Implementing ERTMS on the BetuweRoute

Implementing Operational and Safety Requirements

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Betuweroute engineering

- ERTMS level 2 on the new line (A15 section) “easy”, challenge is in transitions
- ERTMS Level 2 on yards harbour line plans revised completely
- Lack of engineering and application rules at start
- RBC dataprep validation vs real world installation practices
- Coping with maturing technologies
As a reminder, the Betuweroute. The new part of the line, from Kijfhoek in the west as far as Zevenaar in the east, is equipped with ERTMS level 2. The western part of the line, the Havenspoorlijn, is still in operation with conventional interlocking and ATB and will be in operation, with ERTMS level 2, next year. Two small parts of the line, the marshalling yard Kijfhoek and in the east the line between Zevenaar and the German border are equipped with ATB, while trains without ERTMS will also make use of these tracks. Kijfhoek has connecting lines with the northern and southern part of the Netherlands. The line from Zevenaar to the German border is part of the line from Utrecht to Oberhausen. The German high speed train makes use of this line as well.

Shown in purple are the two parts of the line, which will not be equipped with ERTMS. This means that at these places there are transitions between the ERTMS system and the conventional interlocking with ATB. Together with the connections where the lines from Utrecht-'s-Hertogenbosch and Nijmegen-Arnhem cross the Betuweroute (shown in yellow), there are in total 5 locations with transitions.
Here we see the principle of the connection between the line Utrecht-‘s-Hertogenbosch and the Betuweroute. The Betuweroute has a fly over crossing the line Hertogenbosch-Utrecht.

This connection has a total of 4 connecting curves, several points and siding tracks and routes are possible in various directions. The line speed on the Betuweroute is 120 km/h and the speed on all the points in reverse position is 80 km/h.

In this presentation, for simplicity sake, only one curve is taken in consideration, curve E.
Constraints Level Transitions

- Bi-directional traffic
- Connecting tracks also serve as siding (where trains wait until their slot becomes available)
- Maximum speed is 80 km/h
- Transitions combined with voltage changeover 1500V-25kV
- Transitions at connections to existing lines: limited space
- ERTMS braking curves are more conservative than ATB EG
- No overlap in combination with a release speed of 0 km/h

In the Netherlands we have a lack of space. That means that the curves are to be as short as possible. For instance the curve E, the shortest curve from connection Meteren, has a total length between the points of about 800 meters.

The most important implementation constraints are:

The Betuweroute has a traction voltage of 25kV AC and ERTMS, the line Utrecht-‘s Hertogenbosch 1500V DC and ATB system.

The curve itself can be used as a siding track. The maximum train length allowed on the Betuweroute is 750 meter.

At a later stage I will come back on the consequences of the conservative ERTMS braking curves.

No overlap means that the Movement Authority ends at the signal.
Connection Meteren

Bi-directional track
Siding track, effective distance 700 meter

Because the tracks are bi-directional and the curve can be used as a siding track, signals at both side of the curve in rear of the points are needed. Some signals have a speed indication 8, because the maximum speed over the point in reverse position is 80 km/h. The points connecting two lines are mentioned as special danger points. A distance from at least 80 meters is needed between the signal and the danger point and the release speed at those signals is 0 km/h instead of the national value of 15 km/h. That means that the effective siding track length is about 700 meter. On the Betuweroute itself there are no lineside signals, only markerboards. There are no back up signals.
The Betuweroute has a traction voltage of 25 kV and the connecting line 1500VDC. This means that on the curve a voltage change over is installed. There are 3 panels. The first one where the driver has to switch off the power and to lower the pantograph, the second one, immediately in rear of the voltage change over were the pantograph has to be down, and the third where the pantograph can be raised again and the power switched on. Here are only the markers shown towards the Betuweroute. The same type of markers are installed for trains coming from the Betuweroute.
The Betuweroute is equipped with ERTMS and the conventional line with ATB. ATB is not compatible with 25kV, which means that the actual transition between ATB and ERTMS has to take place in the 1500V DC area. At the border between the two systems an extra signal is added, because it is also the interface between two interlocking systems. The signal is shown as a real signal, in reality the signal is a fictive one. Panels indicate that the driver is entering or leaving the area where the cab signalling and so the DMI is active.
Here you can see the Balise locations in relation to a transition. Most balises are passive.
There are two switcheable balises indicated by the small line connected to the triangle. In this figure, the balises point in the nominal direction but they are also read in the other direction. For redundancy reasons the balises are doubled.
Agenda

- Location and layout of the transitions
- Design
- Scenario’s
- ERTMS-braking curve

There are a lot possible scenario’s, for instance “on site routes”, “degraded modes”, “ERTMS train with an unknown trainkey” “start of mission” etc. I will discuss the most common scenario’s.
Connection Meteren

