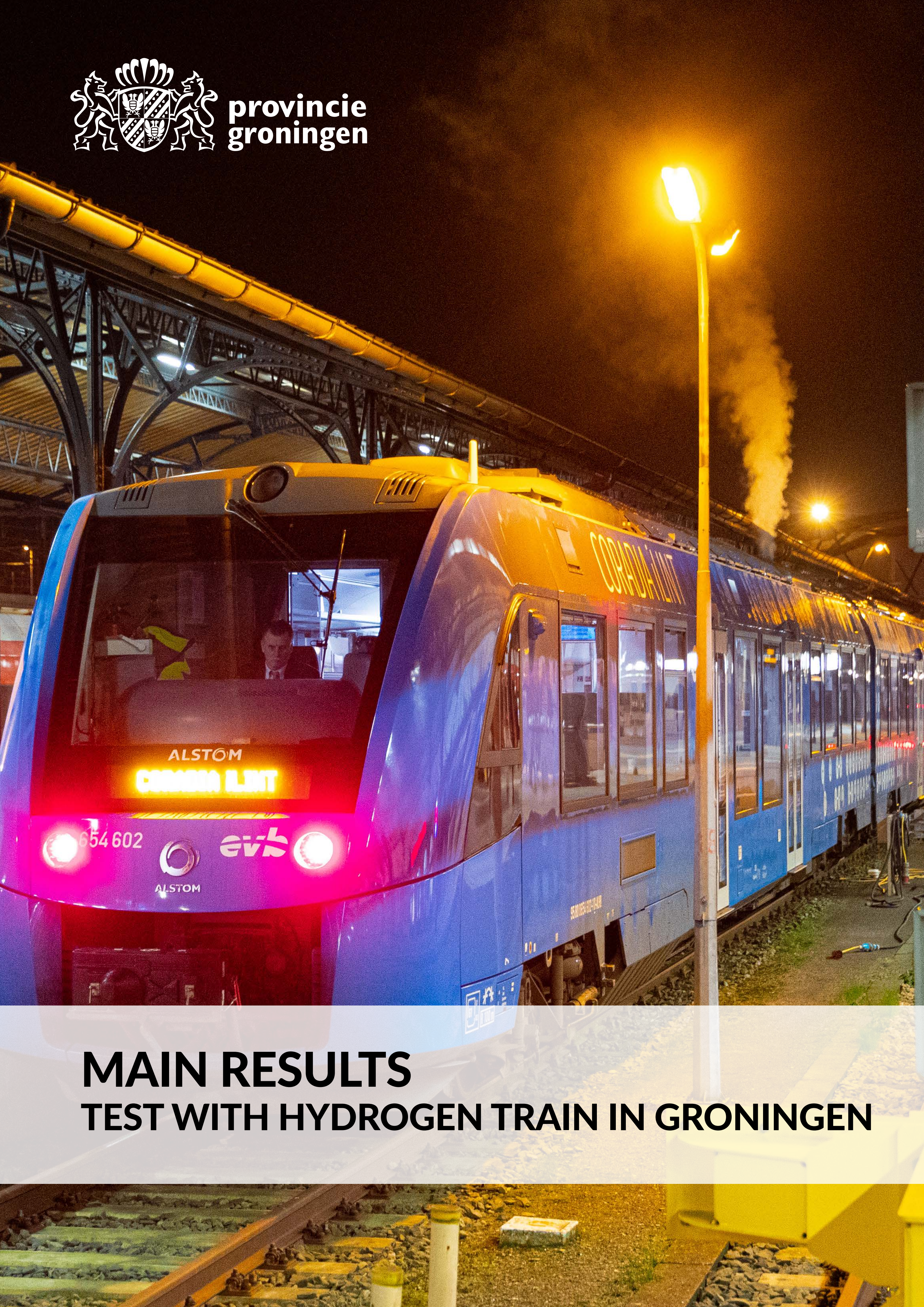
provincie groningen



MAIN RESULTS
TEST WITH HYDROGEN TRAIN IN GRONINGEN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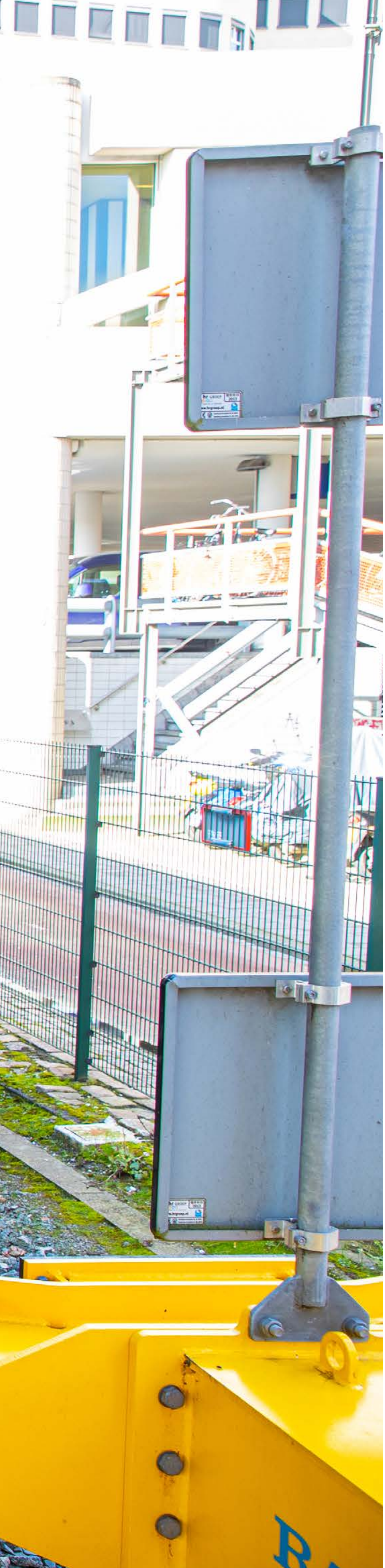
ALSTOM



CONTENTS

Main Results of the Hydrogen Train Test in Groningen

RESULT OF TEST WITH HYDROGEN TRAIN IN GRONINGEN

At the start of 2020, after a long preparation period of as much as one and a half year, the Province of Groningen, together with various partners, did a feasibility study in the form of a pilot test with a hydrogen (battery) train (running on green hydrogen) to explore whether this could be a full-fledged sustainable alternative to the current diesel trains.

