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Summary

The rising volume of traffic, with simultaneously increasing demands in terms of quality and quantity, requires a unique, harmonised and generally-valid understanding to be developed as regards available railway-infrastructure capacity.

The method presented in this leaflet enables Infrastructure Managers (IMs) to carry out capacity calculations - following common definitions, criteria and methodologies from an international standpoint - for lines/nodes or corridors based on different criteria such as traffic quality (market needs or company requirements), timetable quality (requirements of timetable compilers) or effective and economical utilisation of infrastructure (IM requirements).

Capacity as such does not exist. Railway infrastructure capacity depends on the way it is utilised. Therefore, the proposed methodology is based on examination of an existing pre-constructed timetable for train operation on the particular infrastructure. This timetable, which expresses market needs, shall be analysed within a line section through compressing timetable train paths in a pre-defined time window. During the compression, it is not just timetabled train paths that are taken into account: any occupation times, even when not related to the train paths, must be incorporated.

The result of the compression process is the so-called infrastructure occupation. The capacity consumption shall be measured by infrastructure occupation, to which is added buffer times for timetable stabilisation and, where necessary, maintenance requirements.

If the determined infrastructure occupation figure is higher than a typical value, infrastructure shall be declared congested. If this typical value is not reached, a leftover capacity shall then become available. The way in which this leftover capacity can be used for additional train paths shall be determined for each single case on the basis of market needs.

The application of the compression methodology on different lines on several European networks showed that it is always possible to insert additional paths, but one must stop at a certain level due to stability requirements specific to the timetable. It appears impossible to assess standard precise values of the infrastructure occupation time, since generally valid determination of the necessary buffer times that are dependent on many factors has not been possible up to now.

However, in the interests of comparability of the results, this approach is intended as a first approximation. For this reason, only some guideline figures are proposed, which must be further developed through complementary analysis.

1 - Introduction

For an improved understanding of the definition of capacity and the method of calculating it, proper account must be taken of external and internal conditions. If these conditions - several of which cannot be influenced by the Infrastructure Managers (IMs) - are unknown, this can result in erroneous interpretations of the term capacity and in misunderstandings of the information contained in this leaflet.

1.1 - Aim of the leaflet

The rising volume of border-crossing traffic in Europe, with simultaneously increasing demands in terms of quality and quantity, requires a unique, harmonised and generally-valid understanding to be developed as regards available railway-infrastructure capacity.

Any railway-infrastructure evaluation, in order to be generally valid, must be underpinned by a common definition of capacity among railway infrastructure managers.

Due to the different concepts and procedures concerning capacity and the resulting calculations applied by IMs, a comparison is not feasible and general conclusions are not possible, which means that a unique procedure must be developed.

The method presented in this leaflet enables IMs to carry out capacity calculations - following common criteria and methodologies from an international standpoint - for lines/nodes or corridors based on different criteria such as traffic quality (market needs or company requirements), timetable quality (requirements of timetable compilers) or effective and economical utilisation of infrastructure (IM requirements).

1.2 - Basic parameters underpinning capacity

Capacity as such does not exist. Railway infrastructure capacity depends on the way it is utilised. The basic parameters underpinning capacity are the infrastructure characteristics themselves and these include the signalling system, the transport schedule and the imposed punctuality level.

On a given infrastructure, capacity is based on the interdependencies existing between:

- the *number of trains* (per time interval, e.g. trains per hour). When train intensity increases, less capacity is left for quality, as expressed in the parameters described below;
- the *average speed*. The braking distance increases proportionally more than the average speed;
- the *stability*. Margins and buffers have to be added to the running time of trains and between train paths to ensure that minor delays are suppressed instead of amplifying and so causing (longer) delays to other trains;
- the *heterogeneity*. When the differences in running time between different train types worked on the same track are great, similarly the capacity consumption of the same number of trains will increase proportionately.

The relation between these parameters is clearly shown in the "capacity balance", as illustrated in Fig. 1 below. In this qualitative model, an axis for each parameter is drawn from a unique origin. A chord links the points on the axes, corresponding to the value of each parameter. The length of the chord represents *the* capacity. Capacity utilisation is defined by the positions of the chord on the four axes. Increasing capacity means increasing the length of the chord.

