lier – Aarschot - Hasselt



2 junctions/junctions zones where a lot of crossing paths are planned, without conflicts. Paths crossing the 2 junctions are usually hard to insert.





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(2022)

# Bottlenecks : zoom on Lier – Aarschot - Hasselt

If the 2  
constraints are  
considered  
separately, a lot  
of paths can be  
placed across the  
2 junctions :

Nazareth →  
Aarschot

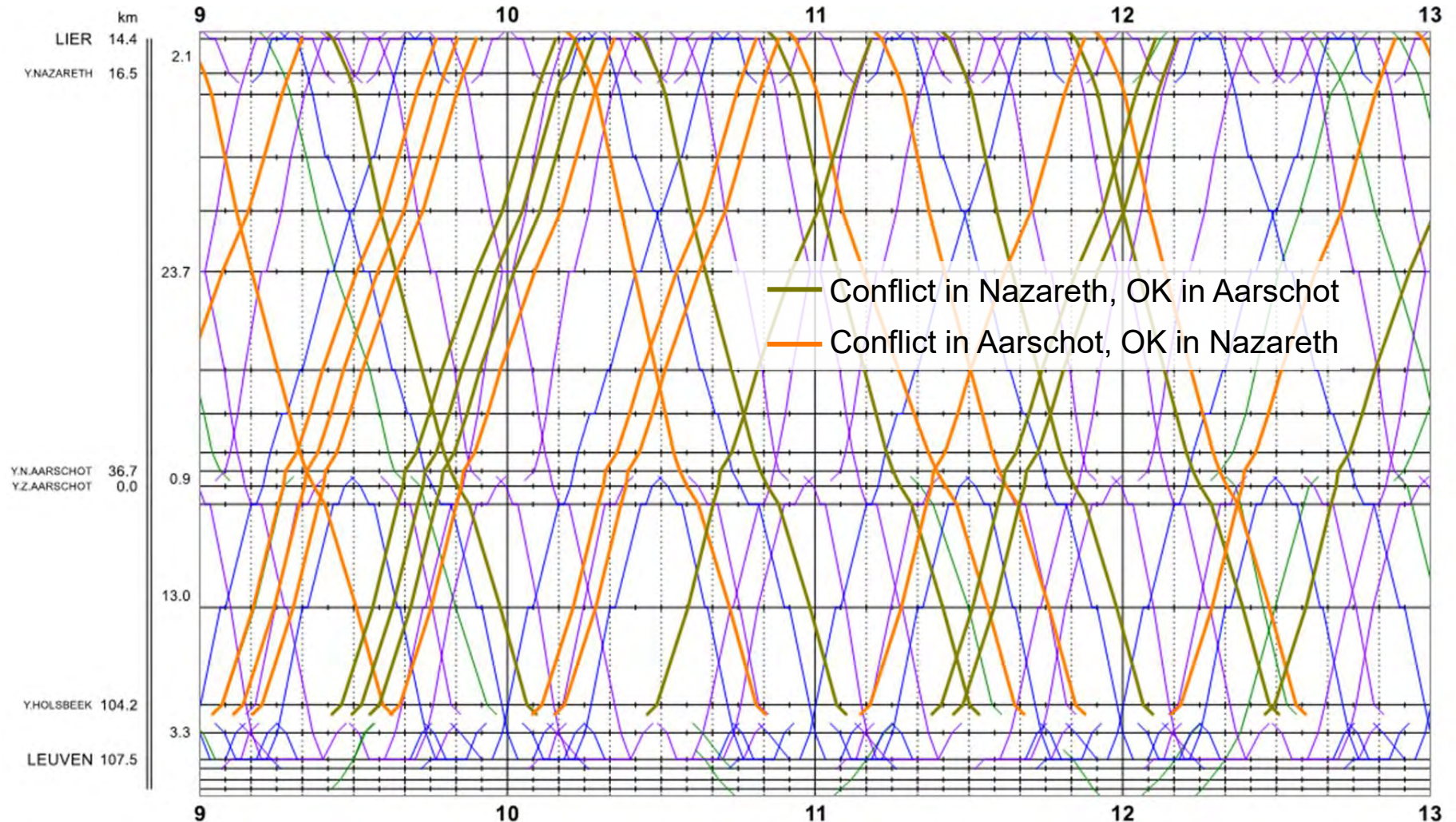
5 trains without  
conflict in Nazareth

5 trains without  
conflict in Aarschot

Aarschot →  
Nazareth

9 trains without  
conflict in Nazareth

7 trains without  
conflict in Aarschot





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(2022)

