APPENDIX 4.1

TECHNICAL STANDARD FOR TIMETABLE DESIGN

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The construction of the service timetable, and more generally the design of the timetable for any time horizon, is based on the technical principles described in this document.

This standard, which sets out the routing principles and referential bases (points 1 and 2 below), is composed of generic technical data, describing SNCF Réseau's strategy for the network, and specific data relating to different lines and stations, the whole standard permitting, with regard to the requests presented, the layout of train paths in the graphic timetable (Articles 3 to 7).

GLOSSARY AND ACRONYMS USED IN THIS DOCUMENT:

- "IM": Infrastructure Manager
- "IPCS": permanent installation of opposite direction
- "LC": conventional line
- "HSL": High-Speed Line
- "LTV": temporary speed restriction
- "GOV": track occupation diagram
- "PC": point of conflict
- "PGF": general windows programme
- "PK": kilometre post
- "PR": remarkable point of reference (isolated junction, passenger building, etc.)
- "IS": information system
- "SIPH": IS used to trace train paths
- "HAZARD": small-scale disruption of an unpredictable nature (e.g. unexpected speed limit, late docking, etc.)
- "BACKGROUND NOISE": small disturbances to normal operations, outside of any hazard (e.g. low dispersion of driving behaviour, low dispersion of signal opening times, etc.)

1. PRINCIPLES

The capacity allowed by a railway infrastructure depends on the physical characteristics of the infrastructure and its operating conditions, but also on the characteristics of the vehicles and their arrangement/succession.

A set of technical rules, described in this appendix, allow this to be reflected in the modelling used in timetable design.

The aim of these technical rules is also to design schedules that reliably deliver the service promised to customers, by ensuring:

- High-quality modelling, true to the performance provided by the infrastructure and mobile devices,
- The compatibility of capacity objects with each other, within the performance limits of the infrastructure and mobile devices,
- The right sizing and positioning of margins.

Attention is drawn to the fact that a technically high-quality graph is a necessary condition but insufficient to deliver the promised service reliably. It cannot compensate for all types of fragility, nor can it absolutely guarantee the reliability of the service delivered.
In addition, the robustness of train design, and the control of differences between the service produced and the service designed, contribute directly to the systemic reliability sought.

In particular, the graphics resulting from the design must be able to absorb background noise (dispersion within the operation) and the hazards of routine operation.

2. PATH MODELLING AND COMPATIBILITY

2.1. Infrastructure modelling

A fixed selection of line parameters is used as the basis for the calculation of timetables:

- Physical paths and signal layouts, describing the predicted state of the infrastructure for which the design is being carried out; some fictitious signals may be modelled, for the purposes of the correct operation of the SIPH calculation algorithms;
- The speed limit, as defined by the Technical Information;
- The performance code resulting from the electrical power available for traction and the level of electromagnetic disturbances allowed;
- Remarkable points (RP), which allow timetabling at geographical points corresponding to physical objects (passenger buildings, substations, switch points, etc.) or limits useful for dividing certain capacity objects (limits of work zones, crossover points, etc.). In addition, a link with the European Primary Location Code (PLC) enables train path data to be exchanged with other IMs;

This computing infrastructure can be communicated to applicants.

2.2. Modelling of the rolling stock

Two families of curves can be used to calculate the timetables:

- generic motor-driven (force x speed) curves over a staggered range of performances covering the field of the various traction units likely to run on the network;
- curves (resistant force x speed) representative of the different types of convoys for trains towed by a locomotive.

The list of these motor-driven and resistant curves constitutes the range of layout conditions that can be used by the timetable design teams and requested by a train path applicant, possibly associated with a towed tonnage.
The calculation of the basic operating time of the route of each train path is performed using the motor-driven curve or the triplet motor-driven curve- resistant curve- tonnage). The applicant must enter the reference rolling stock selected for its train path order.
It is the responsibility of the applicants to only select trains, for a given train path, capable of keeping to the timetable of the allocated train path at any point in time, without risk of coupling failure or deterioration of the track by skating.

2.3. Path compatibility rules

The determination of the time frames separating the train movements is described in the text on "Train path compatibility rules for timetable design" and reference AR02384. It defines the rules for the compatibility of train paths in timetable design.

These rules are implemented by three (3) complementary means:

- Conflict detection in design tools, or in the absence of conflict detection, taking account of layout standards,
- The special conditions of the layout,
- Operational information

- Conflict detection for design tools

The algorithms of the SIPH tool comply with the rules of AR02384.
SIPH can therefore calculate conflicts between train paths dynamically.
The timetable design teams take this conflict detection into account in order to organise the arrangement of the paths in the graphs and eliminate any conflicts.

