Rail to Digital automated up to autonomous train operation

D38.6 – Results of automatic coupling and uncoupling

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EXECUTIVE SUMMARY

Task 38.6 “Remotely controlled coupling and uncoupling” is part of R2DATO WP38 titled “Automatic Stabling, Shunting, and Non-commerical runs Demonstrator”. The aim of this work package is to test the different technical enablers that could enable automatic stabling, shunting and non-commercial runs.

This task aims to assess the impact of Remote Train Operation (RTO) on the efficiency of the coupling and uncoupling processes, specifically comparing the process times under RTO with those in the traditional, non-automatic local operation. The central research question is: *“What is the impact of RTO on the (un)coupling process times compared to the non-automatic situation?”*

The tests are carried out with an existing Sprinter New Generation (SNG) regional trainset on public tracks between station Enschede and shunting yard Enschede and are conducted by an experienced remote driver (RD). For the task, the RTO-trainset will be remotely uncoupled at the platform of the station before moving it to the track of the washing installation in the yard. In the yard the RD will need to switch cabins before driving back to the station. Back at the station, the train will couple again with the other trainset at the platform. During the test runs, qualitative observations were made and precise timings were recorded for each step of the (un)coupling process, by an observer in the Remote Operation Centre (ROC) and onboard of the train.

The tests confirmed that it is possible to remotely control coupling and uncoupling. Test personnel reported that the coupling process was very smooth. The overall process times of the non-automatic and RTO situation are approximately the same. The primary advantage of RTO is the elimination of the walking time required for the operator to switch cabins, which in this test setup was 78 seconds for three carriages. The benefits of eliminating walking time can be more significant for longer train combinations, or when also eliminating the time required for walking towards and departing from the train.

ABBREVIATIONS AND ACRONYMS

ATO	Automatic Train Operation
RD	Remote Driver
ROC	Remote Operation Centre
RTO	Remote Train Operation
R2DATO	Rail to Digital automated up to autonomous train operation
SD	Safety Driver
SNG	Sprinter New Generation
SOM	Start of Mission
TRN	Train Running Number

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1 INTRODUCTION

Task 38.6 “Remotely controlled coupling and uncoupling” is part of R2DATO WP38 titled “Automatic Stabling, Shunting, and Non-commerical runs Demonstrator”. The aim of this work package is to test the different technical enablers of R2DATO that could enable automatic stabling, shunting and non-commercial runs.

The demonstrators within WP38 have been designed to show the performance of ATO and Remote Driving technologies in an operational environment, integrated in an existing Sprinter New Generation (SNG) regional trainset that operates on public tracks. This deliverable “D38.6 – Results of automatic coupling and uncoupling” is the outcome of Task 38.6 and describes the results of specific tests that were performed for this purpose. The exact description of this task is mentioned in the Grant Agreement:

“Remotely controlled coupling and uncoupling. This task will gain insight in the process times needed for coupling and uncoupling, compared to the non-automatic situation.

This task is identical to Task 38.2, with the addition that the ATO-trainset will be remotely uncoupled before moving it to the depot/yard and coupled after it has been moved to the platform track from the depot/yard. The second trainset used to couple with or to uncouple from is a normal trainset, i.e., as used in normal operation, not equipped with ATO-subsystems.”

This report describes the methodology and results of the Tasks 38.6, which were conducted during test runs at night and to provide insight into lessons learned and recommendations for future test campaigns related to remotely controlled coupling and uncoupling.

1.1 PROJECT RELATIONS

This task has a strong relation with the other tasks within WP38, specifically for the demonstrators that are being performed within:

- Task 38.1 "Training guidelines, operational guidelines and instructions, training material"
- Task 38.2 "Stabling a train and bringing a train to the station by remote control (GoA1)"

The above mentioned demonstrations involve the tests in which the tasks of remote driving are performed by regular train drivers with no previous experience of RTO. Task 38.6 has a direct relation to Task 38.2, as this is an application of the remote funtionality as described in Task 38.2.

Considering that the technical solution and the majority of the research environment for the remote control demonstrator of NS is the same in all WP38, it will only be described once as part of deliverable D38.2. The other deliverables will not duplicate these chapters, but instead refer to D38.2 and mention any differences if applicable.

2 RESEARCH DESIGN & METHODOLOGY

2.1 RESEARCH QUESTION

The primary goal of this Task 38.6 is to conduct proof-of-concept experiments to explore the process times needed for coupling and uncoupling of RTO, compared to the non-automatic local situation. Based on this objective mentioned in the introduction, the following main research question is established:

"What is the impact of RTO on the (un)coupling process times compared to the non-automatic situation?"

2.2 TEST ENVIRONMENT

The tests are carried out between station Enschede and shunting yard Enschede and are conducted by an experienced remote driver (RD). In Figure 1, the map of Enschede is visible. On the right side of the map the tracks end at station Enschede. Furthermore, in red the shunting tracks are visible near point A and on the left side of the map the washing installation is indicated by the white box near point B. The track of the washing installation is part of the shunting yard and also used as turning track for shunting operations.

