Chapter 3

Status Quo Definition

3.1 Introduction

This chapter applies a stepwise procedure to find out the possible causes leading to a wrong estimation of the timetable made by RailSys. The starting point is to check whether all the variables and parameters used in previous works were set correctly in order to reject or modify those causing problems. If that is not the case, a more detailed approach is developed to make the system estimations closer to a feasible timetable.

This chapter has been divided in three parts, describing and making use of a checklist to assess what modifications have to be done to come up with a conflict-free timetable approach (section 3.2), performing a conflict resolution strategy by means of Train Path Management based on homogenization of speed profiles of trains (section 3.3), and developing a fine tuning procedure that enables to define the suitable running times to come up with a feasible Status Quo (section 3.4).

The chapter concludes with a presentation of the running times for different timetable approaches researched. Besides, a final summary and overview to the most important aspects of the presented approach to obtain a feasible timetable (Status Quo) are done and used as a starting point for the capacity evaluation to be developed in Chapter 4 and further scenario analysis.

3.2 Development and Implementation of a Checklist

This section aims to define and check several reasons why the software does not estimate a speed-distance diagram in a proper manner. Firstly, a checklist is developed including a set of fields that could influence the performance of a timetable, basically running times and other parameters influencing the blocking times, thus the time-distance diagram calculated. Secondly, the different points contained in the checklist have to be revised in order to not overlook any important issue.
3.2.1 Development of a checklist

A suitable checklist should take into account as many variables as possible to better check the causes for a wrong estimation. In order not to extend this task, some core fields are revised:

1. Infrastructure characteristics defined in RailSys.
2. Traction unit characteristics inserted in RailSys.
3. Train types loaded in RailSys.
4. Detailed analysis of the existing signalling system.
5. Fixed arrival and departure times according to Spoorboekje.
6. Minimum headways according to Dutch railways standards.
7. Running times between stations for the different train series.

If these points are accomplished, the estimations should lead to a conflict-free timetable defining the Status Quo for the study. However, it is difficult to be sure if those settings will always be correct; large uncertainty in these parameters occurs during operation due to weather conditions, driver behaviour, etc., which are not modelled by the software. Hence, small differences are accepted whereas the most meaningful are treated.

3.2.2 Implementation of the checklist

The following paragraphs treat the different points contained in the checklist and variables to be changed or modified are pointed out. Basically, issues concerning to the calculation of blocking times and shape of train paths are regarded since are determinant for the conflict resolution.

1. Infrastructure characteristics

The available infrastructure data defined in previous works (see subsection 2.3.1), was checked again by comparison with real data extracted from OBE maps due to its influence on running times calculations. Among all existing characteristics, special attention was put in the following fields:

**Track lengths:** Longer track lengths than the real ones would lead to higher speeds if arrival and departure times are fixed, causing different effects to the different train series. That would make calculation to lead to non-real train paths and higher likelihood of planning conflicts.

**Design Speed:** Wrong location of speed boards along the track indicating maximum speeds would change speed profiles, making calculations lead to train paths either too steep or too flat in some stretches, at the same time blocking times would vary as well.

**Block lengths:** Distinct block lengths due to wrong allocation of fix signals would not change the train path shape but the blocking time, making it longer if the length is over the real one, thus decreasing the buffer time or even causing overlapping of blocking times.

2. Traction Unit data

Rolling stock characteristics used to run train services defined in the scope of another project (see subsection 2.3.1) were checked with special attention to acceleration and deceleration characteristics due to their influence in running times.
3. Train Types  Through Spoorboekje the different train services running along the line were confirmed (see subsection 2.3.1). Of course, real operation could lead to some train services skipped due to different issues like dispatching measures, hence only the scheduled services can be verified.

Any problem was found with regard to these three points of the checklist. However, for better confirmation, a speed-distance diagram based on minimum running times was manually calculated for intercity trains using external real data and compared with the shape of the diagram provided by the simulation tool. No meaningful differences were found out, hence it could be concluded that infrastructure and trains data provided were correct and not a main cause of the discordances arising from the calculations. Of course, real operation is uncertain, but those differences should not to be relevant in respect of the observed conflicts.