The Province of Groningen sees an important role for green hydrogen

- For greening the chemical sector (raw material).
- As a fuel in heavy mobility (buses, trains, trucks, ships, aircraft).
- As an essential piece of the puzzle regarding energy transition (storage, transportation).
- This will also create new economic opportunities and employment.

Pilot

The trial runs were done on the track between Groningen and Leeuwarden during nighttime for a period of two weeks, with a passenger train running on green hydrogen. During the tests, the train ran a number of times at normal speed – without passengers – alternately as an intercity- and a local train – between the stations of Groningen and Leeuwarden. By these trial runs, practical experience was gained in running on hydrogen. This was the first time a train ran on hydrogen in the Netherlands. The tests focused on, among other things, the actual running, fuel consumption, and refueling. There were four main objectives, which concerned the test dispensation, test runs, the refueling process, and the press- and public information day.

Test train

The hydrogen test-train is manufactured by the Alstom company. It has also been used for tests on German railway tracks and is now running regular services at a number of places there.

Conclusion

These first trial runs have demonstrated that there are already zero-emission trains that can run in the Northern Netherlands. The objectives set for the study have been achieved, and the overall conclusion is that the hydrogen train can be a full-fledged alternative to the current diesel trains.

Follow-up

The test was an important step but, at the same time, it was only just a first step. The results have been projected onto all Groningen railway lines, so we know for those lines as well that the hydrogen train can run a regular service. This was possible by combining the practical test results with a simulation model. The next step will now be to collect sufficient funds for the procurement of the first hydrogen trains that can run a daily service, subject to the approval from IL&T. The first opportunity for this procurement will be when the railway line Veendam-Stadskanaal is realized. According to current plans, this project will be completed in 2025, which means that the contract for tender will have to be put up in 2021.

Collaboration

The aim of the Province of Groningen, ProRail, and Arriva is to have the trains run in the Northern Netherlands on a zero-emission basis. The hydrogen (battery) train offers a good opportunity to do so without huge investments in interference-sensitive overhead wires. Moreover, these zero-emission trains are less noisy than the current diesel trains. They're both smart and green! The Province of Groningen (the commissioning party) carries out these trial runs in collaboration with ProRail (co-initiator and manager of the railway infrastructure), Arriva (transportation provider), Engie (supplier of green hydrogen and tank installation), Alstom (supplier of the hydrogen train), and DEKRA (independent test organization).

THE TEST DISPENSATION

OBJECTIVE

Obtaining a dispensation from the Inspectorate for the Living Environment and Transportation (IL&T) for being allowed to run a hydrogen train on the Northern Netherlands railways. Important for this pilot as well as its follow-up.

RESULT

The only hydrogen train eligible for the pilot is the Coradia iLint, a zero-emission pre-series developed by the Alstom firm. Since September 2018, this train has run a regular service in Germany and has been tested there by the Notified Body (NoBo), Designated Body (inspection body for Dutch requirements), and Assessment Body (independent assessment body for safety in the railway system), and it has an operating permit.

DEKRA Rail, which has been appointed by the Province of Groningen as the Assessment Body (independent assessment body for safety in the railway system) and Designated Body (inspection body for Dutch requirements) has sent the assessment plan, with reference DR/19/170471/003, to the project group on 14 May 2019. This assessment plan was a plan for admission, subject to the restriction that, without an Automated Train Security System, obtaining a temporary testing permit would be the maximum feasible outcome. The Province of Groningen has chosen this option of testing without an integrated Automated Train Security System because the other options involved such high extra costs and long lead times that they were disproportionate to the objectives of the pilot. With the option of testing without an integrated Automated Train Security, it would still be perfectly possible to achieve the objectives of the pilot.

The next step was the drafting of a file. On the basis of this file and the answers to the questions, IL&T sent a positive decision on 10 February regarding a dispensation pursuant to Article 26q, sixth paragraph of the Railways Act for the implementation of demonstration runs with the Coradia iLint 54 (the hydrogen train).