**But if the combination of the constraints is considered, it's very restrictive for capacity, and it explains the low usable residual capacity.**

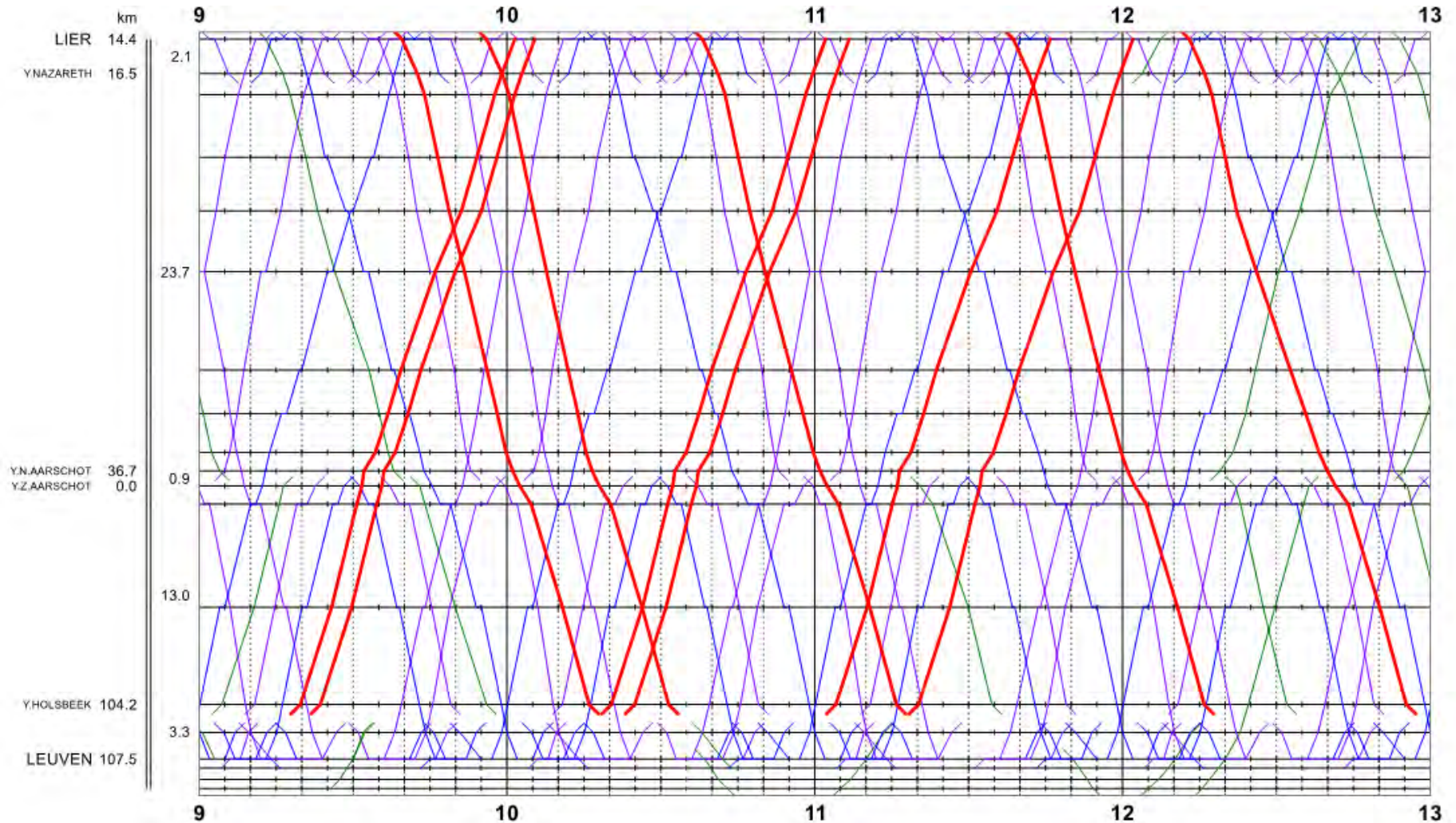
Nazareth → Aarschot

5 trains, 16% to 39% additional runtime (between Lier and Holsbeek)