![Speed-Distance diagram for an IC-train running with minimum running profile along the double-track corridor in southbound direction](image)

**Figure 3.1:** Speed-Distance diagram for an IC-train running with minimum running profile along the double-track corridor in southbound direction

4. Block lengths  Through checking of the existing block lengths (see Appendix B), a small discordance is found. For the double track line in northbound direction, the existing length of block section number 26 is 329 meters. Given the design speed in this stretch, this value is obviously too short to safe-brake from the design speed (100 km/h) for IC-, HST- and INT-trains, assuming that calculations are done according to a three aspects block signalling system. The reason for such a short length in case of braking yields to a double approach signalling also involving the previous block section number 25 (1157 meters). That is to say, the real approaching distance to block section 27 (927 meters) would consists of two blocks, 25 and 26, amounting a length of 1486 meters.

Of course, this fact has to be taken into account when calculating line occupations using the simulation tool, otherwise higher capacity than the existing one would be considered. Besides, it should also be taken into account to fine tune the running times no to have a conflict in that section, thus it does not work like a normal main signal for IC-trains. However, it seems not to be the cause of the estimated conflicts.
5. Fixed Arrival and Departure times  Calculations to estimate the whole timetable are supported by previously inputted scheduled times (see subsection 2.3.1). If calculations lead to times that do not correspond to the real schedule, unfeasible train paths arise and conflicts appear as a consequence.

According to the published times, all fixed arrival and departure times at scheduled stops were revised through the estimated timetable. No difference in minutes (published units) was found; therefore overlapping of blocking times cannot be attributed to this field of the data supplied.

6. Minimum headways  Fixed times between departures and arrivals of trains at the same track must be planned over a threshold of 3 minutes as stated by Dutch railways standards. In this field, it was checked whether the estimated timetable fulfills those minimum headways at station platforms, otherwise trains could conflict between each other. Tables C.13 to C.15 in Appendix C show relevant data calculated to verify the estimations. None of the headways lie below the standards, thus conflicts appeared would not be a consequence of insufficient time distance between departures or arrivals.

7. Running Times  Running times influence directly the shape of the train path diagram or, in other words, they are the different slopes of it. Besides, part of the blocking time size depends also on this variable.

From the published timetable just average running times between stations where stops are scheduled could be derived. In this sense, it was only possible to know running times between departures at intermediate stops (including dwell times at halts) for local trains and running time between departures from Den Haag HS and arrivals at Rotterdam CS for any other train type. The later does not give any idea of how running time for intercity trains is distributed along the line, thus the shape of the train path is not defined precisely.

The estimated timetable by RailSys gives to the user the distribution of running times along the line in seconds and at the different halt locations, even for IC- and other non-stopping trains. It also provides the distribution of time supplements and their exact value in the different stretches of the line. In this sense, more detailed information of their running time profiles is provided compared to the information retrieved from the published timetable. However, it is not possible to know whether these estimated values are correct or not due to the uncertainty of their real distribution.

Given fixed arrival and departure times, RailSys tool spread incorrectly the recovery time over the train paths for each series as mentioned previously in subsection 2.3.2. This situation makes trains run unacceptably slow, especially IC-trains (see Figure 2.6 and Table 2.3). Therefore, it seems logical to think about the possibility of a wrong redistribution of time supplements over the line made by the simulation tool, thus running times, regarding real operation. This could be the main reason for the trains running too fast along the beginning of the line and too slow at the end of it (extremely large scheduled waiting times), changing completely both the shape of the train paths and the blocking times, leading to the conflicts analyzed before. Besides negative buffer times may be estimated because the RailSys tool generates start of deceleration at maximum rate from maximum design speed, whereas the timetable design includes, in fact, larger running time supplements allowing to operate IC-trains at lower speed than maximum speed and the Dutch signalling system requires to start braking to 40 km/h at sight distance of the approach signal to continue running at 40 km/h until the following block section is cleared.
Remarks

Through this assessment it can be concluded that from the available data provided by the published timetable is not possible to conclude a certain distribution of running times between Den Haag HS and Rotterdam CS, especially for IC-trains. Therefore, an extensive analysis should be done to set the suitable running times along the line; in other words, to make the estimated running times match as much as possible with the scheduled running times according to real operation.

