NS introduces a new generation automatic train protection

M. van Leur

Ingenieurs Bureau NS, Postbus 2855, 3500 GW Utrecht, The Netherlands

Abstract

Functional and technical limitations of the existing ATP-system together with higher requirements of the railway performance led to the development of a new generation Automatic Train Protection for NS (dutch railways).

In 1996 a first series of 50 diesel trainsets will go in service with new generation ATP trainborne equipment and 100 km diesel line will be fitted with new generation ATP trackside equipment.

Background

In the eighties NS reached more and more the functional and technical limitations of the existing generation ATP. This ATP system from General Railway Signalling based on trackcircuits supervises 5 speedlevels: 140, 130, 80, 60, 40 km/h. Although a high degree of safety of the dutch railway traffic has been achieved by means of this system, the increasing train traffic and changing rolling stock characteristics (more low frequent noise-components in return current) did feel the need for functional improvements and extensions with regard to the existing ATP-system.

We mention the following problems which cause loss of performance and discontented drivers.

* The speed in the cabin differs of the speed supervised by the ATP. So it occurs that the driver can not reach the necessary speedlevel, or that he can exceed the level.

* The responsetime for the driver after a braking
command is very short. Sometimes this leads to an unnecessary emergency break.

* Due to disturbances in the transmission of the trackside signal, the supervised speed level can change during a number of seconds to a less or to a more restrictive level.

The existing ATP-system could not offer functions that increase safety, improve the timetables and reduce the number of delays through higher availability. Thinking of a new system the following extensions were in picture:

* Protection of a stop signal
* Braking curve supervision
* Temporary speed limits
* More speed levels.

Another reason to develop new equipment was reduction of costs for purchase of trainborne equipment. In the near future NS had to replace a large number of trainborne equipment based on relay-technique, known as phase-2 sets. At that time the supplier offered trainborne equipment designed in the early seventies, called phase-3 sets. These phase-3 sets were expensive in comparison with equipment based on micro-processors. Later on this argument appeared to be of great importance. NS ordered much more sets because the rolling stock fleet extended considerably due to a high increase of trainpassengers.

**Phase-4 gives access to ATBNG**

NS faced the above situation in 1985. A major question was how to realise all demands taking into account that a functional equivalent of the existing trainborne equipment had to be available in 1990 in order to take benefit of a lower price. Therefore the job was organised into two projects. One project developing new trainborne equipment. This equipment should have an open structure so that modules of a new ATP system could be added. In this way NS would realise trainborne equipment that covers the classical trackside signal as well as the new one. The second project was responsible for the specification of a new ATP system and could be worked out parallel to the first one.

The new trainborne equipment for the classical system has been fulfilled in April 1991. This trainborne equipment, now known as a phase-4 set, is functional equivalent to phase-3. It has been developed by ACEC, a Belgian company part of GEC...
Alstom. The equipment can be extended with a new ATP-system. NS ordered up to now 600 of these phase-4 sets. In the next part we will describe the new system, called ATBNG.

Issues of ATBNG

From experience with the classical system we learned that the ATP system imposes unnecessary restrictions to the train. These restrictions do not come from the signalling system or the rolling stock but from the ATP system itself. One example is the limitation in the speed levels. A lineside speed of 100 km/h cannot be supervised. Either 80 km/h or 130 km/h has to be chosen. So one major issue of the new system was that it should protect the train only and not restrict it.

A second issue of ATBNG was that it should be fully compatible with existing operational and technical practices of the signalling system. This implies that the new system has to respect the omission of overlaps on Dutch lines. Later on it will turn out that this omission in relation to the protection of signal at stop conflicts with technical possibilities.

Specifications

As already mentioned NS wanted to extend the functionality of the existing ATP-system. The next summary reflects the most important needs.

* Protection of a signal at stop. With this feature NS could reduce one of the biggest risks. There is a great number of junctions where the driver has to respect the stop signal. In these situations accidents have very serious consequences.

* Braking curve supervision. This feature is linked to the previous one. The existing system supervises the speed of the train but not the deceleration in case the maximum allowed speed changes. Only the brake handle application is supervised.

* Full cab-signalling. With the eye to the future NS would like to give the driver all information inside the cab which he needs to drive the train. This gives NS the possibility to simplify the infrastructure and leave away the application of lineside signals.
* Compatible with the existing ATP-system. In order to transfer from the existing ATP-system to ATBNG, NS has chosen to let the trainborne equipment switch from the classical to the new ATP-system. That implies that the wayside equipment is either classical or new.

Further more some technical constraints had to be taken into account.

