Design and evaluation of a safe and effective DAS

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In IRSE News issue 275 March 2021, a concern was expressed regarding the safety aspects of Driver Advisory Systems (DAS). Between 2015 and 2017 we at Spoorgloren designed and evaluated a Driver Advisory Systems (called RolTijd, or coasting time in English) with the largest rail operator in the Netherlands, Nederlandse Spoorwegen (NS).

RolTijd was designed with the aim to increase safety, rail capacity and sustainability, and was originally designed to be used on an Android telephone. The novel design turned out to be very effective, and increased safety. After the evaluation, NS integrated an updated version of RolTijd with other existing applications on to a tablet. Now most drivers at NS use RolTijd.

Starting position

Most of the Dutch network is mixed-traffic with local, regional, international and freight trains. Almost all of the network is double-track, with a half-hourly repeating timetable. Since 2017 the frequency of regional trains has increased line-by-line from a 15-minute interval to a 10-minute interval between services. This was achieved by lowering the buffer times between trains, combined with infrastructure optimisations. Therefore, there is a requirement to drive trains exactly on-time. To achieve this 'on-time driving', guards were trained to carry out the departure procedure efficiently in order for the trains to leave exactly on time. In 2016 guards could request a smart watch to support them during the departure procedure.

Most lines are equipped with the ATP system ATB-EG. More information can be found in reference [4], but the system uses coded track circuits to transmit either the current line speed, or speed at next signal, whichever is lower. Supported speed steps are 40, 60, 80, 130 and 140km/h. Traction and braking by the driver are monitored, and over speeding results in emergency braking. After passing a Signal Passed at Warning (SPAW) device the code for 40km/h is transmitted to the train. A limited number of signals have an additional protection against passing a signal at danger (SPAD). This ATB-vv addition is installed on a risk basis. Since there is limited SPAD protection a driver should be distracted as little as possible after a SPAW. For example, the driver is forbidden to use the phone after a SPAW. Most stations feature a Station Ahead Sign on braking distance before the next station. Drivers are instructed to reduce speed from that point on, if a stop is foreseen in the timetable.

Drivers have an electronic timetable on a Windows smartphone. This is both used to transmit the rosters for the drivers and to have the actual planned times, e.g., in cases of track works.

Both traffic management and the management of the drivers is focussed on three-minute punctuality. Traffic management generally only gives attention to delays that exceed 180 seconds. The operator and the Dutch infrastructure manager have the data and the feedback loops to evaluate the timetable, when sufficient statistics are available.

Eco-driving analysis and design of display

An eco-driving programme has been in effect since 2011 [1]. All drivers have had two training sessions in eco-driving. The coasting strategy is taught, both on simulators and during runs with buddies. Expert eco-drivers compiled lists with coasting positions, based on the timetable. These were provided as documents and in an app to all drivers. A monitoring system (called EZR monitor) is available to determine the energy savings due to driving style. This is used for management feedback, and can be adapted to measure the effect of specific tests, as in this example the introduction of a DAS.

The DAS system was designed to further support eco-driving.

A first recurring question was whether or not to advise both when cruising and coasting were needed. This was analysed in a separate research stream. Coasting is optimal if the running margin is low and is very close to optimal if running time margin is large, up to 15 per cent [2]. For larger running time margins, the final approach speed with coasting might be too low, causing long closing times of level crossings. If the running time margin is otherwise too large, the timetable in the Netherlands

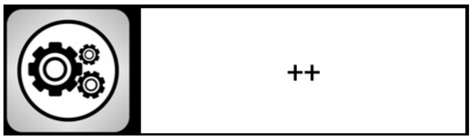
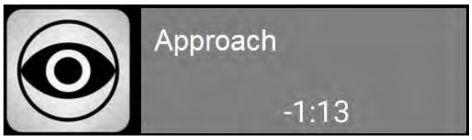
Colour	Interpretation	Example screen
White	Maintain permitted speed	
Blue	Turn off traction and coast to the next stop	
Grey	RolTijd cannot or may not offer advice	

Table 1 – Each of the colours has a supporting icon.

is calculated with a lower speed. The electronic timetable on the Windows smartphone already showed this speed advice, therefore the risk was already mitigated. Furthermore, few trains depart ahead of time at NS.