The following sections deal with an extended analysis of running times distribution over the line and implement tuning measures to the estimated timetable according to other timetable references, leading to a conflict-free and more harmonized planning.

In order to cover all possibilities, if after redistribution of running times according to the available data, and taking into account the outcome from the checklist, overlapping of blocking times still remains, it could be concluded that Dutch Railways made a planning fault for 1999 assuming some conflicts that might cause systematic obstruction of trains during operation. In other words, the planned timetable for 1999 might not fit precisely to the existing infrastructure.

3.3 Tuning Measures

To fine-tune the estimated timetable, a reference harmonized timetable has been applied and a suitable methodology defined to get a new distribution of running times leading to a smooth time-distance diagram much more representative of real operation.

3.3.1 Reference timetable

To better running time edition, a reference timetable is used as a template to make suitable modifications (see Figure 3.2). This timetable was proposed during another time period (2003) to homogenize the traffic along the railway line under consideration. To deal with it, the following measures were applied:

1. Scheduling stops at Delft station for IC-2100 and IC-2400 train series.
2. Use of new rolling stock for stopping trains, speeding them up.
3. Lowering of dwell times at intermediate stations where stopping trains stop.

Applying these measures, all train paths are shifted to more parallel ones, with closer shapes, getting a more harmonized timetable as the shown in Figure 3.2.
Besides, fixed times changed with regard to Spoorboekje due to new planning aims and different rolling stock units. Appendix C shows the timing from this timetable approach in tables where it can be compared with other timetable approaches.

This proposed timetable on the basis of another year planning will be take as a reference to fine tune the estimated train paths by RailSys, but arrival and departure times will be kept as in the planning of 1999.

### 3.3.2 Methodology

Once the train path shapes have been assessed, a methodology has to be defined for blocking time conflict resolution and search of suitable train path. Some ideas are sketched in the following.

A suitable way to harmonize a timetable at the same time overlapping conflicts are removed is based on the *speed fleeting* operational measures (Pachl, J., 2002:170). These are based on making track use more homogenous, thus increasing available timetable capacity (for more details about capacity issues see section 4.2). This methodology will not be applied directly as defined but indirectly to redistribute running time supplements. In this sense, time-distance curves are not displaced but slightly modified.

Figure 3.3 shows a theoretical case where two train paths from different train series need to be harmonized in order to avoid a conflict between trains.
3.4. Redistribution of Running Time Supplements

![Diagram showing trains IC1900 and AR5000 with a conflict at a specific area. The diagram illustrates how time supplements are redistributed to homogenise train paths between slow and fast trains.](image)

**Figure 3.3:** Basic tuning methodology based on redistribution of time supplements to deal with homogenous train paths between slow and fast trains

Taking as an example a conflict between a fast train (e.g. IC1900) following a slow train (e.g. AR5000) as shown in the figure above, a way to deal with the conflict without changing fixed arrival and departure times at stations would be to make both train paths flatter around the area where the overlapping of blocking times occurs, thus homogenising train paths. To succeed, higher time supplements have to be provided at the end of the train path for the slow train, whereas for the fast train, higher time supplements have to be placed at the beginning of it. By this, shapes of train paths would be modified as shown in the figure by the dotted lines, with minimum running times in the area where the conflict takes place and longer ones at edges.

This is not exactly the same case as in our case, but somehow running times can be redistributed following the same philosophy to tune the train paths. Minimum running time depends on the infrastructure and train dynamics inputted in the software, thus they are assumed as correct. In this sense, just variations on the distribution of time supplements along the line could have the desired effect to running times to succeed with a harmonized timetable. In this sense, the idea is to increase the scheduled waiting times by means of redistribution of running time supplements where running time is to be increased, whereas decreasing them where it is to be reduced, keeping fixed times at the edges (stop locations). Of course, this leads to an increase of buffer time and fine-tuning of train paths, thus overlapping of block section can be theoretically removed.

These proposed tuning measures have been applied along the two directions of the double-track line between Den Haag HS and Rotterdam CS, and are detailed in the following section.

