COUNTDOWN ON A PLATFORM: HIGHER PUNCTUALITY AND INCREASED SAFETY AT LEVEL CROSSINGS

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In the Netherlands there are about 150 train stations with a level crossing situated nearby. Closure of the level crossing and execution of the train departure procedure are performed serially, which causes waiting time. A long waiting time causes unsafe behaviour of road users on the level crossing. A countdown on a platform as aid for train staff for quick start of the train departure procedure was developed. In the development of this countdown, there was great emphasis on human factors. Results of the pilot with a countdown were compared with a reference period without a countdown. Train departure with assistance of the countdown occurred about 15 seconds sooner after closure of the barriers compared to train departure without countdown. This favours punctuality of train service and decreases deviation in train departure times. The countdown itself did not influence behaviour of passengers on the platform. Closure time of the level crossings involved was about 15 seconds less, which favours flow of traffic across the level crossings. Behaviour of road users at the level crossings did not significantly change because of the countdown. After adapting to local characteristics the concept of the countdown can be applicable in other countries.

Introduction

In the Netherlands there are about 150 train stations with a level crossing situated within a few hundred meters distance from the station. Automatic route setting for the train triggers closure of barriers of the level crossing. When the level crossing is safely closed, a departure light on the platform is activated and train staff is allowed to start the procedure for safe departure of the train. So first the

train is waiting for safe closure of the level crossing, followed by waiting of road users for safe departure of the train. From the perspective of road users this serial performed process causes a long closure time of the level crossing without any visible reason. Unsafe behaviour of road users, passing closed barriers of the level crossing, occurs in these situations. From the perspective of train service the waiting for closure of the level crossing influences punctuality.

Safety at level crossings

The Dutch infrastructure manager ProRail pays much attention to safety on level crossing. Incident analysis shows that about 40% of all incidents on level crossings with lethal consequences are related to passage of a closed level crossing. For this purpose a model for risk assessment of level crossings was developed (Wilms, 2009). Especially closure time of the level crossing influences unsafe behaviour of road users on a level crossing (Wilms, 2009; RSSB 2005). More specific a perceived long time between the moment of activation of the level crossing and the moment of arrival of the train at the level crossing stimulates unsafe behaviour at level crossings (RSSB, 2005). Road users overestimate this waiting time, whereby perceived closure time is longer than objective waiting time in seconds. Time pressure often is reason for passing a closed level crossing. The more time pressure perceived, the bigger the chance on unsafe behaviour of a road user on a level crossing (RSSB, 2005).

Development of the countdown

Development of the countdown device took place in 2 phases: assessment of the concept of the countdown and engineering of the countdown, including risk assessment according to the Common Safety Method on Risk Evaluation and Assessment (EU, 2013), with special emphasis on human factors.

Assessment of the countdown concept

The definition of the countdown concept started with the following ideas:

- Goal: Shorten waiting time for road users due to a closed level crossing. Waiting time is longest for level crossings nearby a station, because procedure for departure of the train can only start after closing of the level crossing (safety condition).
- Idea: Shorten the time needed for execution of the departure procedure and/or earlier start of the departure procedure. Parallel execution of closing level crossing barriers and procedure for train departure instead of serial execution.

Because human behaviour is essential in execution of the procedure for train departure as well as in behaviour of road users on level crossings, an impact analysis of the concept has been made from the perspective of human factors.

Following requirements were defined (Zeilstra, Wilms, 2012):

- Activation of the countdown device is dependent of safe closure of the level crossing.
- Activation of the countdown device is dependent of safe train route setting for the train before departure.
- The departure procedure has to be executed without a pause.
- Departure of the train (after completion of the manually executed procedure for train departure by train staff) has to be later than departure time as published on the platform.
- The countdown values have to be related to the minimum time needed to safely execute the train department procedure.
- The countdown values has to be related to the time needed for driving the train from the station to the level crossing at normal speed.