In the event of a design in a tool that does not have a conflict detection calculation that complies with the rules defined in AR02384, the default layout standards must be used.
Attention is drawn to the deviations from the graphs that may exist between the use of the standards on the one hand and the detection of SIPH conflicts on the other, resulting from:

- The dynamic nature of the SIPH conflict calculation, as opposed to the static nature of standards which are calculated for typical estates,
- The exhaustive nature of the SIPH conflict calculation, versus the non-exhaustive nature of the standards.

- Special layout conditions

The specific layout conditions are established by SNCF Réseau. They are described in AR30155. Their use complements SIPH conflict detection.

These special layout conditions make it possible to incorporate specific infrastructure or operational features based on feedback or analysis that the SIPH tool alone cannot take into account.
They may especially concern:

- The minimum time intervals to be respected between two train paths at a given PR,
- Specific planning principles,
- Flat-rate journey times,
- Access conditions to certain service track bundles and certain ITEs,
- The reception codes,
- The timetable designer operations,
- Etc.

The special layout conditions are classified by RT (Technical Information) number and structured in two parts:

- Special layout conditions on national lines ;
- Special timetable layout conditions on regional lines;

- Information on operating aspects

The document: The "XXX station operating information", for stations that have it, includes in particular:

- the railway complex (work sites, wharf tracks, routes);
- how the operating pipes work;
- the rules for using the work sites;
- the authorised and recommended routes for technical maneuvres;
- the minimum, robust and maximum operating times defined by SNCF Réseau for back-hauls, coupling/uncoupling, flow speeds, etc. The operator may send the desired operating times in a separate document.

The transport plans and resulting capacity requests must take account of the operating guidelines described in this document where available. In the event of a discrepancy, SNCF Réseau may make counter-proposals.
Should there be no "XXX Station Operating information" document, if the parking times requested are more than 20 minutes and unless there is a framework agreement specifying another value, they are likely to be rejected by SNCF Réseau when the request affects the operating robustness of the site or requires the refusal of another train path.

These texts can be consulted on the SNCF Réseau website, on the "**"Technical documents mentioned in the NS"** page.

3. JOURNEY TIME OF A TRAIN PATH

The journey time of a train path between two points is the sum of the following basic time blocks:

- Basic operating time,
- Running time margin,
- additional work margin,
- parking and other times related to station operations,
- the extra time needed to match train paths to each other. (

The accuracy of the train path staking should be adapted to the accuracy of the traffic and the range of actual trains compared to a typical train. Therefore, the theoretical timetables, except in special cases (suburban system with high time precision, etc.), are not expected to be issued with an accuracy greater than half a minute.

3.1. Basic operating time

The basic operating time is the shortest operating time normally achievable. It is the result of the computation of the convoy (motor characteristics and running resistances) requested by the applicant on the computing infrastructure.

3.2. Running time margin

The running time margin is supplemental time consisting of:

- A-margin, designed to cope with routine operating contingencies and background noise
- T-Margin, intended to compensate for lost time resulting from temporary speed restrictions for works (scheduled or unannounced), use of the IPCS or speed limits related to the infrastructure (when not included in the basic operation time).

3.3. Additional margin for works

When the T margin cannot compensate for the expected loss of time caused by temporary speed restrictions, SNCF Réseau determines an additional works margin (also known as the V margin) on the sections of line concerned. This V-margin is integrated into the train paths:

- over the entire duration of a service ("permanent" minutes),
- and/or a part of the service.

These additional margins are summarised in the "additional minutes table" for an annual service. It is regularly updated and communicated to the Railway Undertakings.

3.4. Parking and other times related to station operations

During the allocation phase, parking times are requested by the applicant (commercial stops and service stops). The same applies to other times linked to station operations (cutting/hooking, for example, or hooking times resulting from sequences)

3.5. Additional time

In order to make the paths inter-compatible, and to take into account the effect of the arrangements on the resilience of the graph as well as on operating conditions, SNCF Réseau may include other additional times: stops [C], lengthening of stops, easing for the insertion of the path on a junction or in a dense domestication timetable), consequence of the staking by a constrained route to ensure the proper functioning of the track circuits.

4. MARGIN MANAGEMENT

4.1. Splitting up the network into LTV segments

The timetable design identifies certain strategic points for timetable staking compliance. These are important geographical nodes, points of convergence, border stations for flows (origin or destination). Compliance with the timetable at these points is crucial if the overall design of the system is not to be disrupted.

The grid of the structuring axes between these strategic points defines the segments, called LTV segments, on which the T-margin is affected.

4.2. Values of the running time margin

The regularity margin is 4.5 min/100 km for journeys on conventional lines outside the Ile-de-France region, and 5% of the basic journey on LGV routes and for services in dense areas of the Ile-de-France region, except in special cases. It is broken down as follows:

- On conventional lines (LC) and outside the densely populated areas of Ile-de-France:
  - ✓ A-Margin: 2 min /100 km,
  - ✓ T-Margin: 2.5 min /100 km.