### 3.4 Redistribution of Running Time Supplements

This section gives an insight to the time supplement redistributions made to the estimated timetable to get a more harmonized time-distance diagram. Train series involved in the timetable with different running profiles are analyzed separately per direction due to infrastructure and scheduling variations between southbound and northbound directions that make running profiles not symmetric. Special detail is put on those trains involved in the conflicts analyzed in the previous chapter.

By means of RailSys tool, blocking time diagrams and train paths are re-calculated according to the new running time distribution to check whether they reach a conflict-free planning. Tables C.1 to C.12 in Appendix C show the newly numerical timetable estimated, where changes done in running
times (modified scheduled waiting times) can be checked through comparison to previous timetable approaches analysed.

Changes applied to redistribute running times for the conflicting train series and get a suitable approach are explained in the following paragraphs. Running times from other train patterns which are not treated here are assumed as correct from previous RailSys estimations.

3.4.1 Local/ Stopping trains (AR5000 & AR5100)

To redistribute time supplements calculated by RailSys for local trains is not recommended. They have fixed departure times at intermediate stations according to the schedule in 1999, thus changes in running times would necessarily change these times, which is not desired in this approach (the reference timetable did so, changing the scheduled arrival and departure times).

Suggestions and argumentations with regard to running times per direction are overseen below.

**Gv → Rtd** (southbound direction)

For train series AR5000, an average 7% time supplement was already distributed along the whole line and any change can be done. It seems logical that there is no more extra time supplement because this train series conflicts with IC-trains (following conflict 1), and more time supplements would be contra-productive with regard to that overlapping of blocking times.

For train series AR5100, slightly faster, some extra time supplement contained at the end of the line was re-distributed, but just some seconds changed in running times and any significant improvement was achieved with regard to conflicts. Therefore, any redistribution is done neither. This time margin would be used during operation to recover the schedule before Rotterdam station if a delay occurs to train series AR5100. Otherwise, if no conflict occurs and all signals are green, trains would stop at station earlier and more dwell time might be expected on it: early delay.

**Rtd → Gv** (northbound direction)

In northbound direction, both train series follows almost the same pattern. As argued above, any redistribution of time supplements is needed, but due to the big extra time added at the end of the line for train series AR5100 according to estimations, part of this time could be spread over the line to have more chance to recover at intermediate stations. It was tried by means of modifying scheduled running times to reach a more logic redistribution, but departure times changed due to variations in dwell times at stations leading from calculations. Finally, any modification was done.

3.4.2 Intercity and high speed trains (IC1900/2500 & IC2100/2400 & INT600/HST9300)

The estimated timetable shows important overlapping conflicts regarding these train series (see Figure 2.6, Figure 2.7 and Figure 2.8). Those conflicts can be attributed to the train path estimated for these trains, especially IC-trains. They run too fast according to the estimated timetable and have too much running time supplement at the end of the line, which makes them running
unacceptably slow. This situation leads to train paths too close and also big blocking times, both causes of the estimated overlapping conflicts.

To get a feasible timetable, running time supplements for IC-trains added at the end of the line in both directions have been spread to get more homogeneous train paths as well as shorter blocking times, avoiding conflicts with slower trains. These redistributions can be done because there are no fixed times between Den Haag HS and Rotterdam CS, and just a constraint regarding departure and arrival times at both stations has to be handled. By this, more suitable and feasible running times over the line compared to the calculated ones are achieved, and the negative buffer times become zero or even few seconds.

Running time characteristics in both directions are also asymmetric, thus tuning is applied as it is overseen below.

**GV → Rot (southbound direction)**

The 215 seconds time supplement added at the end of the line for the following train series IC1900 and IC2500 (see Table C.3 in Appendix C) are spread over it. This measure achieves steeper train path between Den Haag HS and Schiedam stations and flatter between the latter and Rotterdam station. In other words, IC-trains that were calculated running too slow from Schiedam to Rotterdam CS are now speeded up in this section, whereas slowed down in previous stretches were they ran too fast according to estimations. These variations do not change any fixed arrival and departure times at stations where IC-trains stop.