Risk assessment on use of the countdown

Based on several sessions with stakeholders on possible features and technical feasibility a countdown on the platform of a station was preferred. Risk assessment on use of this countdown with emphasis on human factors was performed on behalf of the train operating company (Wilms et al., 2013). Based on the risk assessment, the train operating company formulated the following requirements on use of the countdown in a pilot (Welle Donker, S.W., 2014):

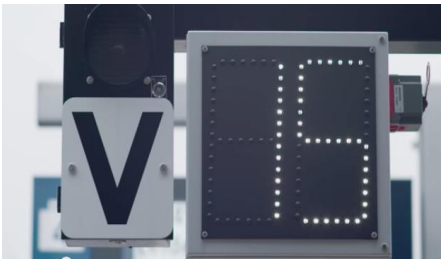
- The countdown starts counting with a value that minimizes the chance on unsafe departure of the train. For purpose of the pilot a countdown value of 15 seconds suits this requirement.
- The pilot has to be performed with rolling stock that is equipped with door systems that prevent herniation of passengers.
- Instruction about correct use of the countdown to train staff who were to work with the countdown is necessary.
- Monitoring safe execution of the departure procedure by train staff and safety of passengers on the platforms.

The risk assessment on the behaviour of road users at the level crossing, made by the Dutch infrastructure manager, concluded that identified risk levels were acceptable.

Pilot with the countdown

Final concept of the countdown

Figure 1 shows the final concept of the countdown (countdown in background) with the train departure procedure (Kootwijk e.a, 2015).



Departure procedure with countdown:

- Start procedure after activation of countdown (countdown value = 15)
- First safety check of train staff
- Give auditory signal to passengers on countdown value = 8
- Close all but one door of the train
- Last safety check alongside the train
- Check activation of departure light on the platform (countdown value = 0)
- Close last door of the train

Figure 1: Final countdown device with deactivated departure light and procedure of departure of the train

Pilot with the countdown

A pilot with the countdown was performed in the period of November and December 2014 (piloting period). Reference data about train departures without assistance with a countdown was collected earlier in June and October 2014 (reference period) and during piloting period when the countdown was not activated because of safety requirements formulated for execution of the pilot. The pilot was performed at the stations of Hilversum and Hilversum Sportpark. Both stations have a level crossing nearby the station. Both level crossings are known as level crossings with unsafe behaviour of road users. During the pilot project members monitored train staff in trains involved. There was also monitoring on the platforms and monitoring on the level crossings involved.

Methods

During the pilot following aspects were evaluated:

Time needed for execution of the train departure procedure

Time needed for execution of the train departure procedure is evaluated based on data out of the track based signalling system (Zeilstra and Kamps, 2015). Measure for Time needed for train departure procedure is the difference in time of the moment that the departure light is activated and the moment of passing the first line side signal in the direction of the level crossing.

Behaviour of train staff during train departure procedure

Qualitative evaluation of behaviour of train staff during the train departure procedure took place by assessment of video images (Kamps and Zeilstra, 2015). The following events are evaluated on safe and prescribed behaviour:

- Starting moment of the departure procedure in accordance to regulation (train departure procedure without countdown) or as required in risk assessment (train departure procedure with countdown).

- Starting moment of the departure procedure and moment of last safety check related to countdown values
- Location of train staff on the platform

Behaviour of passengers on the platform

A change in the departure procedure can change behaviour of passengers on the platform. Although the countdown is not meant for passengers, it is not possible to prevent passengers reacting on the countdown. Based on risk assessment on behaviour of passengers on the platform, running along the train and pressing the button for opening the doors of the train are defined as possibly hazardous behaviour (Wilms, et al., 2013). This behaviour is only hazardous when the train starts moving. Evaluation of behaviour of passengers on the platform took place by assessment of video images during piloting period with countdown and reference period without countdown (Kamps and Zeilstra, 2015). The same selection of train departures is assessed as is done for evaluation of train staff behaviour. The following events are evaluated on safe behaviour of passengers on the platform: moment of start of departure procedure; closure of all doors of the train except the door meant for train staff; moment of executing the last safety checks by train staff; and after closure of all doors of the train.

Punctual departure of the train

Evaluation of punctual departure of the train took place by assessment of video images (Kamps and Zeilstra, 2015). Measure for punctual departure of the train was the difference in time of the moment of coming in motion of the train and the departure time published at the platform.

Closure time of the level crossing

Closure time of the level crossing is evaluated based on data out of the track based signalling system (Zeilstra and Kamps, 2015). Measure for closure time of the level crossing is the difference in time of the moment of activation of the level crossing and the moment of arrival of the train at the level crossing.

Behaviour of road users on the level crossing

Behaviour of road users on the level crossing was evaluated by assessment of video images (Werkman and Hek, 2015). The following possibly hazardous behaviour of road users is defined in terms of: crossing while white alarm lights are activated and barriers are going down; crossing while barriers are completely closed; and crossing when barriers start rising up after passage of the train.