Based on research [2], it was concluded that the DAS system only needed to support coasting. This enabled a substantial simplification of the interface.

Test device and test group

For the pilot, a S-DAS device (called RolTijd, which translates to Coasting Time) was prepared on a separate Android phone. All timetables for the current two-month planning period were stored in the app.

The display was simplified to a three-colour design, as shown in Table 1.

To have predictable behaviour to the driver, a time difference was shown in the coloured area, with the number of seconds that the train would be late if coasting were to be applied from this point. This number is positive in a white state and negative in the blue state. On the change in this number, the driver can already estimate when to start coasting. Furthermore, during coasting, this number gives feedback on how well the coasting behaviour of the specific train matches the coasting behaviour of the average train.

The DAS shows coasting phases so that exact passing times are realised in three different situations. 1) for all stops, 2) for the start of stretches with reduced speed, and 3) for locations where traffic crosses ahead. Using these points, the DAS regulates the train to pass exactly at the time in the timetable.

In addition, the device shows the current kilometre-signage, the planned passing or stopping time and the distance to the next stop or passing point. The final design is shown in Figure 1.

For the pilot, 60 out of 3000 drivers were selected. Half of the drivers were experienced eco-driving experts. The other half were volunteers with only basic eco-driving training. For both groups, we monitored on-time arrival (in seconds deviation from the planned time), energy-use and the number of SPAWs.

Safety analysis

Before the test, a safety analysis was made. The requirements were validated against the requirements published by the UK Rail Safety and Standards Board (RSSB) requirements for C-DAS systems [3, 4].

Figure 1 – The RolTijd app as used in the test.

This safety analysis determined that the advice from RolTijd could not conflict with other signals to the driver, because:

1. There is no braking advice.
2. There is no speed advice.
3. A grey display is shown after SPAWs for home signals, and after a Station Ahead sign for the next stop.
4. The device is placed in the peripheral vision of the driver.
5. The device made no sounds.

Still, any change could cause some distraction for the drivers, and thus the following measures were taken before a driver was admitted to the test group:

1. The driver's manager would assess that the driver was not easily distracted.
2. Each driver was assessed after an instruction run with the DAS by an instructor.
3. The driver could reach out to the test team, and was allowed to leave the pilot at any moment.
4. Interviews on the positive and negative effects were conducted.

The conditions for this pilot were accepted into the safety management system of NS. The test drivers were allowed to show the device to drivers that did not participate in the test, e.g., while travelling in a train in the passenger compartment. However, the other drivers were not allowed to use the DAS while driving.

Feedback and learning, especially towards timetabling

Most of the drivers accepted the DAS device immediately at the instruction sessions.

During the test, a few things were added, such as a setting for shorter trains (which have a higher deceleration) and showing the platform the train was planned for.

In the first weeks of the pilot, most drivers were able to arrive within 20 seconds of the planned time. They did not consider this good enough. During the coasting phase, they could keep the shown time difference within 10 seconds, and so they expected the passing and arrival times also to be within 10 seconds. Thereafter, the calculations in the DAS were adjusted to better represent driver behaviour during braking.

Most of the comments from the drivers during the pilot actually addressed the timetable. During the pilot, the public Dutch timetable was in whole minutes (60 second increments) and no separate internal timetable existed. The timetabling system provided tight-running times between timing points in six-second increments. For the DAS users, an internal timetable was constructed with times in six-second increments. In this timetable, the running time margin between major stops was distributed evenly over the time in between. For stops, we made sure the departure times were in the minute after the published public timetable. For timing points, the times agreed within 60 seconds.