On high-speed lines and in the dense Ile de France area, the regularity margin is, by default, allocated to the A margin. However, in the case of works on LGV allowing a speed limit greater than or equal to 220 kph, SNCF Réseau reserves the right to use half of the margin of the segment to compensate for the loss of works time, without exceeding 1 minute 30.

For certain train paths, on an exceptional basis, the conventional line margin may exceptionally be reduced to a rate of less than or equal to 3 min/100 km. The margin may only be reduced after a risk analysis has been made of the robustness of the path concerned and of the entire timetable of the routes covered. The decision to lower it is taken at the express request of the stakeholders concerned.

The distribution of A and T margins is then as follows:

- For margin rates equal to 3 min/100 km: A-margin = 0.5 min/100 km, and T-Margin = 2.5 min /100 km. Important: during LTV works periods, the total path margin may be reduced by up to 0.5 min / 100 km, which implies it is sensitive to random events and requires strict operating standards to minimise the differences between the planned timetable and the timetable achieved in operation,
- For margin rates strictly less than 3 min/100 km, the A-margin and T-margin distribution is discussed with the applicant.

When an applicant wants a change in the margin rate, the request must be made as far in advance as possible, and as soon as the timetable has been structured:

4.3. Distribution of the running time margin

- Excluding LTV periods

The running time margin is distributed with the aim of favouring the best stability of the timetables. Part of the margin may for this purpose be concentrated at the approach to certain individual points.

On a high-speed line, the distribution of the running time margin between two staking points is therefore allowed to have an average value of 5%.

For the other lines, the distribution of the linear margin may be modulated, i.e. concentrated at the end of the LTV segment to absorb the impact of unexpected work and potential delays when approaching nodes "to be protected".

In addition, in the context of short segments (generally less than about 150 km), part of the A-margin may be transferred from one segment to the neighbouring segment to better absorb the traffic constraints in the important nodes.

These allocations are made within the limits necessary to preserve the traffic flow.

- During the scheduled LTV period

In the event of known works on a LTV segment, the T-margin and any additional margin may be concentrated in the vicinity of the works zones

In the case of work on a given LTV segment, resulting in loss of time greater than the T-margin of the segment, part of the T-margin of an adjacent LTV segment may be used. This preserves journey times by avoiding the need to add extra margin on a segment. This provision does not apply to either sides of complex nodes.

4.4. Route with varying timetables for technical reasons

As an exception to the general principles set out in the preceding paragraph, in order to limit the creation of variants for technical reasons, no variant will be created if the difference between the total travel times is less than or equal to three minutes. In this case, the timetable is constructed:

- on the basis of the worst performing variant, for the calendar variants on a given train path,
- on the basis of the material of the train, for the train paths in the timetable (in the case of a less performing material on a train path of the timetable, a variant will have to be created).

These principles may also be applied for deviations longer than three minutes, unless the applicant has specifically requested the creation of a timetable variant.

5. GRAPH LAYOUT

5.1. Compatibility between train paths

Train paths are laid out so that 2 trains running at the same time do not interfere with each other (subject to the availability of infrastructure in accordance with the planned state, and the conformity of the traffic with the planned route and convoy characteristics).

The layouts are based on open signals, except in cases where it is necessary to used layouts with closed signals (crossing, reception on closed signal, stops [C], planned reception on occupied track, etc.).

NB: the journey times calculated take account of these situations through the principles described in § 2.3

5.2. Line/station interactions

The compatibility of train paths is coordinated between line and station.

The compatibility of track occupations does not, however, give rise to a check of the sets of lanes globally allocated to an applicant for a fixed period.

5.3. Compatibility between train paths and work capacity objects

The SIPH tool can be used to calculate conflicts between train paths and work. Incompatibilities are resolved at the different phases of timetable design, depending on the scope of the work objects taken into account, and as described in chapter 4 of the network statement.

The timetable design limits the calendar variations in order to preserve the readability of the timetable, the stability of the network effects and a robustness with regard to uncertainties surrounding work sites. This limitation of variants takes account of the effects on journey times and the implications for the different market segments and the Railway Undertakings.

5.4. Compatibility between train paths and the line, station and substation opening times

The SIPH tool is used to calculate the compatibility between train paths and the opening times of lines, stations and substations. This consistency is especially ensured from the pre-construction phase, as described in chapter 4 of the RRD.

5.5. Overall effects on the resilience of the timetable graph

The design endeavours to propose layouts that take into account the overall effects on the graph's natural time resetting capacity. Particular attention is therefore paid to the risks of domino effects, leading to the risk, when trains are running, of delays from one part of the grid being exported to other parts of the grid, or of these delays being amplified.