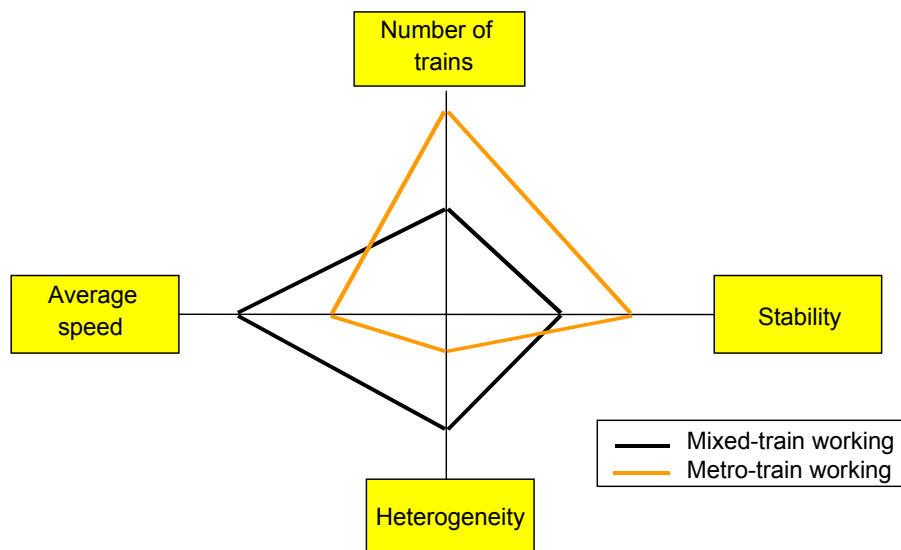


Fig. 1 - Capacity balance

1.3 - Different views of capacity

Due to differences in requirements, capacity is viewed differently from the position of the market, infrastructure planning, timetabling and operations. These are summarised in Fig. 2.

Market (customer needs)	Infrastructure planning	Timetable planning	Operations
expected number of train paths (peak) expected mix of traffic and speed (peak) infrastructure quality need journey times as short as possible translation of all short and long-term market-induced demands to reach optimised load	expected number of train paths (average) expected mix of traffic and speed (average) expected conditions of infrastructure time supplements for expected disruptions maintenance strategies	requested number of train paths requested mix of traffic and speed existing conditions of infrastructure time supplements for expected disruptions time supplements for maintenance connecting services in stations requests out of regular interval timetables (system times, train stops, ...)	actual number of trains actual mix of traffic and speed actual conditions of infrastructure delays caused by operational disruptions delays caused by track works delays caused by missed connections additional capacity by time supplements not needed

Fig. 2 - Different views of capacity

While capacity demands from the market standpoint are oriented towards satisfying peak values, infrastructure planning by contrast must be oriented towards a definition of capacity that, on average, guarantees profitable utilisation of the infrastructure. From a timetable point of view, capacity considerations bring together a given infrastructure and existing demands for train paths. From an operational point of view, on the other hand, the capacity situation is always in flux and depends on current infrastructure availability, progress with building measures, delays, diversions and the number of additional trains.

Each of these different situations is correct in terms of its own specific background. The parameters mean, however, that each viewpoint leads to a different capacity-requirement result.

1.4 - Capacity-relevant constraints

Alone, each set of circumstances mentioned below can lead to considerable capacity limitations. If, however, several points come together, this translates into virtually insoluble capacity problems.

1.4.1 - Priority

Existing priority regulations influence available capacity, through which the mix ratios can be specified or influenced. Different priority regulations can have a more restrictive effect on cross-border traffic than capacity restrictions for other reasons. IMs cannot influence priority regulations directly but can give advice about how to flesh them out.

1.4.2 - Timetable structure

Small and large-scale traffic networking, e.g. integrated regular-interval timetables for local transport, line systems for long-distance passenger trains, create a variety of constraints both on routes and at junctions. Line and integrated timetable systems are relatively rigid and result in infrastructure occupation with little train-path planning flexibility. Particularly critical is the superimposition of several different systems on the same infrastructure, which then leaves hardly any room at all for other traffic.

1.4.3 - Capacity allocation process

Different schedule chains and methodologies for capacity allocation constitute constraints, especially in the case of cross-border train pathing. Any conflicts arising are dealt with in different ways in accordance with different rules whereby significant differences exist in capacity allocation for freight traffic at short notice.

1.4.4 - Design rules

Differences exist in the design method, in the determination of the possible physical journey time, in the treatment of time allowances to ensure the individual train-path timetables plus timetable stability, as well as in the consideration given to building and maintenance measures. All of these factors can translate into restrictions for cross-border traffic.

1.4.5 - Environmental protection

Rules for environmental protection, e.g. those relating to noise emissions, have a restrictive impact not only on the volume of all traffic but also on special, noise-intensive train movements, e.g. at certain times of the day. Prohibitions on hazardous loads exclude the use of certain routes and force traffic onto predefined routes and junctions.