Appendix E

Analysis procedure for optimal second track extensions

This appendix gives detailed information on the logical procedure followed to find out the optimal second track extension with regard to the travel forecasts expected for year 2020. The analysis is performed in each of the predefined cases derived from different track occupation thresholds accepted. Figures and tables obtained in the theoretical approach for different alternative capacity scenarios are used as a support for calculations to get a numerical result for the elected approach.

Section E.1 shows the whole development followed to obtain the results, while sections E.2, E.3 and E.4 only describe the final result without developing again the whole procedure.

E.1 Case ISouth

This section tries to find out the suitable second track extension in southbound direction assuming the following approximate values:

- 80% max. track occupation
- 15% track occupation / AR-train / cluster
- Figure 6.6 and table 6.5 (track occupancy of the existing services in 1999 running along different infrastructure extensions)

Given these variables, a maximum track occupation to be constrained before inserting the additional train per cluster needs to be determined. According to the above values, assuming 80% maximum track occupation and 15% occupation per additional local train, it is imposed a track occupation around 66% after extension of the second track. The theoretical approach supplies two possible enlargements leading to this value depending on the extension origin: from Rijswijk (forward extension) or from Rotterdam (backward extension). Both scenarios can be easily determined through the theoretical results obtained, and it is shown in Figure E.1.
Two minimum extensions might be required to reach 66% track occupation referring to forward and backward enlargements: $X_{IS}$ and $Y_{IS}$ respectively. However, computational experiments only refer to the plotted dots in the graph, thus straight shapes of the curves are uncertain. In this situation it might be better and more reliable to consider extensions involving the next closest station. In this sense, obtained enlargements are round off to calculated extensions (see table 6.3):

- Forward extension $F_4$: 5.2 km (including Delft Zuid)
- Backward extension $B_4$: 12 km (including Delft Zuid)

Of course, extensions $F_4$ and $B_4$ lead to higher capacity than the 66% estimated, but they are the only reference values from previous theoretical analysis that fit the best. These extensions would imply the following track occupations (see table 6.5):

- Forward extension $F_4$: 62%
- Backward extension $B_4$: 62%

In this case, taking into account the additional infrastructure length that extension scenario $B_4$ represents, extension $F_4$ would be realized. Of course, other factors involving track extensions as emplacement constraints and design difficulties are not considered in this approach (“the shorter the extension the cheaper it is”).

According to the above procedure, the same approach is carried out for the remaining cases. The following sections summarize the extension results and concerned track occupations per case by means of graphical and numerical representation.

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**Figure E.1**: Minimum $(X_{IS}, Y_{IS})$ and considered $(F_4, B_4)$ extensions to reach the maximum track occupation constrained in *case 1*
E.2  Case I_{North}

This section tries to find out the suitable second track extension in northbound direction assuming the following approximate values:

- 80% max. track occupation
- 15% track occupation / AR-train / cluster
- Figure 6.7 and table 6.6

The same logic as in the previous section is applied. In this case, the maximum track occupation to be constrained before fitting an additional train amounts also 66%. Figure E.2 indicates the graphical procedure followed.

![Graphical representation](image)

**Figure E.2:** Minimum (X_{1N}, Y_{1N}) and considered (B_{10}, F_{10}) extensions to reach the maximum track occupation constrained in case I

The graphical output yields to the following extensions (applying table 6.4):

- Forward extension F_{10}: 12.5 km (including Delft Zuid)
- Backward extension B_{10}: 4.5 km (including Delft Zuid)

leading to the following track occupations (see table 6.6):

- Forward extension F_{10}: 57%
- Backward extension B_{10}: 64%

Assuming that both track occupations might be enough sufficient to meet the case requirements, the shortest, extension scenario B_{10}, would be chosen as the optimal.
E.3 Case II_{South}

This section tries to find out the suitable second track extension in southbound direction assuming the following approximate values:

- 89% max. track occupation
- 15% track occupation / AR-train / cluster
- Figure 6.6 and table 6.5

The same logic as in section E.1 is applied. In this case, the maximum track occupation to be constrained before fitting an additional train amounts up to 75%. Figure E.3 indicates the graphical procedure followed.

![Figure E.3: Minimum (X_{II,S}, Y_{II,S}) and considered (F_2, B_3) extensions to reach the maximum track occupation constrained in case II](image)

The graphical output yields to the following extensions (applying table 6.3):

- Forward extension F_2: 3.2 km (including Delft)
- Backward extension B_3: 11.5 km (before Delft Zuid)

leading to the following track occupations (see table 6.5):

- Forward extension F_2: 57%
- Backward extension B_3: 64%

Assuming that both track occupations might be enough sufficient to meet the case requirements, the shortest, extension scenario F_2, would be chosen as the optimal.
This section tries to find out the suitable second track extension in northbound direction assuming the following approximate values:

- 88% max. track occupation
- 15% track occupation / AR-train / cluster
- Figure 6.7 and table 6.6

The same logic as in section E.1 is applied. In this case, the maximum track occupation to be constrained before fitting an additional train amounts up to 74%. Figure E.4 indicates the graphical procedure followed.

The graphical output yields to the following extensions (applying table 6.4):

- Forward extension F_8: 4,4 km (including Schiedam)
- Backward extension B_9: 3,1 km (including Delft)

leading to the following track occupations (see table 6.6):

- Forward extension F_8: 73%
- Backward extension B_9: 70%

Assuming that both track occupations might be enough sufficient to meet the case requirements, the shortest, extension scenario B_9, would be chosen as the optimal.

**Figure E.4**: Minimum (X_{II.N}, Y_{II.N}) and considered (F_8, B_9) extensions to reach the maximum track occupation constrained in case II.