Aarschot → Nazareth

6 trains, 26% additional runtime (between Holsbeek and Lier)

## Bottlenecks : zoom on Lier – Aarschot - Hasselt



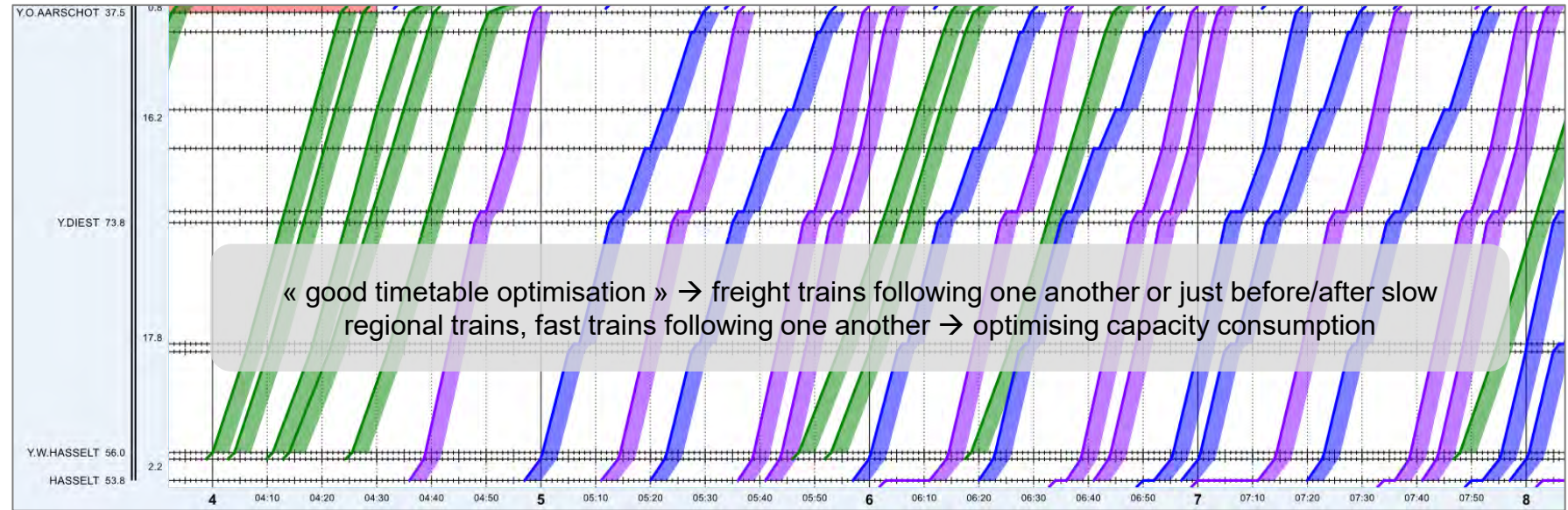
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CAPACITY AT A  
GIVEN MOMENT  
(2022)

# Bottlenecks : zoom on Lier – Aarschot - Hasselt

Y. Nazareth is a bottleneck characterised by the KPI “compression timetable in junctions”.

Y. Zuid Aarschot is the only Aarschot junction which is not green in this KPI.

Sections on line 16 and 35 from Lier to Aarschot to Hasselt sometimes (on some days, during some daily periods) > 50% in timetable compression KPI.








If you look at the optimisation level, here compared to Colmar Mulhouse for example, these 2 sections are not bad.