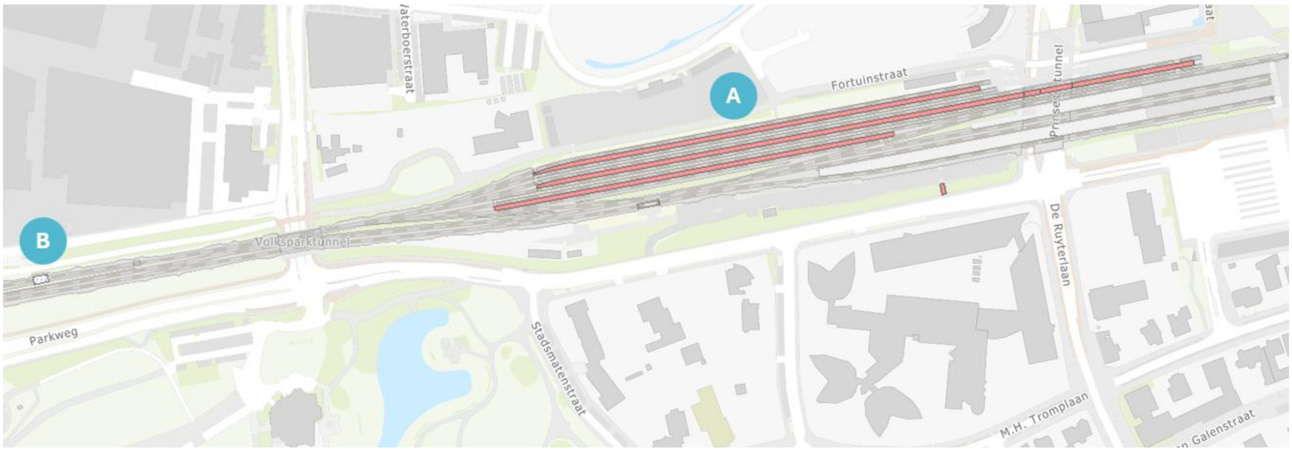

Figure 1: Map of Enschede

2.3 Experimental setup

Next to the normal test setup of the RTO test of Task 38.2, another trainset is needed to couple with or to uncouple from. A reservation for this trainset was made to be available at the platform of station Enschede. Prior to the performing of the tests, this trainset was manually put in the right configuration for coupling. The two trainsets have to be coupled in order to start with the task. Finally, a driving route to the yard and back to the station has to be planned.

For the task, the RTO-trainset will be remotely uncoupled before moving it to the track of the washing installation in the yard. In the yard the RD will need to switch cabins before driving back to the station. Back at the station, the train will couple again with the other trainset at the platform.

2.4 Methodology

To support answering the research question stated in Section 2.1., an analysis methodology was developed based on two data sources: task observations and process times. Additionally, after the task an interview with the crew on the train and the RD has been conducted to obtain knowledge regarding their experience with remotely controlled coupling and uncoupling.

The task observations contain qualitative observations written during the test run by an observer on the train. The task observation includes:

- Train Running Number (TRN)
- Timetable train number
- Route driven
- Weather information
- Coupling speed
- Video from outside and inside the cabin
- Documentation of events during the test run, such as poor video quality, loss of connection, unexpected stops, test driver intervention, signification weather changes etc.

In Figure 2, the different process steps of the non-automatic local (un)coupling task are visualised. The following process times are timed and written down:

- Uncoupling time
- Driving time
- Cabin switch time (including turning cabin on/off, walking time and train tests)
- Driving + coupling time

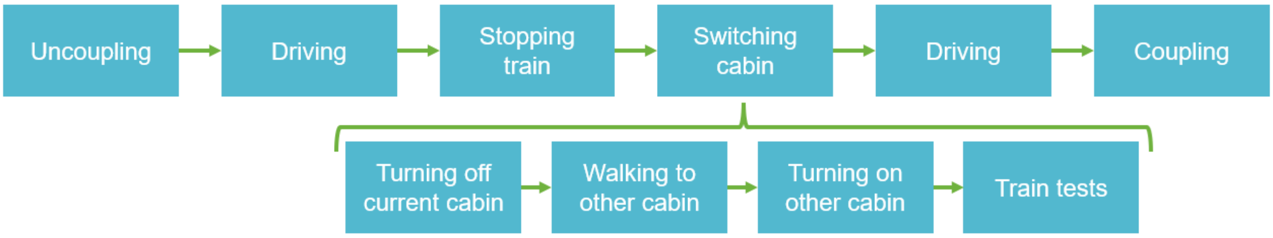

Figure 2: Process steps of (un)coupling

3 RESULTS

While the procedure of coupling and uncoupling has been performed occasionally throughout the duration of the research campaign, the results described in this deliverable are based on two dedicated research runs which focused on (un)coupling. These runs took place in the night of July 8 2025 with one RD. It was possible to split and combine the ATO trainset with a normal trainset. The results addressing the research question are presented in Sections 3.2 and 3.3.