To reach the most feasible running time distributions and homogenous train paths, a combined work with the reference timetable presented previously is done to define suitable IC-train paths. As it can be assessed in both approaches, the running times are close in both proposals, unless some differences that may lead to slightly different train paths shapes (see Appendix C).

Figure 3.4 visualizes the homogenization of train paths, both for AR- and IC-trains: from the previous estimated timetable where overlapping of blocking times took place, to the new approach where fine-tuning of running times has been achieved leading to harmonized train paths.

![Figure 3.4: Homogenization of IC1900 and IC2500 train paths according to train series AR5000 by means of running time supplements redistribution](image-url)
Besides, overlapping of blocking times is removed due to new smoother blocking time graphs. Figure 3.5 shows how in this new approach blocking times do not overlap as in the estimated timetable (make comparison with Figure 2.6). However, remaining minimum buffer time of 12 seconds as marked in the graph might be rather critical for a stable timetable operation.

![Figure 3.5: Conflict-free blocking time stairways between AR5000 and IC1900/IC2500 trains (removed following conflict 1)](image)

For train series IC2100/IC2400 and INT600/HST9300, running time supplements were also redistributed. Conflicts between these preceding train series and AR-trains (following conflict 2) are not as huge as the previous one, but they could also be removed by means of new time supplement redistributions.

As it can be checked in tables C.4 and C.5 in Appendix C, higher time supplements are added at the end of the line (about 1 minute for IC-trains and 38 seconds for HST- and INT-trains). To remove the overlapping of blocking times, these preceding trains should be speeded up upwards compared to slow following trains. In this sense, IC- and HST- or INT-trains would loose their running time supplement at the first half of the line, scheduled at minimum running time, whereas at the second half the entire time supplement would be spread in three parts.

This approach might be contra-productive if these trains suffer a small delay at the beginning, because no recovery time is provided, thus delays would occur with regard to passing moments. However, as long as only arrival time at Rotterdam CS is determinant given a departure at Den Haag HS, trains are scheduled with minimum running time until Delft, and time supplement is spread from Delft to Rotterdam CS. By this, slower trains following them would not be delayed permanently. On the other hand, if a small delay occurs where no time supplement is added, it will be recovered at the last part where all time supplements are scheduled and amount the same.

No big improvement is achieved by means of these changes, but conflicts are removed to IC2400/IC2100. However, to HST/INT-trains small overlapping of few seconds still remains. Figure 3.6 shows some of the improvements achieved by these running time redistribution although 4 seconds of minimum buffer time as indicated would make the operation rather critical to delays.
3.4. Redistribution of Running Time Supplements

Figure 3.6: Conflict-free blocking time stairways between IC2400/IC2100 and AR5000 trains (removed following conflict 2)

\[ \text{Rot} \to \text{Gv} \quad \text{(northbound direction)} \]

The 156 seconds of running time supplements located at the end of the northbound direction for both train series IC1900 and IC2500 (see Table C.9 in Appendix C) were redistributed. By this, a more harmonized time-diagram arises for IC-trains with faster train paths that otherwise would conflict with them (following conflict 3).

Figure 3.7 shows blocking time “stairways” once tuning measures have been applied. In this case, remaining minimum buffer times (about 55 seconds) are not as critical as in the previous cases and less stability problems might arise from it.

Figure 3.7: Conflict-free blocking time stairways for IR2200 and IC1900/IC2500 trains (removed following conflict 3)
3.5 Presentation of Running Times

The following table summarizes all running times between stops involved in the line for each of the presented timetable alternatives and the new tuned approach.
### Table 3.1: Running Times between stations for each of the presented timetable alternatives