Results of the pilot

This paper presents the results of the pilot at Hilversum station.

Time needed for execution of the train departure procedure

In a situation without a countdown, the activation of the departure light on the platform is the safety condition for starting the departure procedure by train staff.

In a situation with a countdown, the countdown is activated 15 seconds before activation of the departure light and train staff is allowed to start the departure procedure. Statistical analysis (ANOVA) shows that during the piloting period train departure with a countdown is in average 16.80 seconds faster than train departures without a countdown during reference period (Table 1, $p<0.05$). During piloting period train departures with a countdown is in average 14.88 seconds faster ($p<0.05$) than train departures without a countdown during piloting period. Both results are quite similar to the design specification (Wilms et al., 2013: with countdown 15 seconds sooner completion of the train departure procedure). Table 1 also shows that deviation in departure times is less when a train departure procedure is executed with assistance of a countdown.

Table 1: Difference in time needed for train departure procedures with and without countdown, piloting period and reference period

Station of Hilversum	**N**	**Mean difference in time needed for train departure procedure**
Piloting period with countdown vs. reference period with countdown	828	-16,80
Piloting period with countdown vs. piloting period without countdown	5.715	-14,88
Piloting period without countdown vs reference period without countdown	150	- 1,92
Total	6.693	

Behaviour of train staff during train departure procedure

Because of time and budget constraints it was chosen to evaluate quickly executed train departure procedures and slowly executed train departure procedures. During all evaluated train departures train staff showed safe behaviour according to regulation for train departure procedure without countdown and safe behaviour as required in risk assessment for train departure with assistance of a countdown (Kamps and Zeilstra, 2015).

Table 2 shows that most of the departure procedures starting moments are during the first 5 seconds after countdown activation. Most of the last safety checks are executed during the last period of 5 seconds of activation of the countdown or after deactivation of the countdown. This is somewhat earlier than required in the procedure for train departure with a countdown as shown in Figure 1.

Table 2: Countdown values during procedure for train departure, percentage of quick/slow train departures

Station of Hilversum	**Value of countdown # quick / slow departures**				
Departures	**15-11**	**10-6**	**5-1**	**Countdown**	**No data**

				deactivated	
Moment of starting train departure procedure	83%/32%	10%/16%	-/-	10%/36%	10%/16%
Moment of execution last safety checks	-/-	-/3%	40%/6%	40%/78%	20%/13%

Table 3 shows that during piloting period with a countdown a majority of train staff is at the desired location. During the reference period without a countdown, location of train staff at the moment of the departure procedure is not as regulated. Parallel to the reference period and piloting period the train operating company paid much attention to safe execution of the departing procedure, which may explain differences between reference period without countdown and piloting period with countdown.

Table 3: Location of train staff during train departure procedure, percentage of quick/slow train departures, with and without countdown

Station of Hilversum	**Start of procedure**		**Last safety checks**	
% of quick/slow departures	**No countdown**	**Countdown**	**No countdown**	**Countdown**
In the train (not allowed)	5%/5%	-/-	68%/17%	-/-
On the platform (required in all situations)	58%/90%	94%/84%	32%/83%	93%/87%
One leg in the train, one leg on the platform (not allowed)	5%/5%	3%/6%	-/-	-/3%
No data	32%/-	3%/10%	-/-	7%/10%

Behaviour of passengers on the platform

Table 4 and Table 5 show that for quick departures without a countdown in the vast majority of cases there is no possibly hazardous behaviour of passengers on the platform. For quick departures during piloting period with a countdown there is more cases of train departures where passengers where running along the train, but in all relevant situations the train was still at a standstill along the platform, so there were no dangerous situations during reference period without a countdown as well as during piloting period with a countdown.