3.1 TEST EXECUTION

While the arrangements and timetable for the (un)coupling tests were precisely planned in advance, the other trainset did not show up at the designated location on the platform track but was instead positioned on the shunting yard. The test plan was therefore updated to the shunting yard instead of the platform, while maintaining the (un)coupling actions. Therefore, this change had no impact in the use case and test results itself. The test location for (un)coupling is shown in Figure 3.

Figure 3: Test setup

3.2 Task observations

Upon completion of the shunting/stabling runs towards the target train for coupling, the RD approached at a coupling speed of 1 km/h towards another parked SNG trainset until the coupling mechanism successfully engaged. Test personnel on train noted that the combining action was very smooth.

However, the RD was not able to split the trainsets when attempting to uncouple due to a mechanical issue. This mechanical issue happened during both test runs, which was probably due to a contaminated coupling. This mechanical issue appears to be coincidental and unrelated to the remote driving setup, whereas it was also not possible to uncouple from the onboard cabin and these issues did not occur during previous (remote) uncoupling with other train sets. To resolve the mechanical issues, it was necessary to physically uncouple the trains and disconnecting the couplers that was performed by the onboard staff. For the future implementation, it is important to look into how these mechanical issues will be solved when the train operator is located at a remote location.

During normal uncoupling operations, the driver would put the train in reverse to separate the trains after uncoupling. The reverse function of the train is not implemented in the Remote Operation Centre (ROC), but can instead be achieved by operating the other cabin in the forward driving direction.

Figure 4: Coupling perspective from the Remote Operation Centre (ROC)

While it was possible to drive remotely, it is important to note that the current test setup is not a fully mature solution yet. Several functionalities are not yet included in this setup. For instance, the train tests that need to be conducted in order to start up the train. During the tests, these train test happen on the train before the train is handed over to the RD. Because of this, the RD can easily switch between cabins without performing these tests, which shortens the cabin switch time for the RD. However, in the future these tests will need to be performed by the RD, with every cabin switch, influencing the cabin switch time.

Figure 5: Demonstrator trainset coupled with normal trainset

3.3 Process times

When comparing the regular coupling process with the remote coupling it is important to understand that some aspects of the current tests do not yet represent a target solution, this specifically concerns:

1. The presence of a Safety Driver (SD) on the RTO trainset. This driver needs to walk to the other cabin before being able to switch driving directions. In a target situation, it would be possible to make this remote switch instantaneously.
2. The inability to perform safety checks and the start of mission (SOM) from the ROC, as well as the inability to drive backwards from the ROC. Requiring actions of the SD before being able to depart that would not be necessary in a target solution.

To take these differences into account, but also consider the potential of the remote driving benefits an overview was made considering the non-remote situation, the current test set-up and a potential target solution of remote driving. This is shown in Table 1.

	Regular process time	Test process time	Target solution process time
Uncoupling	4 sec	4 sec	4 sec
Cabin switch	78 sec (walking) 180 sec (SOM & Cabin prep) 10 sec (cabin on/off)	78 sec (walking SD) 180 sec (SOM & Cabin prep) 1 sec (cabin switch)	0 sec (walking) 180 sec (train tests) 1 sec (cabin switch)
Driving + coupling	130 sec (driving) 26 sec (coupling)	135 sec (driving) 31 sec (coupling)	130-135 sec (driving) 26-31 sec (coupling)

Table 1: Process times of (un)coupling

The time required for physically uncoupling the trains was observed to be similar for each scenario. For the driving time towards the coupled train, some differences were observed. It appeared that the RD opted for a more defensive driving style when approaching for coupling compared to the (experienced) onboard driver, resulting in a longer total driving time. More analysis is required to further study this effect, specifically when the RD is more experienced.

The process of switching the active cabin of the train takes time because the onboard drivers must physically move to the other cabin. The test solution demonstrated the ability to switch the selected cabin of the ROC instantly (in under 2 seconds), but immediate departure was not possible because a SD must be physically present in the cabin and the SOM has to be performed onboard.

4 CONCLUSIONS

Concluding, it was possible to combine the ATO trainset with a normal trainset. Test personnel reported that the coupling process was very smooth. Because of the test setup it is not possible for the RD to drive a few meters back after uncoupling. Instead, the operator must first switch to the other cabin to complete the uncoupling procedure. Furthermore, because of the mechanical issue during uncoupling, it is important to look into how these mechanical issues will be solved for the future implementation when the train operator is located at a remote location.

To answer the research question 'What is the impact of RTO on the (un)coupling process times compared to the non-automatic situation?' the process times during (un)coupling have been timed and observed. The overall process times of the non-automatic and RTO situation are approximately the same. The primary advantage of RTO is the elimination of the walking time required for the operator to switch cabins, which in this test setup was 78 seconds for three carriages. The benefits of eliminating walking time can be more significant for longer train combinations, or when also eliminating the time required for walking towards and departing from the train.