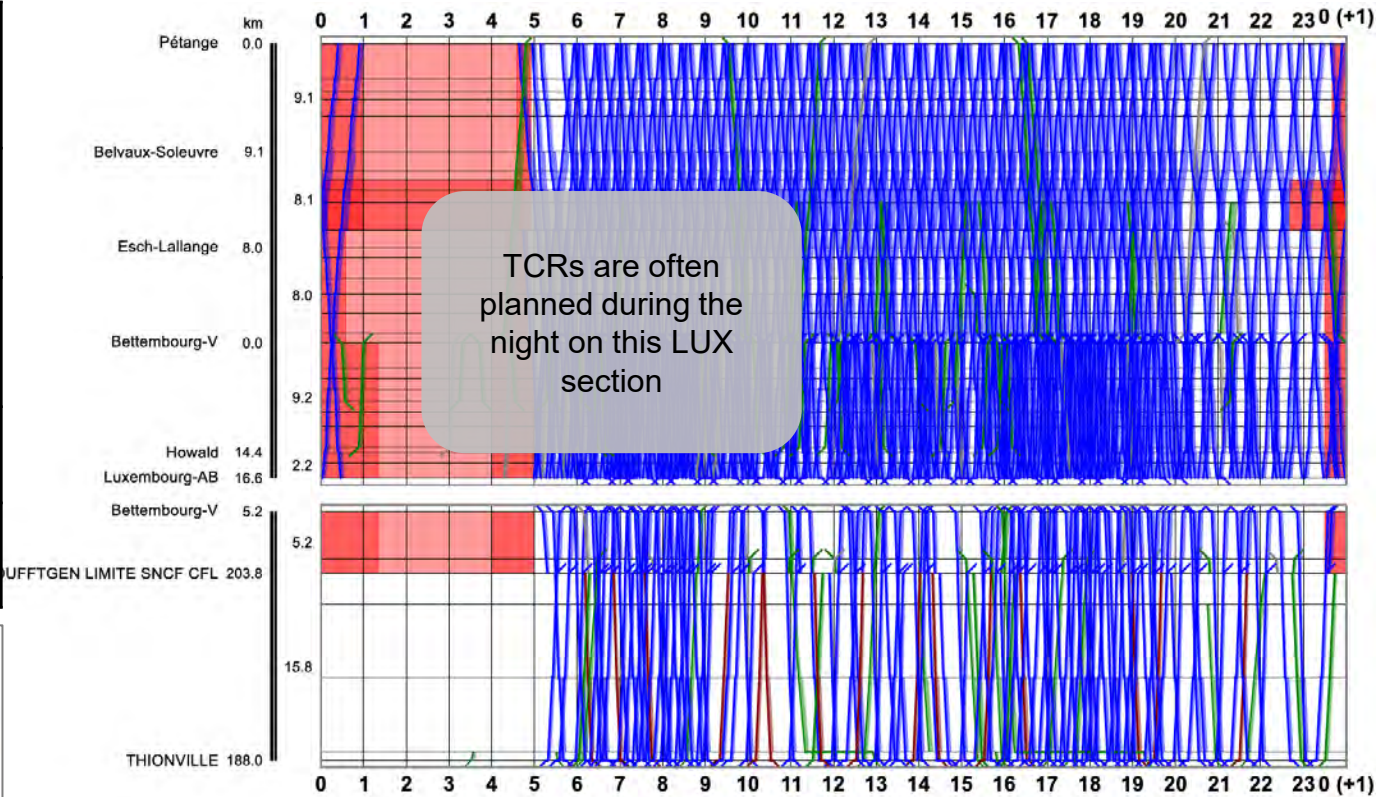
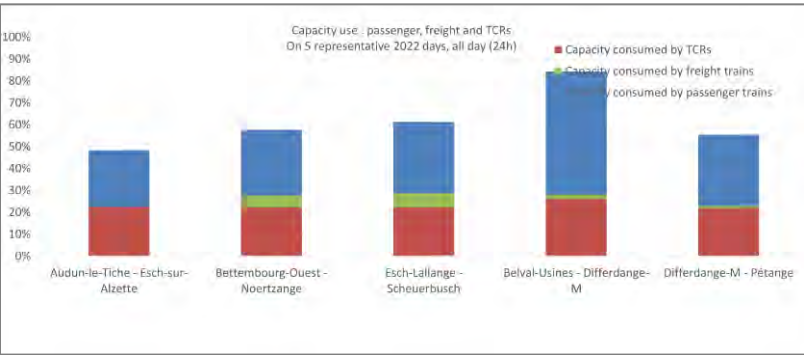




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GIVEN MOMENT  
(2022)

# Bottlenecks : zoom on Luxembourg / Pétange – Bettembourg

▼ negative impacts on capacity		Very high volume of trains during all day : freight, regional and local trains
		Bad signalling performance
		TCRs often planned during the night
▲ positive impacts on capacity		Good timetable optimisation
		Low level of runtimes heterogeneity

