

Shunting of Passenger Train Units

(Nederlandse Spoorwegen NS)



S t u d i e g r o u p
e p i s k u n d e m e t d e
I n d u s t r i e
<http://www.math.utwente.nl/swi2008>

Outside the rush hours, an operator of passenger trains usually has a surplus of rolling stock. This idle rolling stock is parked at a shunt yard. In particular, most rolling stock is parked at a shunt yard during the night. Shunting of passenger train units is a highly combinatorial optimization problem, in which the resources (i) time, (ii) infrastructure, and (iii) crews have to be utilized as efficiently as possible.

In the Netherlands, most trains are operated by train units. Train units are classified according to their types and subtypes. Train units of the same type can be combined to form longer trains. Figure 1 shows an example of an ICM train unit with 3 carriages (ICM = Inter City Material). This type of train unit consists of subtypes with 3 or 4 carriages.



Figure 1: An ICM train unit with 3 carriages

Figure 2 shows the layout of the railway infrastructure of station Alkmaar. Tracks 1, 2, 3, 4, and 5b are platform tracks. Tracks 5a, 6, 7a, 7b, 8a, 9, 10, and 11 are shunt tracks. Tracks 24, 30 and 33 can be used for so-called saw-movements between the platform tracks and the shunt tracks.

Problem formulation. As stated above, shunting of passenger train units is a highly combinatorial optimization problem, in which the resources (i) time, (ii) infrastructure, and (iii) crews have to be utilized as efficiently as possible. In more detail, the shunting problem has the following aspects.

- Routing. Train units have to be routed from their arrival track to a shunt track. Later they have to be routed back from the shunt track to their departure track. Shunt movements should not hinder each other nor the regular train movements inside the station.
- Matching. Train units of the same subtype are interchangeable. Therefore, the train units that arrive at a shunt yard have to be matched in an appropriate way to the train units that depart from it.
- Parking. Train units have to be parked at a shunt track in such a way that they do not block each other's arrival or departure. In particular, one-sided shunt tracks should be approached in a LIFO (Last In First Out) order.
- Crew scheduling. Each shunting movement must be carried out by a train driver. Since the number of train drivers is limited, there should not be too many shunting movements at the same time.

The objective is to make sure that the railway processes in the early morning can start up as smoothly as possible, while the total number of shunting movements is as small as possible.

Available model. Recently, a model was developed that can be used to solve part of the shunting problem. This model matches the arriving train units to the departing train units, and it parks them at a shunt track. The objective is to keep combined trains as much as possible together, and to minimize the number

of shunt tracks with more than one train unit type. The model assumes that, after a train unit has arrived at a shunt track, it is not moved until it is shunted back towards a platform track to depart from the station. More information on the available model can be found in Kroon et al. [1].

More flexibility is required. The main drawback of the available model is that it is not quite flexible. In contrast, in practice the shunting process is a dynamic process, in which a lot of flexibility exists with respect to the number of shunting movements and their time instants. For example, by switching the order of two shunting movements, the order of two train units in a train may be switched.

However, the available model is more an assignment model than a scheduling model: it assumes that the time instants of the shunting movements are known a priori. As a consequence, also the total number of shunting movements is basically fixed. This often does not provide the required flexibility to compose the trains exactly as prescribed, or to deal with e.g. temporary unavailability of some of the tracks inside the station.

A primary objective of SWI is to describe the shunting processes in a more dynamic way, so that the resulting model is both an assignment model and a scheduling model. Moreover, the available model does not take into account the routing aspect nor the crew scheduling aspect of the shunting. However, including these aspects is only a secondary objective of SWI.

Example. An example of the missing flexibility is the following. Suppose that two trains consisting of an ICM3 unit and an ICM4 unit arrive at 23:00 and 23:15 in Alkmaar from the direction Amsterdam (= left in Figure 2) at platform tracks 2 and 3. These train units must be parked during the night at the shunting yard of station Alkmaar. Assume further that at 6:00 on the next morning a train is leaving from Alkmaar back to Amsterdam. This train must be composed of an ICM3 unit and an ICM4 unit, where the ICM3 unit is the front unit of the train.