Table 4: Passenger behaviour during first 2 moments in train departure procedure, percentage of quick departures, with and without countdown

Station of Hilversum,	**Start of procedure**		**Door closure**	
% of quick departures	**No countdown**	**Countdown**	**No countdown**	**Countdown**

Running along the train	-	7%	-	17%
Pressing buttons of doors	-	-	-	-
No dangerous behaviour	100%	90%	100%	83%
No data	-	3%	-	-

Table 5: Passenger behaviour during last 2 moments in train departure procedure, percentage of quick departures, with and without countdown

Station of Hilversum, % of quick departures	**During safety checks**		**After door closure**	
	No countdown	**Countdown**	**No countdown**	**Countdown**
Running along the train	-	17%	-	3%
Pressing buttons of doors	5%	3%	11%	3%
No dangerous behaviour	95%	80%	89%	94%
No data	-	-	-	-

Punctual departure of the train

Table 6 shows that with a countdown trains depart earlier than without a countdown. This effect is in accordance with the results about shortening of time needed for train departure procedure with countdown as shown in in Table 1.

Table 6: Train departure related to departure time published on the platform, percentage of quick/slow departures, with and without countdown

Station of Hilversum	**# quick departures**		**# slow departures**	
	No countdown	**Countdown**	**No countdown**	**Countdown**
Departure before published departure time	-	-	-	-
Departure 0 – 30 sec after published departure time	37%	70%	-	45%
Departure > 30 sec after published departure time	63%	30%	100%	45%
No data	-	-	-	10%

Closure time of the level crossing

As stated earlier, unsafe behaviour of road users at a level crossing is related to the time between closure of the level crossing and arrival of the train at the level crossing. Figure 2 shows the results of data-analysis (Kootwijk et al., 2015). The difference in time is in average 16 seconds less (ANOVA, $p<0,001$), quite

similar to the design specification (Wilms et al., 2013: 15 seconds sooner departure of the train with assistance of the countdown).

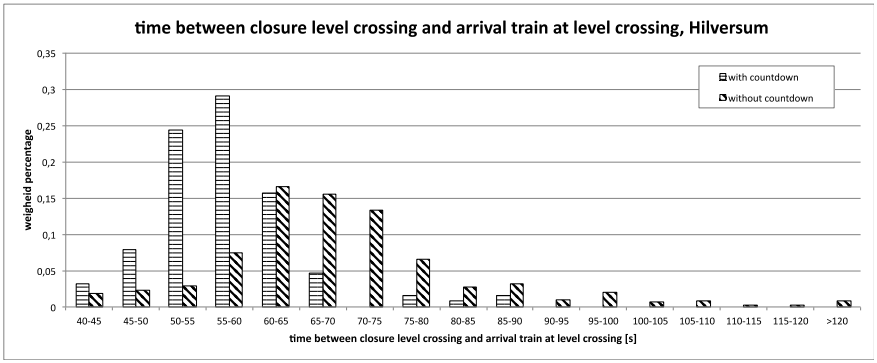


Figure 2: Time between closure of level crossing and arrival of the train at the level crossing, with and without countdown

Behaviour of road users on the level crossing

Table 7 shows that during every level crossing closure about 1 road user crosses while alarm lights are activated and barriers start going down. Statistical analysis shows there is no significant difference in situations with or without a countdown. For road users crossing the level crossing when barriers are completely closed, the number of situations with dangerous behaviour was too small to perform any statistical analysis. Regarding behaviour related to crossing when barriers start rising up after passage of the train, the difference is statistically significant (ANOVA, $p<0.01$); with countdown is less possibly hazardous behaviour. But as stated before this behaviour is only hazardous in so-called second train situations.

Table 7: Behaviour of road users on level crossing, station of Hilversum, with and without countdown during piloting period

Station of Hilversum	**# of road users with certain behaviour per closure of level crossing**	
Road user behaviour	**No countdown**	**Countdown**
Crossing while alarm lights are activated and barriers start going down	1,02	0,96
Crossing when barriers are completely closed	Total of 8	Total of 0
Crossing the level crossing when barriers start rising up after passage of the train	2,00	1,09

Conclusion

The countdown as piloted is a successful aid for earlier start and faster execution of the train departure procedure. Departure of a train with countdown was about 15 seconds sooner compared to departure without countdown. This favours punctuality of train service and decreases deviation in train departure times. The countdown itself did not influence behaviour of passengers on the platform. Closure time of the level crossings involved was about 15 seconds less, which favours flow of traffic across the level crossings. Behaviour of road users at the level crossings did not significantly change because of the countdown.

It is decided to implement the countdown throughout the Netherlands. For further development of the countdown attention should be paid to training of train staff, visibility and conspicuity of the countdown, application of the countdown in crowded situations together with other procedures for departure of a train and maintenance management for the countdown. After adapting to local characteristics the concept of the countdown is also applicable in other countries.

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