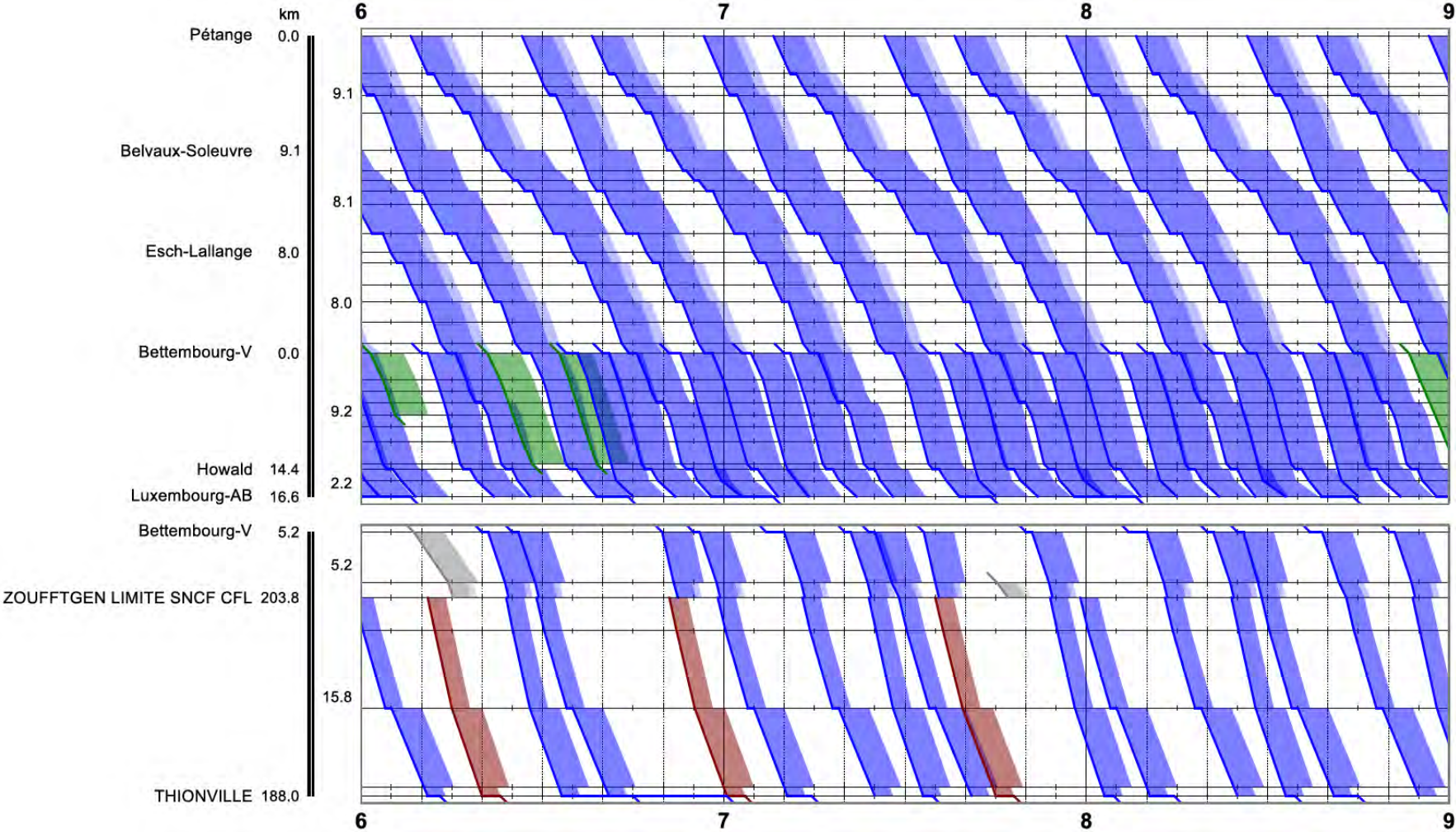




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GIVEN MOMENT  
(2022)

# Bottlenecks : zoom on Luxembourg / Pétange – Bettembourg

Very high volume  
of passenger  
traffic.