Then the available model will park the two train units at different tracks, since it does not have the flexibility to postpone the shunting movement of the ICM3 unit until after the arrival of the ICM4 unit. However, by postponing the shunting movement of the ICM3 unit, one shunting movement can be saved when the train units are composed into one train upon departure.

References.

- [1] L.G. Kroon, R.M. Lentink, and A. Schrijver. Shunting of Passenger Train Units: an Integrated Approach. Erasmus University Rotterdam, ERIM Report Series 2006-12-20.

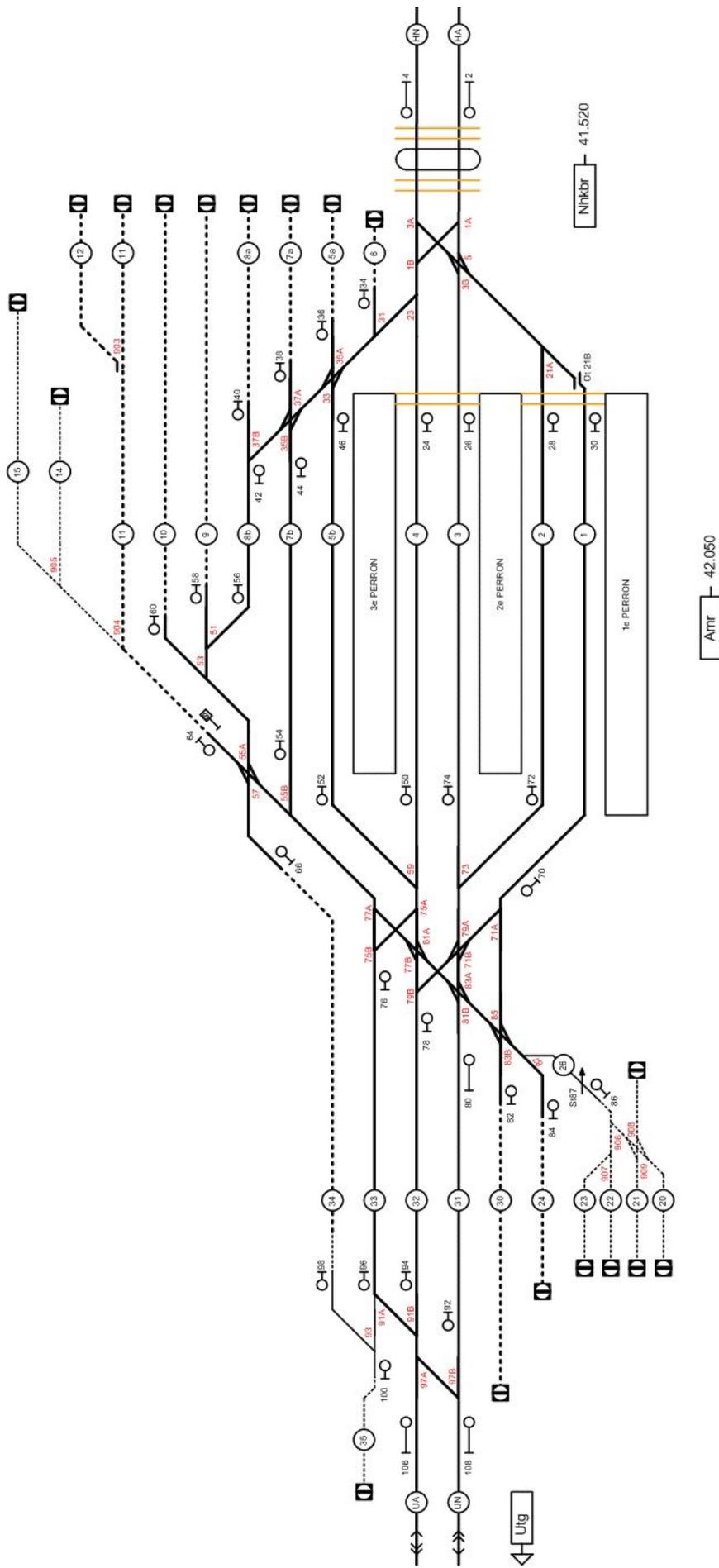


Figure 2: The layout of station Alkmaar