* The ATBNG trainborne equipment has to be implemented in phase-4 trainborne equipment. As already explained the basis for this feature was laid at the start of the phase-4 project.

* No use of electrical characteristics of the wheel-rail contact and the rails itself. In other words the existing transmission, coded track currents inductively picked up by the train, has to be replaced.

Results

At the end of 1989 NS finished the functional specification of ATBNG. By that time the development of phase-4 was at full power. In 1990 NS decided to develop ATBNG and in that year the project started. Its task was to have the new system available at the end of 1994.

In 1990 ACEC started a feasibility-study. This study resulted in a cross-check of functional and technical specifications and showed that the NS specifications could be carried out.

So the way was free to go and ACEC and NS started the detailing of the functional specifications and the writing of a general technical design. During 1991 and 1992 the system was developed. In march 1993 the first prototype test took place with a push pull train on a 160 km/h line equipped with 3 beacons. The project advanced successfully and since february this year ATBNG has been functioning during daily service in 9 diesel trainsets on 24 km line. To give a reflection of the new ATP-system we will give a consice description of its technical architecture, its safety and operational features.

The wayside equipment has its inputs from the signalling system. A two out of two encoder translates the signal aspects in a speed distance profile which is coded in a track to train message. Beacons and loops transmit this message to the train by means of a 100 kHz carrier signal. With this
semicontinuous transmission we think to offer an ATP-system which is suitable for each kind of traffic.

The trainborne equipment consists of a two out of three computer, a data entry unit, a cab display and the usual peripherals. Speed and distance are computed on basis of speed sensor pulses. The speed sensor is mounted on an axle. The system supervises the speed distance profile decoded from the track to train message. The cab display gives information to the driver in such a way that he can use the maximum of the speed-distance profile without crossing unwillingly the safety limits.

The main safety and operational features of ATBNG can be summarized as follows.

* Braking curve supervision on basis of individual train data, such as length, maximum speed and braking capacity. This means that the brake distance and maximum speed needs not to be programmed any longer in the infrastructure and that modern rolling stock can take advantage of its high maximum speed and big braking power.

* Speed supervision in steps of 10 km/h, so the speed-distance profile can be adapted to every situation.

* Supervision of temporary speed restrictions by means of a parameterplug to be placed in the encoder of the wayside equipment. This means reduction of safety risks during work on the lines.

* Protection of junctions only. ATBNG can be used as an overlay system on the existing ATP-system. Against low costs a significant risk can be taken away.

* High availability of trainborne equipment by redundancy. This avoids trains running with ATBNG out of service and offers the possibility to repair the train at a suitable moment.

* The speed-distance profile, send by the beacons, contains redundant information. There will be no loss of safety and no disturbance of the train in case of a beacon is in failure.

* Release speed in front of a signal at stop.

As mentioned we would come back on the protection of the signal at stop. Dutch lines do not provide overlaps in rear of the signal at stop. From a top down view that means that the
value of the limits of speed and distance used by the driver for normal operation and the value of these limits to be supervised by the ATP-system are very close. This proximity of control and safety limits are the main difficulty of the dutch ATP. On one side we want to reach the signal at stop at almost zero distance and on the other hand we want to protect the train from passing the signal. This functional requirement comes down to the technical problem of a very accurate and failsafe odometry. On this subject we are still working. Failsafe speed and distance measurement of rolling stock covering all circumstances and against reasonable costs appears to be very difficult.

The inaccuracy of the odometry can be minimised by resetting the position of the train in front of a signal at stop by means of an beacon at short distance, about 300 m. Never the less we had to introduce a release speed of 15 km/h close to the signal to be able to reach the desired position in a comfortable way without disturbing normal operation. Of course the price of this release speed is the possibility passing the signal at stop with a certain distance.

Up to now evaluation shows that the specification has been realised almost for 100 %.

Still some items need more attention such as the odometry. Further more some specifications are evaluated. For instance the data entry procedure, entering traindata in the ATP-system by the driver, will be reconsidered with the aim to simplify it as much as possible.

Future

In the second half of this year we will implement the final software on the 9 diesel trainsets and collect experience up to the end of the year. We do not expect any problems any more for the first application in a new series of diesel trainsets. The odometry problem is for this particular case solved by the availability of a free axle, which is only braked during an emergency brake. In this way we created time to solve the odometry problem in a general way.

In the near future NS will fit the track Zevenaar-Winterswijk and Nijmegen-Roermond with ATBNG, which is a total length of 100 km. At the same time a series of 50 new diesel trainsets will be equipped as well. Operational service will start in the second half of 1996.