# Bottlenecks : zoom on Lille / Lens – Somain

▼ negative  
impacts on  
capacity



Medium heterogeneity of  
runtimes on the sections (on  
Douai – Lille)



High volume of trains during  
all day : freight, regional and  
local trains with a difference  
on runtimes due to a lot of  
stops



Low timetable optimisation  
due to commercial constraints

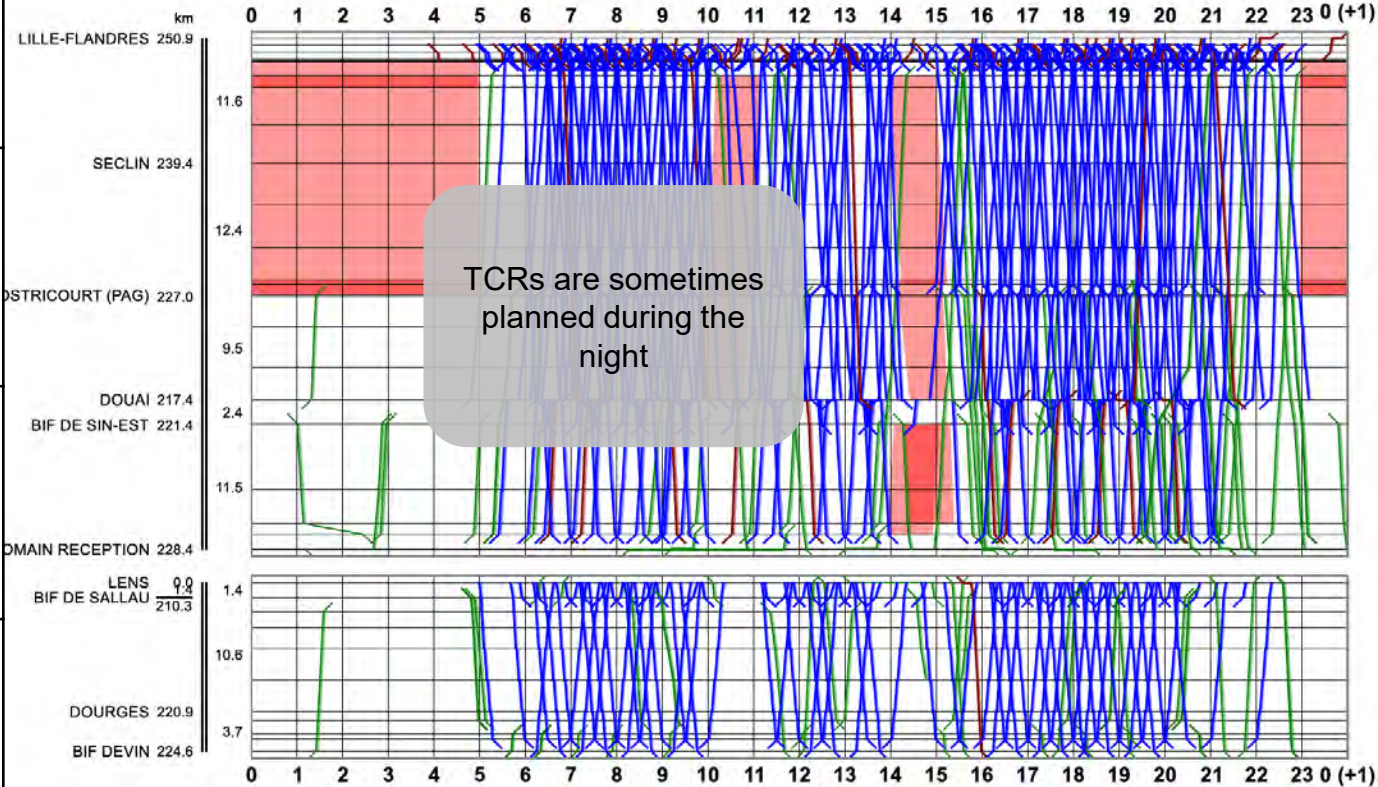


Low signalling performance at  
some points (Ostricourt,  
Dourges) and average on the  
line

▲ positive  
impacts on  
capacity



Some TCRs during the night  
(not a majority of the nights) +  
1h during the day