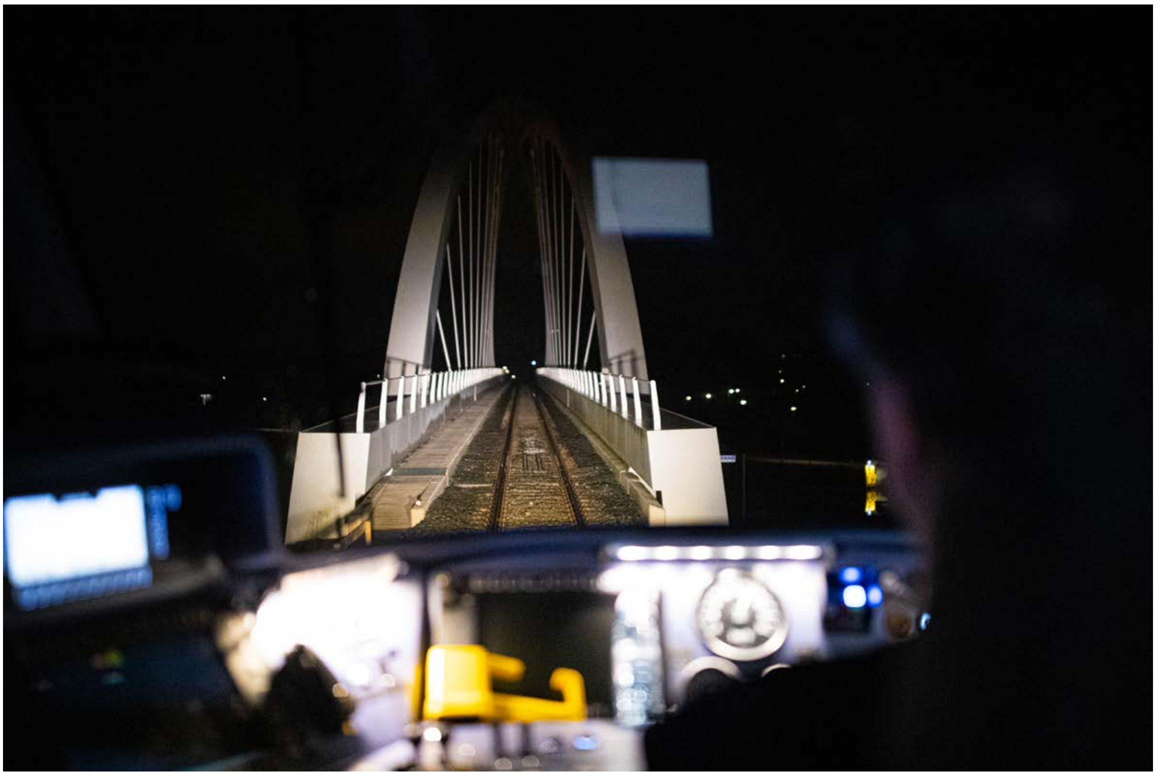
CONCLUSION

By obtaining the dispensation on 10 February 2020 pursuant to Article 26q, sixth paragraph, of the Railways Act, this objective has been achieved.

THE TRIAL RUNS

OBJECTIVE

For several nights (over a period of two weeks), tests of the running characteristics of the Alstom hydrogen train on the railway line between Groningen and Leeuwarden were done. The tests took place without passengers. Both the local- and the intercity train services were tested multiple times. Together with the information already gathered in Germany, and also based on simulations, it gave a good idea of the possibilities with regard to all railway lines in the Northern Netherlands.



Testplan

date at 0.00 h	Test	kms	Test	result ok/nok	Remarks
do 27-feb	iLint arrival, full tank, sensors mounted			OK	
	test towing		Coupling GTW-iLint	OK 27/02/20	
za 29-feb	detection and inclination max 40km/h inclination max speed?	110	Detection	OK	
			Inclination	OK	
zo 1-mrt	inclination max track speed Test IC / reg	201	inclination max speed	OK	
			timetable sneltrein Lw-Vvl	OK	timetable start time changed, due to TVP
			timetable sneltrein Vvl - Lw	OK	
			timetable stoptrein Lw-Vvl	OK	
			timetable stoptrein Vvl - Lw	OK	
ma 2-mrt	timetables	219	inclination max speed	OK	
			timetable sneltrein Lw-Gn	OK	
			timetable sneltrein Gn - Lw	OK	
			timetable stoptrein Lw-Gn	OK	
			timetable stoptrein Gn - Lw	OK	
di 3-mrt	timetables	220	timetable sneltrein Lw-Gn	OK	
			timetable sneltrein Gn - Lw	OK	
			timetable stoptrein Lw-Gn	OK	
			timetable stoptrein Gn - Lw	OK	
Wo 4-mrt	timetables	220	timetable sneltrein Lw-Gn	OK	delay due to delay 37698
			timetable sneltrein Gn - Lw	OK	
			timetable stoptrein Lw-Gn	OK	
			timetable stoptrein Gn - Lw	OK	
do 5-mrt	timetables	113	timetable sneltrein Lw-Gn	OK	successful over 41 km
			timetable sneltrein Gn - Lw		Could not Run BD Gn + Lw
			timetable stoptrein Lw-Gn		Could not Run BD Gn + Lw
			timetable stoptrein Gn - Lw		Could not Run BD Gn + Lw
za 7-mrt	timetables	56	timetable sneltrein Lw-Gn	OK	
	day for press and public				
zo 8-mrt	timetables	54	timetable sneltrein Gn - Lw	OK	Run to GRS (sts s346)
ma 9-mrt	no testing -> maintenance	0	X	x	
di 10-mrt	no testing -> maintenance	0	X	x	
wo 11-mrt	timetables	110	timetable sneltrein Lw-Gn	OK	
			timetable sneltrein Gn - Lw	OK	
	total kms	**1303**			
wo 11-mrt	towing to Germany	X	X	x	X

iLint arrival at track 75, photo by Henk Zwoferink

GTW-iLint ready for towing

In the project group, sub-objective 4, i.e. the feasibility of current timetables, has been described more explicitly in terms of the feasibility of achieving 5 successful intercity-train runs and 5 local train runs between Groningen and Leeuwarden. That is a total of 20 runs.

RESULT

The test program has been expanded in order to achieve the test objectives, The following sub-objectives have been tested:

1. Towing-test FTW DMU – Cradia iLint
2. Correct detection (28/29 February 2020)
3. Vehicle stability in relation to rail-installation inclination (risk of derailment)
4. Feasibility of current timetables
5. Ambient noise in a comparative measurement study GTW DMU – Coradia iLint

Results of towing-test, correct detection, and vehicle stability

On arrival from Germany at the Leeuwarden railway station, a towing-test was carried out straight away. The coupling procedure with an Arriva GTW train went well (see figure 2), by which it was demonstrated that, if necessary, these trains can tow away the hydrogen train. Next, during the first test night (28 to 29 February), a test was carried out at a low speed of no more than 40 km/hr to see if the hydrogen train is always detected properly and that all barriers at railway crossings are closed. Tests were also done to measure what the vehicle stability is at, for example, railway points (switches).