<table>
<thead>
<tr>
<th></th>
<th>AR 5000</th>
<th>AR 5100</th>
<th>IC 1900 / IC 2500</th>
<th>IC 2100 / IC 2400</th>
<th>INT 600 / HST 9300</th>
<th>IR 2200</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gv</strong></td>
<td>180</td>
<td>195</td>
<td>153</td>
<td>195</td>
<td>240</td>
<td>240</td>
</tr>
<tr>
<td><strong>Gvmw</strong></td>
<td>180</td>
<td>183</td>
<td>180</td>
<td>180</td>
<td>180</td>
<td>240</td>
</tr>
<tr>
<td><strong>Rsw</strong></td>
<td>360</td>
<td>342</td>
<td>300</td>
<td>342</td>
<td>300</td>
<td>300</td>
</tr>
<tr>
<td><strong>Dt</strong></td>
<td>180</td>
<td>180</td>
<td>150</td>
<td>180</td>
<td>150</td>
<td>180</td>
</tr>
<tr>
<td><strong>Dtz</strong></td>
<td>360</td>
<td>427</td>
<td>282</td>
<td>427</td>
<td>285</td>
<td>381</td>
</tr>
<tr>
<td><strong>Sdm</strong></td>
<td>300</td>
<td>239</td>
<td>270</td>
<td>300</td>
<td>285</td>
<td>279</td>
</tr>
<tr>
<td><strong>Rtd</strong></td>
<td>1560</td>
<td>1566</td>
<td>1335</td>
<td>1566</td>
<td>1560</td>
<td>1350</td>
</tr>
<tr>
<td><strong>Gv - Rtd</strong></td>
<td>1020</td>
<td>960</td>
<td>960</td>
<td>960</td>
<td>960</td>
<td>960</td>
</tr>
</tbody>
</table>

Table 3.1: Running Times including dwell times at intermediate stations (sec)
The running time values proposed to represent the Status Quo, according to the time supplement redistributions, lead to a time-distance diagram with higher homogeneity of train paths and conflict-free blocking time graphs. However, as it has been noticed in the previous analysis, short buffer times obtained may lead to less stability of this timetable if perturbations during operation occur, but this fact is inevitable given the present constraints.

Figure 3.8 represents the graphical layout of the proposed timetable approach to represent the existing the Status Quo for 1999.

**Figure 3.8:** Graphical timetable for the proposal *Status Quo 1999*
3.6 Conclusions

The most important findings from this chapter, also with regard to Chapter 2, where the study of the different timetable approaches presented to come up with a suitable Status Quo. The estimations obtained from the simulation tool indicated a need of homogenization of speed profiles to get a more suitable and harmonized timetable approach.

In principle, IC-trains have fixed arrival and departure times at Rotterdam CS and Den Haag HS stations, and any other passing time through intermediate stations is fixed by the Spoorboekje. Taking into account the output obtained from the checklist, running time supplements can be redistributed in a way that more homogenous train paths for IC-trains regarding slower trains are achieved. This means to slow down IC-trains on average along their running profile keeping their average scheduled line running times, instead of adding the entire extra time supplement at the end which would imply too low operational speeds. In other words, IC-train behaviour is shifted closer to slower trains, leading to more realistic and smoother operation. However scheduled waiting times (see last column of tables C.1 to C.12), especially for IC-trains, could be considered rather large regarding some standard values obtained in other research approaches (Hertel, 1996).

Compared to the estimated running times by RailSys, proposed running times for IC-trains lead to a more harmonized time-distance diagram as well as new optimized blocking times. Hence, overlapping of blocking times arising from the estimated timetable are largely removed and negative buffer times disappear, leading to a conflict-free timetable. Nevertheless, remaining minimum buffer times are still too short and might lead to a non-stable and critical operation of the timetable in case of a small delay to a train.

Besides, it can be checked through the numerical timetables in Appendix C that both running times between Delft Zuid and Schiedam presented by the Spoorboekje and estimated by RailSys differ about 1 minute, longer running time for the later. This might lead to passengers waiting at the platform for departure at Schiedam station because the published timetable shows one time, whereas the real departure might be later. The same happens in the opposite direction between the same stations, thus it could be concluded that trains technically need more running time to run that distance compared to the time assumed by the Spoorboekje.

A last comment regarding large time supplements located at the end of the line needs to be done. Usually these times are concentrated at the end of the train runs before large terminals like Den Haag HS or Rotterdam CS due to scheduled connections that require avoiding delays not to lose passengers’ transfers. Then, enough recovery time is usually concentrated at the end of the line as indicated in Figure 3.9b), although spread distributions are also used. RailSys estimations indicated too large time supplements regarding this requirement, not logic from an operational point of view.
Figure 3.9: Principles of Adding Recovery Time to a Schedule (Pachl, J., 2002:179)