Route setting

Virtual Signal 4194
The control system sets a route from signal 444 towards the Betuweroute the signal 4204.
The signal 444 will change from red to yellow and the automatic block signal in rear from yellow to yellow 8, indicating that the train has to slow down to 80 km/h because the reverse position of the point 439 allows a maximum speed of 80. The virtual signal 4194 at the border between the conventional system and ERTMS will also change to yellow.
First the ERTMS equipped train will drive over the radio announcement Balise group. The trainborne will initiate a radio link with the RBC. The distance between the announcement Balise group and the following one, has to be long enough to establish the radio communication link. The time is about 40 seconds driving time to the next Balise.
Connection Meteren

First entering train

When the train drives over the B Balise group, the switcheable Balise will send a telegram telling the train that the signal shows yellow 8 with the point in reverse position towards the Betuweroute. The train sends this message to the RBC. The RBC will conclude that the train is the first entering and signal 4204 called CS (Cab signal) will turn from red to a white bar as shown, indicating that the train is an ERTMS train and the driver has to follow the instructions on the DMI.

The CS signal has only two aspects, red and white, but might nevertheless be a bit confusing. When a non ERTMS train is accidentally routed to the Betuweroute, the train will not announce itself as the first entering train, the train will reach the CS signal, but the signal will stay at danger even when a route is set in advance of the CS signal. But as shown here, when the train is a ERTMS train the signal will show white even when no route is set in advance of the CS signal.

The RBC sends a Movement Authority to the train.

The train will switch from mode STM to ERTMS on balisegroup E.
Here you see a train still in rear of signal 4204.
Therefore, our next train is not the first entering train, when driving over Balise group B, the associated signal will show yellow and the Balise will send a telegram from which the RBC can not conclude that our train is the first entering one. The second train will drive on till signal 444.
Some time later, when the first train has moved on and is in advance of signal 4204, a new route will be set to the Betuweroute, the second train will drive over Balise group C and that Balise group sends the train the telegram from which the RBC can conclude that our second train has now become the first entering and the CS signal will show a white bar.
If the train is not the first entering train, when driving over balisegroup B, the related signal will be yellow and the Balise will send a telegram from which the RBC can not conclude that it is the first entering one. The second train will drive on till signal 444.
When the first train has moved on, a new route will be set to the Betuweroute, the second train will drive over Balise group C and there the train will get the telegram from which the RBC can conclude that the train is the first entering and the CS signal will show a white bar.
When a ERTMS train has a route set from 's-Hertogenbosch to Utrecht, the train will make an announcement to the RBC on the A balisegroup, will send positions reports on the balisegroups B and C and will terminate the connection with the RBC on the F balisegroup.
Connection Meteren

From ERTMS to ATB

Trains driving from the Betuweroute will receive ATB code when passing signal 432. The DMI shows an allowed speed of 80 km/h. On the X-balisegroup the train will switch from ERTMS to ATB.
Connection Meteren

From ERTMS to ATB

Virtual Signal 4194
Agenda

- Location and layout of the transitions
- Design
- Scenario's
- ERTMS-braking curve
ATB intermezzo

- Frequency coding of track circuits
- 5 speed limits (40, 60, 80, 130, >130 km/h)
- Below 40 km/h no code
- No control of speed profile; only prevention of exceeding the speed limit
- Check on activating brakes when necessary

For those (who are) not familiar with ATB, I will now give some information for you to be able to understand the next slides.

ATB uses frequency coded track circuits. Each frequency reflects a maximum speed limit. When a train doesn’t receive a code, the maximum speed is 40 km/h. There is no control of a speed profile. Only a check is made that the brakes are activated when the actual speed is higher than the allowed speed.
ERTMS braking curve at transition

In case of the transition situation the maximum speed allowed by ATB is 80 km/h. When there is a movement authority as far as the first signal within the ERTMS area, the CS signal, the train will have a related braking curve. However, the braking curves in ERTMS are a lot more restrictive than the actual braking capabilities of the train. Especially for heavy cargo trains it may be cases where at the transition the ATB allows 80 km/h while the ERTMS braking curve only allows 50 km/h as soon as the transition to ERTMS has been completed and that could lead to a brake intervention.
ERTMS braking curve at transition

In these cases a signal is added showing an advisory speed to the driver if the Movement authority ends at the Markerboard. The driver can deduce from his knowledge of the train characteristics whether it is necessary to slow down to the advised speed.
This slide shows where such a signal is placed and what it looks like. It is remarkable is that the introduction of a system with no line-side signals, led us to introduce two new types of signals.
Other Operational Issues

- Maintenance regime in NL requires maintainer to take, secure and check possession
- Hand Held Terminal in L2
- No physical observation of result possible in L2: No Signals!
- Track Train Integration
About the speaker

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