Conclusion of towing-test, correct detection, and vehicle stability (sub-objectives 1 through 3)

The towing-test and the first night of testing for detection and vehicle stability were successful and everything was approved for the actual test runs to start.

Simulation results

The results of the simulation test by Alstom demonstrated that the iLint is able to run according to the timetable with regard to departure- and arrival punctuality at, respectively, the initial station and the terminal station.

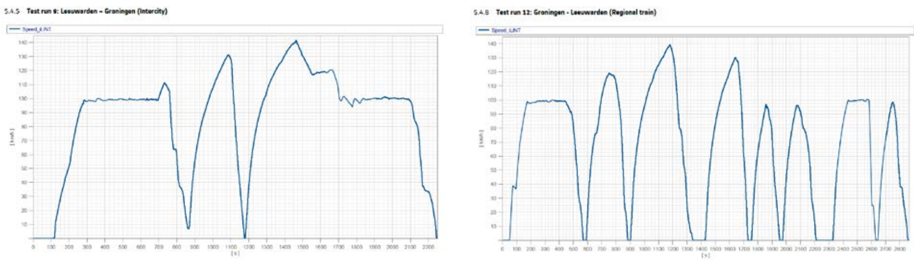
Railway section Groningen-Leeuwarden

To	requirement (= time table) [s]	driving time all-out [s]	difference to requirement [s]	driving time energy saving [s]
Zuidhorn	540	524	16	540
Grijpskerk	300	279	21	300
Buitenpost	480	391	89	480
De Westereen	300	300	0	300
Feanwâlden	240	176	64	240
Hurdegaryp	240	205	35	240
Lw Cammingh.	240	297	-57	300
Leeuwarden	300	190	110	240
Total (running time)	**2640**	**2362**	**278**	**2640**

Railway section Leeuwarden-Groningen

To	requirement (= time table) [s]	driving time all-out [s]	difference to requirement [s]	driving time energy saving [s]
Lw Cammingh.	180	216	-36	220
Hurdegaryp	360	270	90	320
Feanwâlden	240	231	9	240
De Westereen	180	176	4	180
Buitenpost	360	300	60	360
Grijpskerk	420	391	29	420
Zuidhorn	360	290	70	360
Groningen	540	517	23	540
Total (running time)	**2640**	**2391**	**249**	**2640**

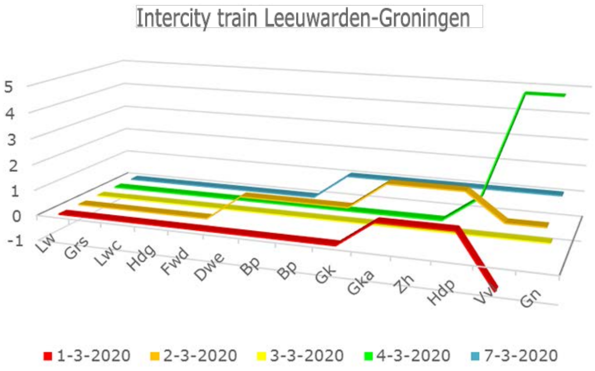
Based on the measurements of vehicle stability, the speeds that were reached over time on the whole railway section were plotted in the diagram. From this it appears that, on the most challenging stretch, the iLint is capable of reaching a speed on the GPS of 140 km/hr.



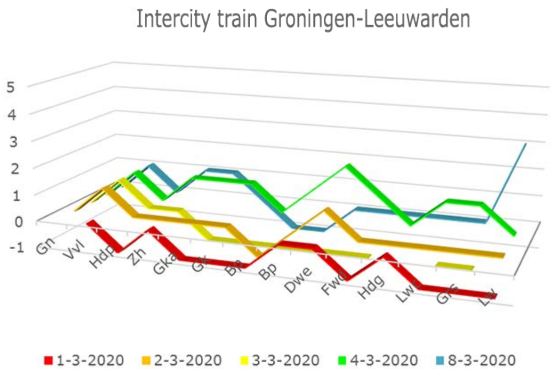
example from the supplement of "test report of running dynamics"

Results of actual runs

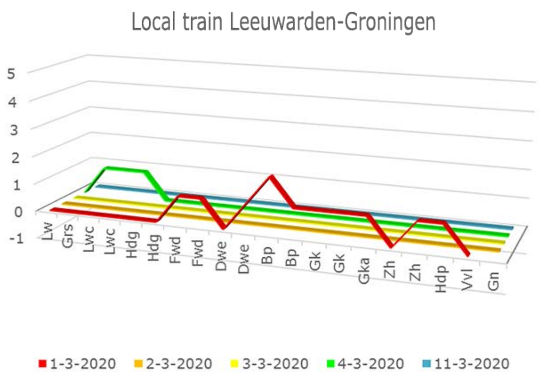
Based on the details obtained by ProRail, the deviation of the hydrogen train vis à vis the planned timetables has been plotted in the following four diagrams. The horizontal axis shows the train-stops from left to right, and the vertical axis shows the deviation in minutes (late or early arrivals) vis à vis the timetable.