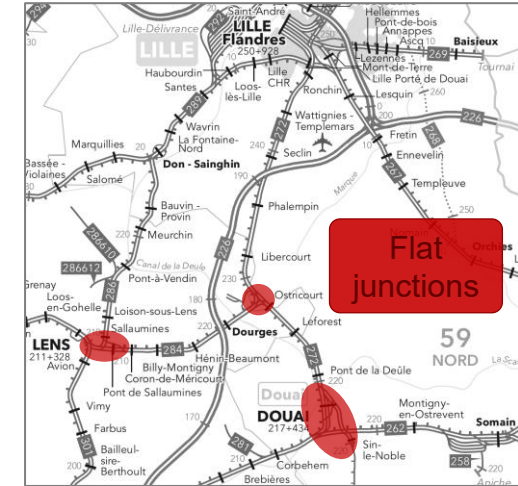
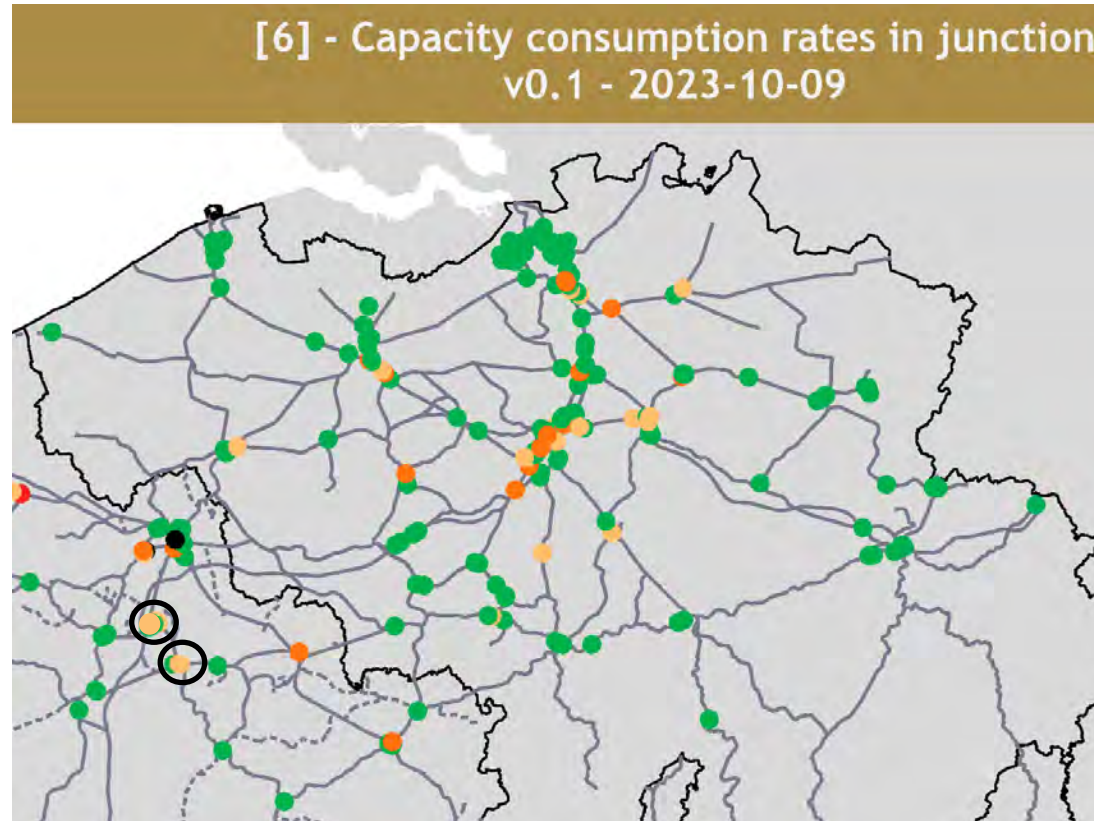




## AVAILABLE CAPACITY AT A GIVEN MOMENT (2022)

On Lille – Ostricourt, sections have a compression rate  $> 50\%$  calculated on all the day. The 3 flat junctions zones also have high capacity compression rates, and the combination of all these constraints leads to difficulties when trying to add some paths.