During the test period, the drivers requested many small changes to both the public and the internal timetables, in order to have running times that enabled smooth running. One of the drivers got an internship at the timetabling department. Using the feedback from the DAS runs, the timetable was adjusted so that at least the critical points were well matched. The planners were impressed that drivers were willing and able to drive within a few seconds. This motivated the planners to improve the plans. Furthermore, a number of improvements in the run-time calculation received a higher priority. These improvements were implemented in the timetabling system after the DAS test finished.

During the test, drivers found that with the DAS, they could introduce eco-driving to trainee drivers at an earlier stage. This allowed trainee drivers to use coasting earlier in their training, and to avoid SPAWs.

Results

During the test, we measured on-time driving, energy use and number of SPAWs. We found that the eco-driving experts drove as energy efficiently as before, while the non-experts saved several per cent in energy. Both groups arrived on-time far better. Before using the DAS, the eco-driving experts arrived often with delays measured in tens of seconds, and the others with even greater delay.

Interestingly, not only the dispersion in seconds improved. The 180-second punctuality improved as well by a few percent points. This is due to the fact that many of the three to four minute delays originated from accumulated delays of less than one minute. With RolTijd, the drivers arrived on time, and small delays no longer built up to larger delays.

Furthermore, we analysed the number of SPAWs. We excluded signals that were passed at warning for all trains (e.g., home signals). The remaining SPAWs were reduced by tens of per cents, both for the train itself and trains passing behind the train where the drivers used the DAS.

In the evaluation, we conducted an interview with the drivers. One of the questions was to instruct an illustrator to convey the benefits of the DAS device. Unanimously, they reacted that the main benefit was that the DAS made their driving more relaxed. Figure 2 shows the resulting figure from one of the groups. Their tasks (which were to arrive on-time, and drive energy efficient) were unchanged, but the DAS just made their job easier. The acceptance of the system was high, and many drivers outside the test group wanted to have the device as well. The main disadvantages of the test device were that it was another device to carry and that it was not integrated with the electronic timetable.

Figure 2 – Driver reaction.
Figure used with permission of Nederlandse Spoorwegen.