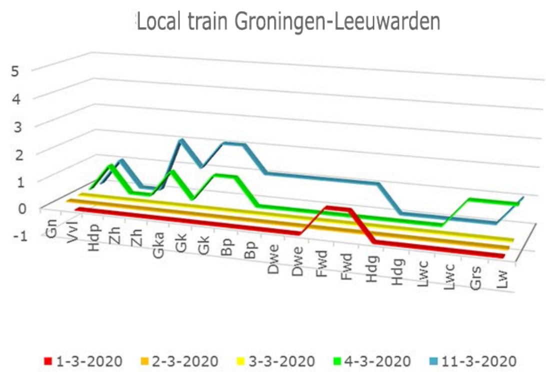
Regarding the intercity train Leeuwarden-Groningen, the delay was limited to +2 minutes, with the exception of a peak of +5 minutes at Vierverlaten and Groningen on 4 March 2020 due to the fact that the intercity train had to wait for the departure of the delayed train 37698 at Groningen.



Also regarding the intercity train Groningen-Leeuwarden, the delay was limited to +2 minutes, with the exception of a peak of +3 minutes at Leeuwarden on 8 March 2020 due to an error in the timetable (signal 164, before arrival at Leeuwarden, had turned red).

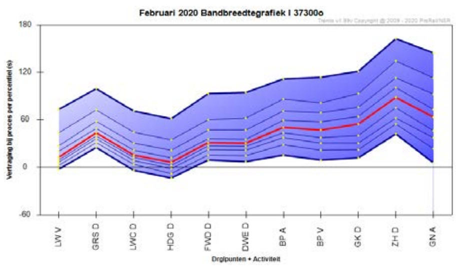


Regarding the local train Leeuwarden-Groningen, the maximum deviation was +2 minutes at Buitenpost.

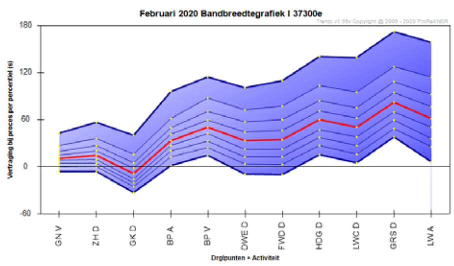


Regarding the local train Groningen-Leeuwarden, the delay was limited to no more than +2 minutes.

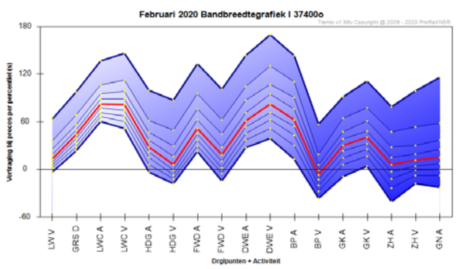
For comparison purposes, four bandwidth graphs have been depicted below (from the 10th to the 90th percentile (the red line is the 50th percentile)) of the current diesel trains (February 2020). The horizontal axis shows the train-stops from left to right, and the vertical axis shows the deviation in seconds (late or early arrivals) vis à vis the timetable.



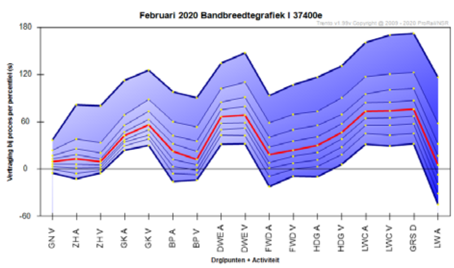
Bandwidth graph of the intercity train Leeuwarden-Groningen



Bandwidth graph of the local train Groningen-Leeuwarden



Bandwidth graph of the intercity train Leeuwarden-Groningen



Bandwidth graph of the local train Groningen-Leeuwarden

Based on the data, the ProRail Presentation Analysis Bureau made the following comments about the differences:

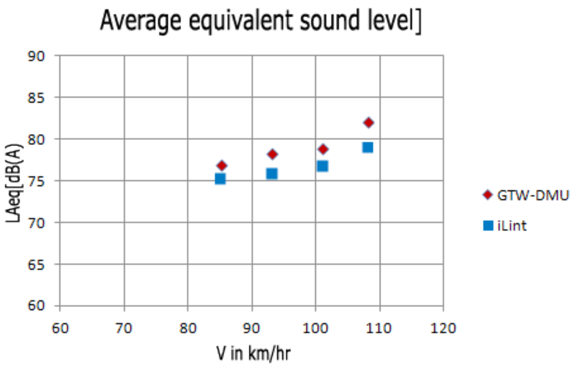
- The extra leeway during daytime is necessary for crossing in Feanwâlden and Zuidhorn, which was not permitted during the test runs. The timetable used by the test train is tighter than the timetable used by the GTW.
- In the direction from Groningen to Leeuwarden, the trial runs had to veer off near Vierverlaten while passing through the railways points (switches), i.e. at 60 km/hr instead of the typical 100 km/hr.

Conclusion regarding operational behavior (sub-objective 4)

Based on their data, the Performance Analysis Bureau concludes: the hydrogen train is capable of operating according to the planned timetable of the GTW. This means that sub-objective 4 has been met. The project team agrees with this conclusion.

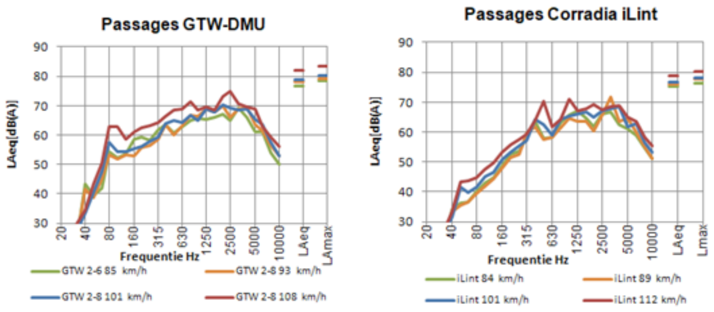
Sound

In the evening and during the night of 4 to 5 March 2020, DEKRA Rail did passage measurements near kilometer marker 66.7 to establish objectively the variation of ambient sound. The description of the measurement and the results were laid down in the report “sound measurement comparison of GTW-DMU versus Coradia iLint prototype” with reference DR/20/190550/005, version 1.0, dated 18 March 2020.



