Train Delays and Punctuality

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Indicators of expected quality of service in public contracts are often based on some kind of “punctuality”, usually defined in terms of the percentage of trains arrived “on time”, i.e., within a given delay, at stations, which can mean either at their final destination or also at intermediate “significant” stops. Of course, this requires defining in which circumstances an arrival is counted as a delay. Passengers, however, tend to use the word “punctuality” with a more general meaning, mostly as a synonym for expected delay at their own destination, and especially in case of commuters are much less tolerant of even smaller delays than train operators would normally allow. Overall, punctuality is claimed to be one of the most important quality indicators both in railways and, widening the discourse, in schedule-based bus operation, and is crucial for customer satisfaction.

punctuality delay indices performance indicators

1. Introduction

In an ideal world, trains would always operate perfectly on time. In the real world, of course, train operations are actually subject to many factors which may cause small or larger delays; thus, the overall quality of train service is a complex issue from the technical, economical, and user experience viewpoints.

From the technical viewpoint, *train delay* can be defined as “the deviation from a scheduled event or process time of this train”; there, *punctuality* is seen as an aggregate measure, defined as “the percentage of the trains arriving (or departing, or passing) a location with a delay less than as certain time in minutes” [1].

More generally speaking, as highlighted in [2], delays and punctuality are different in that delays refer to measures in time units, while punctuality is expressed as a percentage.

From the microeconomic/performance accounting viewpoint, the definition of expected quality of service in public contracts can take into account “punctuality indicators” [3][4], typically defined in terms of the percentage of trains arrived “on time”, i.e., within a given delay, at stations, which can mean either at their final destination or also at intermediate “significant” stops. The delay threshold varies from country to country [5] (e.g., 3 min in the Netherlands [6], 5–10 min in the UK [5], 6–10 min in Belgium [7], 5 min in Germany [5], and 5–15 min in Italy for commuter and long-distance trains, respectively [4][8][9][10][11]; for a full list, readers are referred to [12][13]). Measures can also be based on the “average delay per train” [3][14], on the standard deviation of the travel time [3], and on other metrics [12]. Indeed, punctuality is “claimed to be one of the most important quality indicators” [2] in railways, and is crucial for customer satisfaction. Such performance targets, especially the commuter ones, can refer to

specific lines in a given region, or possibly to the typical weekday, or to peak hours only. In certain cases, a bonus/penalty system is introduced for awarding/fining train operators whose indices meet/do not meet the expected standards, in which case forms of compensation can be established in favor both of the public commissioner and/or final customers.

Widening the discourse, analogous considerations hold for schedule-based bus operations, where a service is often considered on time if "it runs between a certain amount of minutes early and minutes late" [15], and punctuality is usually measured at the origin and at several stops along the route, in particular, at "regulation stops" [16], i.e., key stops along the route. Suitable punctuality indicators are defined for business models purposes [17], and a bonus/penalty system can be established [16] based on whether operators exceed or fall short of a pre-defined standard.

Customers, however, tend to use the word "punctuality" with quite a more general meaning, mostly as a synonym for "expected delay" [18][19] experienced at their own destination on the specific lines and trains they normally use, borrowing the semantics from their everyday life where "punctual" means no or little delay on a given clearly-identified event. Accordingly, the customers' viewpoint is both "multidimensional, subjective" [12], and quite a lot *less forgiving*: indeed, passengers experience even small delays of a minute or so quite negatively, which is much stricter than the 5-minute allowance adopted by many train operators in considering a train "on time". Delays of 30 min or more exacerbate passenger frustration, with notable policy implications for train operators [20]. Notably, the passengers' viewpoint is *situated*, i.e., specifically focused on the passengers' own experience, leading to a possible difference in perceptions of delays and punctuality with respect to the statistical definition of punctuality that is traditionally adopted by train operators and infrastructure managers, which is rather meant to provide a comprehensive view of performance for professional use (including line planning and timetabling [12][21], timetable stability analysis and optimisation [22], delay management [23], simulation [22], and performance evaluation in terms of reliability and availability of service [3][5]). In fact, the average delay has been found to be inconsistent with travelers' preferences [3].

2. Delays and Punctuality

According to [24], quoting [25], train punctuality is "related to trains running according to schedule", while [26] refers to punctuality as a "numerical measurement (…) part of trains arriving on time to the stations." Olsson [27] reports that "in most cases, this is measured to the terminus, but in some cases, it could also be measured at intermediary stops." In fact, in [28], punctuality is measured at any stop.

Of course, this requires defining in which circumstances an arrival is counted as a delay. Indeed, one of the basic measures used to classify a train as "on time" or "late" has long been the delay at the final destination. On top of this basic value, punctuality indicators are usually defined in terms of the percentage of trains arriving within a given delay, which is typically lower for short-haul and commuter services (e.g., 3–5–6 min, depending on the country) and larger for long-haul services (e.g., 10–15 min) [12][13]. This approach is both easy to understand and somewhat natural from a train operator's viewpoint, as the goal is to guarantee the overall stability of the timetable

from the operational perspective, which clearly depends on rolling stock being available for the next train at the expected time in the expected location to ensure that the delay of one train is not transferred to the next.