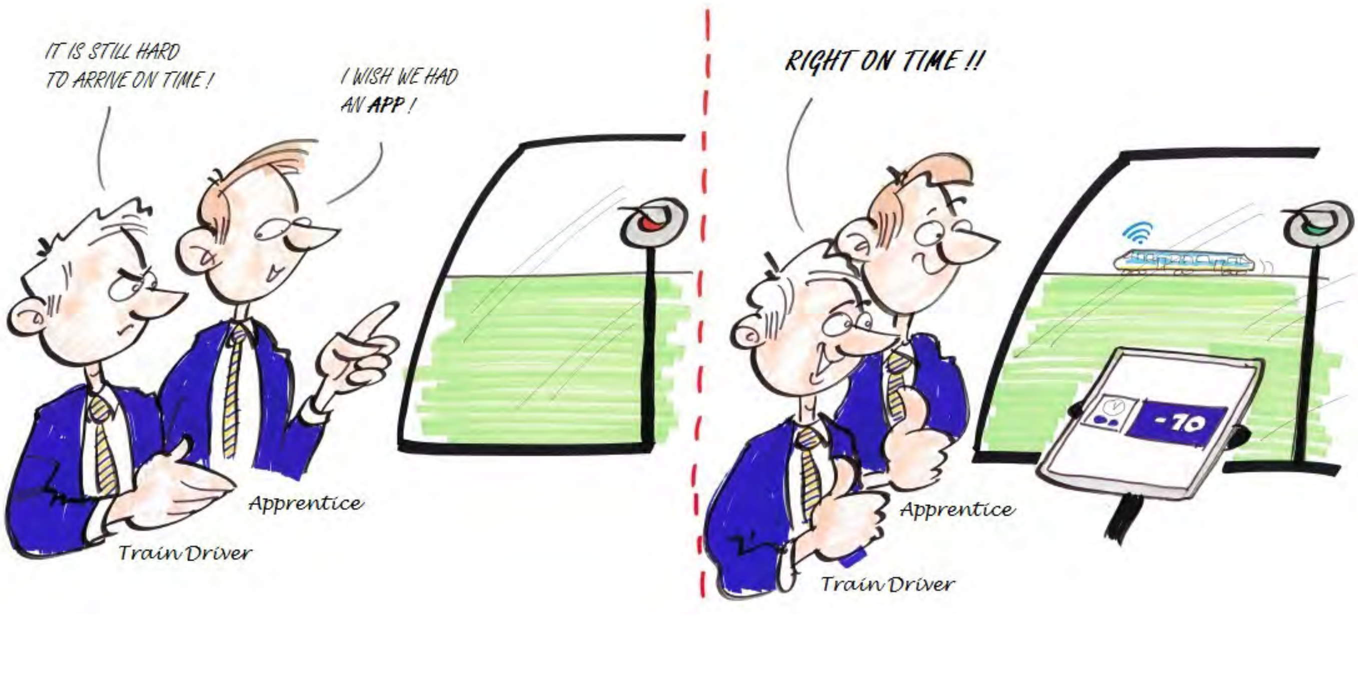


Figure 3 – Final, integrated solution.
Figure used with permission of Nederlandse Spoorwegen.

Follow up

In 2019, the DAS system as tested was integrated in the tablet which is the successor of the Windows smartphone. A graphical dial indicator is added to the number shown, as shown in the top left of Figure 3. The electronic timetable function is integrated with the DAS function. This way, a C-DAS function was realised. The timetabling software was updated so that the maximum deviation in the running time calculation is reduced to 20 seconds. Starting with the timetable for 2020, a national internal timetable in six-second intervals is used for the entire Netherlands. Many drivers now use the system and there are several YouTube cab-drive videos [6] that show the C-DAS in action.

For the drivers, a new target was introduced: running within 30 seconds of the planned time if possible given departure delays and other trains. Improving this target will improve safety (less SPAWs) and opens the possibility of increasing track capacity by lowering buffer times.

During the RolTijd pilot, infrastructure and signal aspect data was collected manually. During the pilot, data sources were identified to automate the data collection. In parallel with the implementation on the tablet, NS, ProRail and several other UIC members have worked on a standard for the data preparation of DAS systems. This has resulted in UIC IRS 90940, which will be the basis both for future versions of the C-DAS and for ATO operation on the class B system [7]. The versions up to 2020 used the route data from the timetable. The upcoming 2021 version will use SFERA data that is prepared jointly with ProRail on the route planned by the signaller. This enables the update of the advises if the track is changed.

Conclusion

We designed and evaluated a DAS at the largest rail operator in the Netherlands. RolTijd was designed with the aim of increasing safety, rail capacity and sustainability, and was originally designed to be used on an Android telephone. The novel design turned out to be very effective, and increased safety.

After the evaluation, NS integrated an updated version of RolTijd with other existing applications onto a tablet. Now most drivers at NS use RolTijd.

References

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About the author ...

Jan is an AMIRSE, and company director and owner of the Dutch consultancy firm for mobility and transport, Spoorgloren BV. Jan has a PhD in Physics and extensive knowledge of, and experience within the railroad sector.

Jan worked as a programme manager, change manager and as a test and quality manager. For NS, he has organised and monitored eco-driving and eco-stabling programs. For the Amsterdam-Utrecht ERTMS pilot, Jan has helped to create and manage the research programme. He has participated in the development of ATO over ETCS. Jan developed the Dutch RolTijd Driver Advisory system, along with laying the foundation for UIC IRS 90940: the standard for DAS data exchange.