In terms of the overall dB(A) sound level, it appears that iLint is approx. 2 to 3 dB(A) quieter within the speed range (velocity range) between 80 and 110 km/hr than the GWT-DMU. In this regard, it should be noted that the results are based on a limited number of train passages.

As a sound reduction of 2 to 3 dB(A) generally does not mean much, some explanatory remarks will be made here. A difference of 2 to 3 dB(A) is just perceptible by the human ear. A reduction by 3 dB(A) means a halving of the sound intensity. Pursuant to our laws, sound levels at particular locations are expressed in long-term average assessment levels and measured in dB(A).



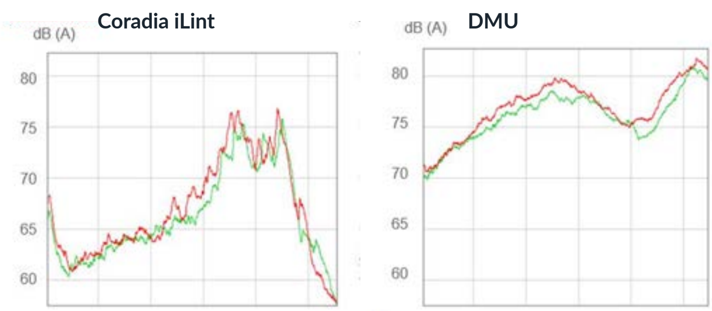
average frequency spectra

Alstom had its own sound measurement done by an ISO-17025 accredited measurements institute. In this, the Coradia iLint was compared with the latest version of the Coradia iLint 54 (i.e. the diesel-engine-operated version DMU, built after 2012). This measurement was done in the context of the TSI NOISE 2014/1304/EU at a distance of i.a. 7.5 meters.

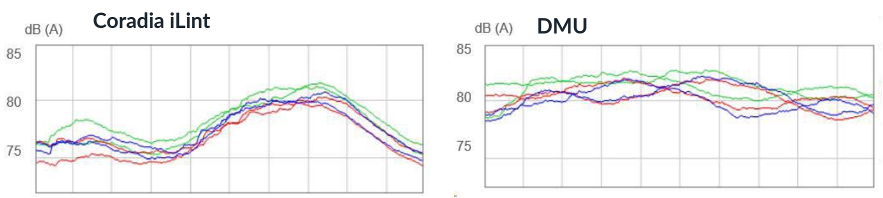
This measurement produced the following results.

1. Sound emissions when the train was at a standstill and ready-to-start (running stationary):
   - Coradia iLint: 52 dB(A)
   - DMU: 68 dB(A)

2. Sound emissions during acceleration from standstill to 30 km/hr:



3. Sound emissions of the train passing by at 140 km/hr (maximum speed):



Conclusion regarding sound (sub-objective 5)

The Coradia iLint pre-series trains comply with the requirements of TSI Noise (EU 1304/2014) for diesel-multiple units (DMU) and electrical multiple units (EMU). The applicable certificate of a Notified Body (NoBo) is available. In addition, the Coradia iLint results in a considerable reduction of sound emissions in comparison with similar diesel trains (DMU):

- by 16 dB(A) at standstill
- during acceleration from 0 to 30 km/hr, there is a peak reduction by 5 dB(A) and also a reduction of the duration of the peak.
- at a maximum speed of 140 km/hr, there is a peak reduction by approx.. 2 dB(A) and also a reduction of the duration of the peak.

In summary, the Coradia iLint pre-series results in a considerable reduction of sound emissions at standstill, during acceleration, and at maximum speed. Moreover, Alstom has evaluated some other ways of further reducing sound emissions for future generation of Coradia iLint trains in specific situations by 2 to 3 dB(A). These improvements will be implemented in the next two Coradia iLint series projects in Germany.

CONCLUSION

Based on the results from the five sub-objectives, the overall conclusion is that the objective for the trial runs has been achieved successfully.

THE REFUELING PROCESS

OBJECTIVE

Testing the refueling process with green hydrogen, both in practice and with a simulation model. For this purpose, the refueling process is simulated on the basis of information obtained from Germany (to get a good idea of the refueling process during regular services), and a temporary tank installation is placed in Leeuwarden. With the results of these tests, it should be possible to make some observations about the impact of this process on the timetable. A secondary objective is also to test the degree of hydrogen consumption during the trial runs.

RESULT

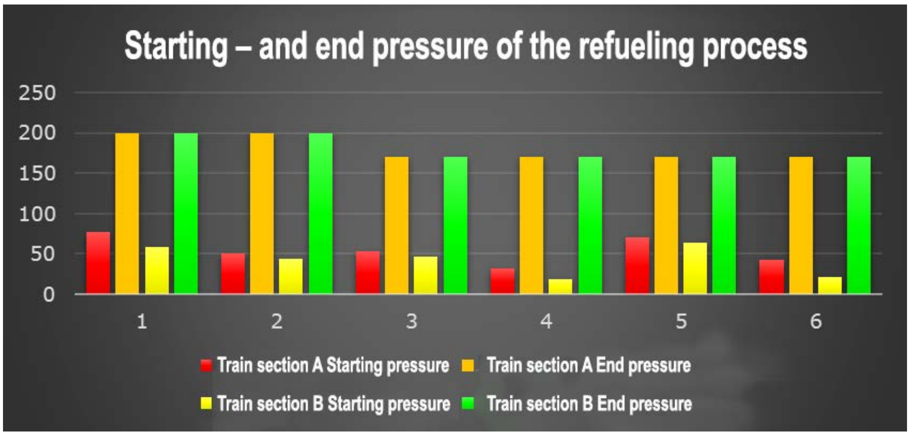
For the purpose of the test, green (sustainable) hydrogen was locally produced in the province of Groningen via electrolysis by using renewable electrical energy (Dutch Guarantee of Origin). This was the first time ever that a hydrogen train has been fueled by renewable hydrogen, thereby implementing a zero-emission solution from source to end-consumption.