However, both in commuter lines and long-haul journeys, only a minority of passengers actually makes the whole trip from the train origin to the final destination, with the possible exception of short shuttle services with few or no intermediate stops. Indeed, most passengers get on and off at intermediate stops, especially if the train serves one or more major hubs. For such passengers, delays at intermediate stops do matter, as they cause delays in reaching their work site, school, business meeting, etc. [3]; yet, if the train recovers from the delay in the subsequent part of its journey, such delays can virtually disappear in the statistics and in the official quality of service reports, undermining passengers' trust in official punctuality figures and, overall, in the service itself [18]. This is why, as pointed out by U. Martin in 2008 [5], the reporting points where punctuality is recorded should be distributed over the whole network (at least at major intermediate stations) and not limited to terminal stations. Indeed, more recent approaches [29] aim to measure the delay of each train, at least in principle, at each intermediate station, other than its final destination.

In schedule-based bus operation, a service is usually considered on time if it runs between a certain amount of minutes early and minutes late (in the USA, commonly between 1 m 30 s early and 5 m late per bus stop [15], typically measured at the origin and at several stops along the route), in particular at the so-called "regulation stops" [16] (short early arrivals (30s) are often considered on time as well). Accordingly, punctuality can be defined as "the share of buses departing within a certain time window with respect to the planned timetable from several key stops along the route" [16].

Over the last fifteen years, awareness has been growing around the importance of taking the passengers' viewpoint into account. Among the major train operators, Infrabel [7] explicitly states the idea of measuring punctuality "during the entire train journey", namely, "at 95 strategic measurement points on the network", to consider the case when a train succeeds in eliminating a previously-accumulated delay and arrives on time at its final destination. Train operators in UK and Sweden used to consider the "average delay per train" as a valuable indicator [3][19]. Other authorities (e.g., [4]) establish that the delay be evaluated at "relevant" intermediate stations, where the relevance is based on a pre-defined classification that takes into account the number of served passengers, interchange stations, provincial capitals, etc.

From a different perspective, the comprehensive study by Transport Focus (the operating name of the Passengers' Council in the UK) [18] investigated the passengers' viewpoint more in detail. Essential findings include the fact that punctuality is a vital prerequisite for building trust between passengers and a train company, and that the passengers' concept of a train being 'on time' is much stricter (about one minute) than most industry standards (usually 5 min, often 10–15 min for long-distance trains; see [12] for a comprehensive table). Moreover, passenger satisfaction appears to decline quickly for each extra minute of lateness, especially for commuters. As a consequence, quoting [18], "a significant degree of passenger satisfaction is lost when trains are officially on time according to the industry measure, but late in passengers' eyes." Not surprisingly, passengers observed that "punctuality should be measured at all stations, not just where a train terminates." The passenger survey

conducted in [3] confirmed that “the common practice of using average delay as performance indicator is misleading, if the aim is to reflect travelers’ preferences.” In fact, more recently the passengers’ perspective is being taken into account in railway timetabling [30].

Another interesting finding is that the actual indicator to be measured should possibly be the number of *passengers* arriving on time, rather than number of trains. This suggests that in order to find the actual picture of the inconvenience caused to people, delays should somehow be weighted by the number of passengers who experience the delay itself. Moreover, passengers in [18] objected to the standard practice of adding extra time into the timetable on approach to the destination station, seen as a way to “adjust” the train performance rather than an effective technique to absorb delays and prevent a delay from being transferred to the subsequent trains. This point further stresses the need for a kind of measure able to see “the whole picture” of a train journey from the passengers’ eyes.

This is why recent indicators [31] esplicitly take the passengers’ perspective, introducing a family of delay indices (*D-indices)* aimed at capturing the overall performance of a train “as a whole” by taking into account both the delays at the sampling points (mainly, stations) and the mutual location and order of such sampling points (*situatedness*).

Technical studies take a different viewpoint, and are mostly rooted in the operations research, transportation, and microeconomic areas. There, the train delay is typically defined as “the deviation from a scheduled event or process time of the train” , whereas punctuality is “the percentage of the trains arriving (or departing, or passing) a location with a delay less than as certain time in minutes” [1]. All the relevant technical aspects of train operation are considered, from delay distribution models [32], line planning and timetabling [21], timetable stability analysis and optimisation [22], delay management [23], simulation [22], and performance evaluation in terms of reliability and availability of service [3][5][12]. In [13], a systemic classification of delay causes was proposed based on a comprehensive literature review which includes the main definitions of punctuality and reliability, together with delay thresholds in many European countries. In , the focus is on punctuality reporting systems, aimed at performing an in-depth analysis of the delay causes and of the train run.

For timetable planning purposes, in particular, the train movement is first carefully modelled taking into account its acceleration/deceleration and the allowed speed on different sections of the railway line based on its characteristics in order to find the pure running time, then the dwell time at stations is taken into account and recovery times are further added to allow for small delay compensation (usually, a percentage of the running time). Train paths are then modelled (which in turn require proper infrastructure modelling) and proper separation schemes (e.g., block sections, protected zones) and infrastructure (e.g., signalling) are considered to guarantee the necessary train separation [22]. Buffer times are added to prevent the transmission of small delays. Train scheduling is then performed, usually in a computer-assisted way. Finally, train running times are carefully estimated for different train configurations. Clearly, such a complex process strongly builds on optimisation techniques, the desired result being a *robust* timetable, that is, a timetable which does not suffer considerably from small perturbations [22]. Other aspects, as mentioned above, range from timetable stability analysis, which includes,

among others, the study of delay propagation, to simulation tools, which allow for a very cost-effective way to check hypotheses, verify interactions, highlight possible conflicts, etc., not to mention optimisation of energy and cost issues.

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