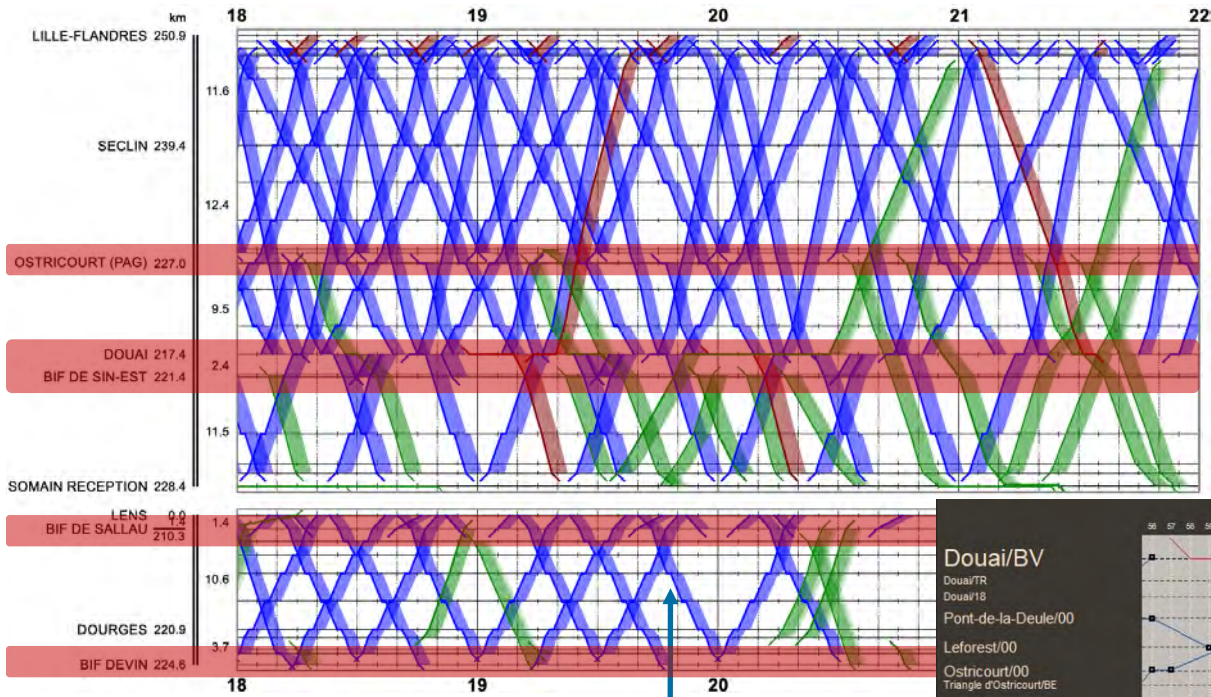
# Bottlenecks : zoom on Lille / Lens – Somain



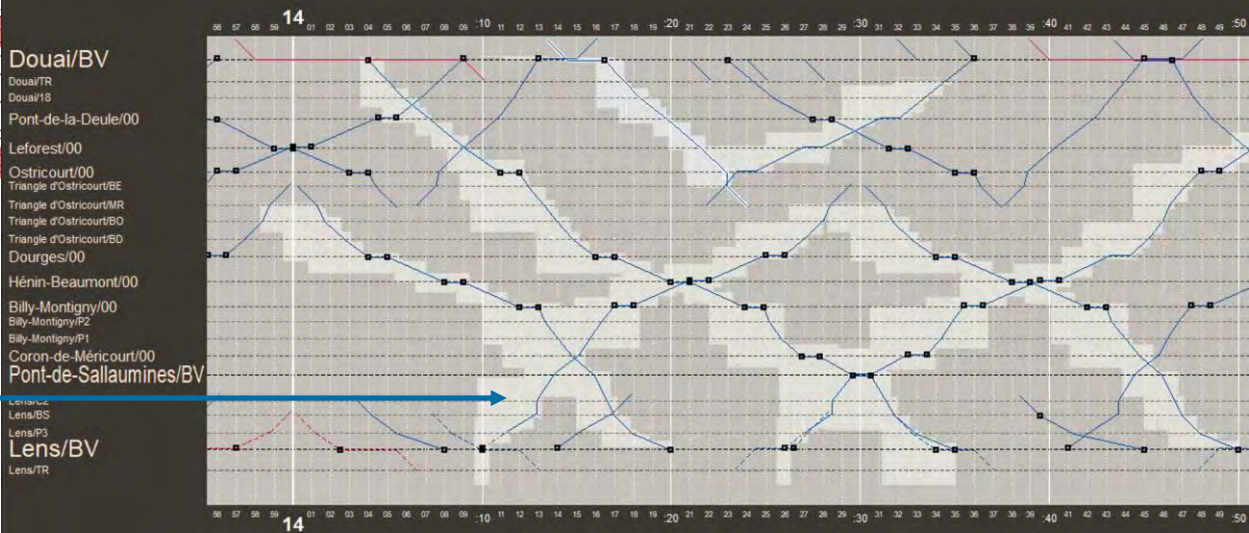


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GIVEN MOMENT  
(2022)

# Bottlenecks : zoom on Lille / Lens – Somain



Headways from « normes de tracé » are optimistic, even though flat junction separation times are realistic and very unfavourable for the available capacity



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