ENGIE refueled the Coradia iLint 6 times. Refueling took place during the morning hours between 09:00 and 13:00 hours, after the nightly trial runs.

Refueling the iLint with hydrogen was done according to plan in good collaboration with Alstom and ENGIE. In practice, the lead time of refueling appeared to be considerably less than had been predicted on the basis of previously calculated simulations. In this regard, it should be noted that, after the refueling had been completed, a waiting time of 30 minutes was observed – in accordance with procedure - due to the equalization of pressure in the hydrogen cylinders of the Coradia iLint. After this waiting time, the pressure had lowered by values of up to approx. 8 Bar, and a short top-up action was required. This action was not been logged separately.

The details are derived from the transfer sheets filled out by Alstom and sent to ENGIE. The pressure- and temperature-values are based on readings from the Coradia iLint train.

Date	Train section	Time START	Time READY	Pressure START [Bar]	Pressure READY [Bar]	Temp. START [°C]	Temp. READY [°C]
1 Mar.	A	9:10	9:25	77	200	4	-2
	B	9:30	9:53	59	200	4	6
2 Mar.	A	11:43	12:00	50	200	2	5
	B	11:25	11:41	44	200	2	5
3 Mar.	A	11:13	11:34	53	170	1	4
	B	10:53	11:10	47	170	0	1
4 Mar.	A	9:50	10:24	32	170	4	8
	B	10:25	11:02	19	170	4	16
6 Mar.	A	9:45	10:05	70	170	5	0
	B	10:00	10:40	64	170	6	0
9 Mar.	A	9:40	10:00	42	170	7	5
	B	10:05	10:40	22	170	8	5



The measurement in the train of H2 consumption was re-set at each test-night before the train's first departure from Leeuwarden (i.e. at the starting point of the timetable at the station). H2 consumption was measured all night, and the details were saved into the file at the time the train arrived in the stabling area.

Based on these details, Alstom has summarized the results as follows:

a) Over time, average consumption is fairly constant at 0.20 / 0.21 kg H2/km.

b) Consumption during the intercity-train service (first run of the night) is always slightly lower than consumption during the local-train service (second run of the night). There are two reasons for this result:
   - The local-train service has more stops. Even if the battery recuperates when the brakes are used, there are losses throughout the system when a lot of braking and subsequent acceleration occurs. The effects of this on consumption are not so great, according to Alstom.
   - The operating time of local trains is longer, which leads to longer use of the onboard electricity network (such as air-conditioning, heating, and lighting). The operating time of the equipment connected to the onboard power supply does not depend on distance, so specific consumption per km increases. The effect of this longer travelling time has the greatest impact on the difference in consumption.

c) In the night of 4 to 5 March, there was only one trial run, with a long waiting time at Vierverlaten. The relation between time and traveling distance was worse as a result of this. Due to the longer waiting time in relation to the short traveling distance, the specific consumption per km increased (0.24 kg H2/km). This night is not representative of consumption in a normal operational situation.

d) The first night, during which the train did not run to Groningen, but to Hoogkerk Vierverlaten, shows the same average as the other nights and can therefore be considered in its entirety.

e) The transfer-night from and to Groningen for the presentation day has the same average as the other intercity-train service and can therefore be considered together as a complete intercity run.

f) The last night, with only one local-train service, shows the same average as the other local-train service.

g) During the intercity-train service, there is always a slight discharge of the batteries. This means that the fuel cells were not able to supply sufficient power in their stand-alone mode during the time of power consumption. That is why the train is fitted with backup batteries.

h) During the connecting local train service, the batteries were always fully recharged again.

i) The combination of g) and h) means:
   - The train is able to run for an entire day, alternating between intercity- and local train services.
   - For the pre-series trains, there is a maximum of 2 consecutive intercity services without break (afterwards a break of approx.. 20 minutes per intercity service is required to recharge the battery). However, the fuel cell in the series-train production has been designed for higher continuous performance and is therefore capable of operating in the intercity-train service throughout the day.

CONCLUSION

Refueling the iLint with hydrogen can be done safely on the basis of ENGIE's plan. No safety incidents occurred, and there were no unsafe situations for the environment.

The test of the refueling process shows that filling the tanks of the iLint train by means of a mobile tank installation is possible on the basis of the pressure difference between the hydrogen trailer and the train, without the use of a compressor. The train was partially refueled up to a filling pressure of 170 Bar instead of the maximum pressure of 350 Bar. This was sufficient for testing purposes.

During the test, the train ran approx.. 225 km a night. After refueling the train up to 170 Bar, the daily residual pressure after the test remained well over 10 Bar, which had been defined as the lower limit.

With more preparation time, different equipment could have been used, enabling a higher filling pressure and probably a shorter filling time. In addition, Alstom notes that the refueling process in Bremervörde currently takes place with a so-called Transportable Hydrogen Refilling Station (THRS). In the future, the Coradi iLint series trains, which are currently manufactured for two clients in Germany, with the new filling station and depending on the temperature, will be refueled in approximately 15 minutes, after which they will be able to run for another 1,000km.

PRESS- AND PUBLIC INFORMATION DAY

OBJECTIVE

Organizing at least one and at most two press- and public information days during the test period at Groningen CS. These days will be a way to realize the objective of giving publicity to this zero-emission solution.

RESULT

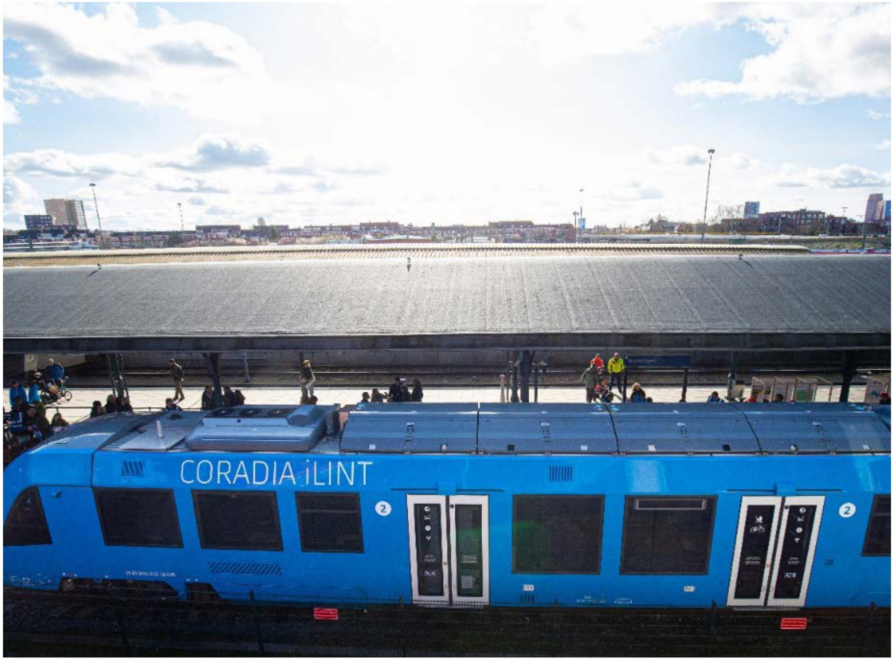
On Saturday, 7 March, a press- and public information day took place on platform 1a of Groningen Central Station (CS). During the preparation period, this date was chosen because it fitted in best with the panning of the trial runs. Moreover, it is also easier for the public to drop by on a Saturday afternoon than on a weekday.

For the day itself, a program was made, beginning with a press moment from 11:00 to 12:00 hours. On platform 1a, amid great press interest, Minister Van Veldhoven and the directors and administrators of the parties concerned were interviewed by the Province's spokesperson. The directors/administrators were then given a guided tour through the train by Alstom. After that, there was plenty of opportunity for one-on-one interviews, which were well attended by the press.

After the press moment, from 12:00 to 16:00 hours, the public had ample opportunity to see the train inside out, and take pictures. This opportunity was eagerly seized upon. People visited the train all afternoon.

CONCLUSION

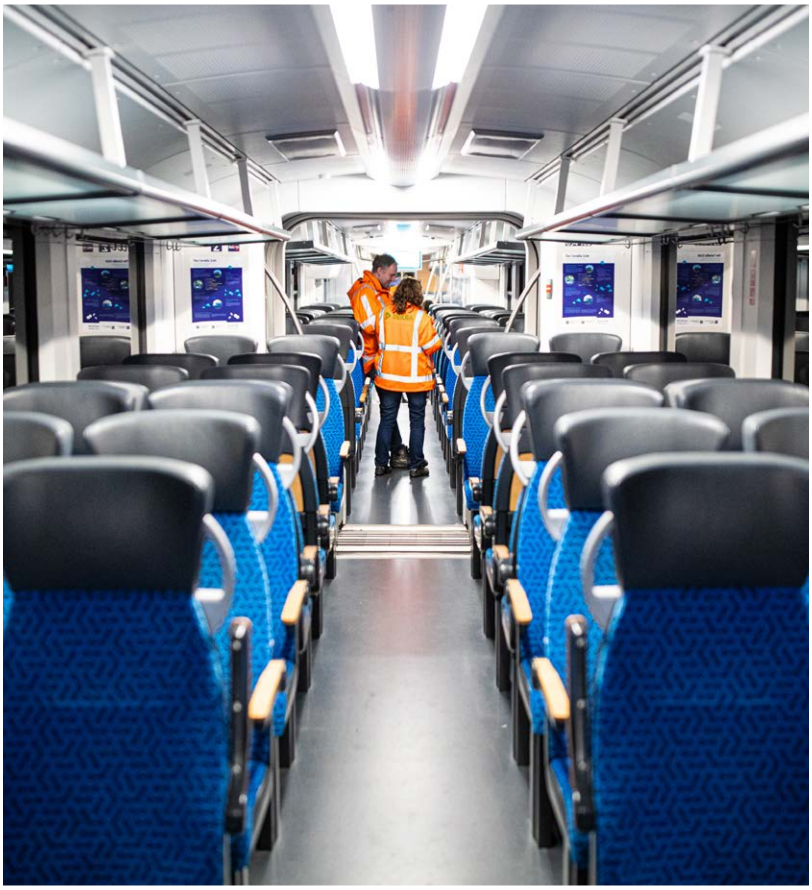
By organizing the press- and public information day on 7 March, the fourth objective of the test with the hydrogen train has been achieved successfully.



OVERALL CONCLUSION

In the context of the sustainability objectives of the Province of Groningen, a feasibility study was started to explore whether a hydrogen train can be a full-fledged sustainable alternative to the current diesel trains.

These objectives have all been achieved and the overall conclusion is that the hydrogen train can be a full-fledged alternative to diesel trains.

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