Interreg Baltic Sea Region Programme project

"BSR Hydrogen Air Transport – Preparation of Baltic Sea Region Airports for Green Hydrogen" ("BSR HyAirport")

Group of Activities 2.3

Report by project partner 4

RIX Riga Airport

Report on hydrogen powered baggage tractor MULAG Comet 4FC testing at RIX Riga Airport on March 2025

Version 1.5 (07.08.2025)

2025

Contents

Introduction

This Test Report provides an account of the testing process for the hydrogen powered baggage towing tractor MULAG Comet 4FC. The purpose of this report is to verify the successful cold start after cold nights and reliability of the equipment (full functionality) during test drives, fulfilling normal ground support equipment work.

Device Information

Field	Value
Device Name:	Hydrogen powered baggage tractor (Ground support equipment for airports)
Manufacturer:	MULAG Fahrzeugwerk Heinz Wössner GmbH u. Co. KG Gewerbestraße 8 77728 Oppenau Germany
Model:	MULAG Comet 4FC

General testing data

Preparatory phase for testing: 22.02.2025.-17.03.2025.

Preparatory phase description: Arranging the deliver, dealing with administrative questions, including harmonisation and signing of user contract between producer (MULAG Fahrzeugwerk Heinz Wössner GmbH u. Co. KG) and the testing organisation (SJSC “Riga International Airport”).

Test Date: 18.03.2025.-31.03.2025.

Location: Latvia, Mārupe municipality, RIX Riga Airport airside and engineering-technical zone

Test Conducted by: SJSC “Riga International Airport” (RIX Riga Airport)

Involved personnel:

- Pāvels Ždanovs - project testing supervisor - GH head of technical unit
- Helmuts Masaļskis - project testing controller – GH ground service equipment supervisor

- Jānis Čibulis - equipment testing operator
- Artūrs Leitāns - equipment testing operator
- Sergejs Šemonajevs - equipment testing operator
- Jānis Titavs - equipment testing operator
- Kārlis Jānis Babulis - equipment testing operator
- Mārtiņš Grels - project coordinator, ensuring refuelling

Testing supported by:

MULAG Fahrzeugwerk Heinz Wössner GmbH u. Co. KG which provided MULAG Comet 4FC vehicle for testing.

Latvian Hydrogen Association which provided consultations and support in transporting the equipment from Germany to Latvia and back to Germany.

GLOBE Fuel Cell Systems GmbH which trained RIX Riga Airport staff.

The refuelling service provided by:

SIA "HySol" according to procurement contract No. D-25-50.

Objective

The hydrogen powered baggage tractor was tested for "cold start" (after cold temperatures at night) and then continued in all operating modes necessary for full-fledged cargo, mail and baggage handling in the conditions of RIX Riga Airport. The equipment was operated in low temperatures without any significant technical problems.

After testing the equipment functionality was compared to similar electric powered baggage towing tractor.

Testing Conditions

Ambient Temperature:

Test day	Temp. range C
19.03.2025 08:30 – 16:00	3.3 - 10.6
21.03.2025 09:00 – 22:00	3.8 - 1.8
24.03.2025 07:30 – 20:30	3.5 - 4.7
25.03.2025 11:00 – 23:00	8.5 - 6.1
26.03.2025 09:00 – 00:00	5 .7 - 3.7
27.03.2025 08:00 –21:00	3.5 - 7.2

28.03.2025 11:00 – 23:00	7.5 - 7.3
29.03.2025 09:00 –21:00	8.7 - 11.2
31.03.2025 11:0 –17:00	10.5 - 10.4

Weather Conditions:

Test day	Rainfall max (mm)
19.03.2025 08:30 – 16:00	0.00
21.03.2025 09:00 – 22:00	0.00
24.03.2025 07:30 – 20:30	0.00
25.03.2025 11:00 – 23:00	1.70
26.03.2025 09:00 – 00:00	0.10
27.03.2025 08:00 –21:00	0.00
28.03.2025 11:00 – 23:00	0.00
29.03.2025 09:00 –21:00	0.00
31.03.2025 11:0 –17:00	0.00

Data source: Latvijas vides, ģeoloģijas un meteoroloģijas centrs, VSIA

Ambient humidity[1]:

	RH%
Ambient Humidtity Max [RH%]	79.6
Ambient Humidtity Min [RH%]	15.8

Test Parameters

Cold Start Performance

- Good, no deviations

Tractor startup after prolonged exposure to cold temperatures

- Without technical issues

Time taken to start the engine.

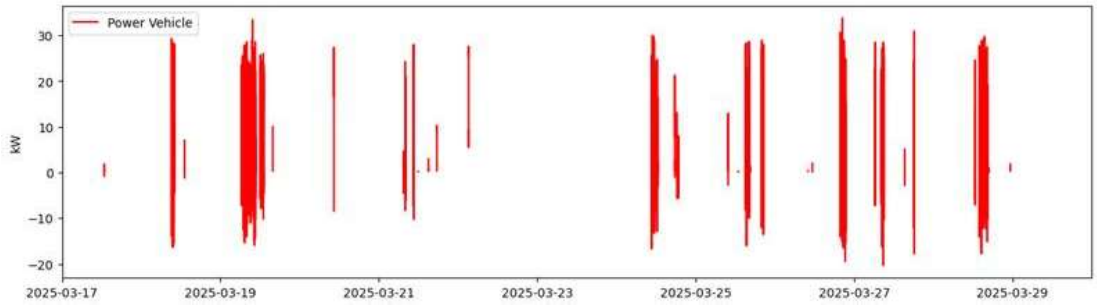
- Less than 30 s

Any operational issues observed

- No issues

[1] Source: GLOBE Fuel Cell Systems GmbH, 2025

Power (KW) measurements during testing are shown in this graph[2]:



Total hydrogen consumption during the testing period due to time and refuelling limits was 7.507 kg of hydrogen[3].

Motor hours during tests - 17 h.

Average hydrogen consumption rate (kg per motor hour): 0,44 kg/h.

Operational Performance description

General tractor functionality

The tractor performed like electric powered baggage tractor. The overall functionality of the tractor was found to be satisfactory, with no significant complaints.

Considering the technical design of the tractor, it was concluded that the equipment is not suitable for cargo transportation in the conditions of RIX Riga Airport, since too much hydrogen is consumed when transporting a large amount of cargo over long distances.

Due to the characteristics of the Airport infrastructure and safety aspects, it was problematic to refuel the tractor with hydrogen (the tank was never full of hydrogen), besides the tractor fuel tank has only 1,8 kg capacity, which made the test process difficult. However, MULAG Fahrzeugwerk Heinz Wössner GmbH u. Co. KG planned an increase in hydrogen tank capacity to increase the range.

Motor Hours during testing[4]

17 motor hours during tests

Initial motor hours: 651

Final motor hours: 668

[2] Source: GLOBE Fuel Cell Systems GmbH, 2025
[3] Source: GLOBE Fuel Cell Systems GmbH, 2025
[4] Source: GLOBE Fuel Cell Systems GmbH, 2025

Observations & Findings

The drivers testing the vehicle observed no challenges switching from conventional/electric baggage tractors to this hydrogen powered baggage tractor.

The test tractor is not suitable for transporting cargo in the conditions that full tank refuelling was not possible in Riga Airport. In this case, it consumes a relatively large proportion of the tank and requires several refuelling due to refuelling station remote location from terminal and active aircraft stands.

The refuelling option was with hydrogen flow regulating panel (by SIA "HySol") and had no compressor which is why the pressure in the tanks did not allow the refuelling to full tank (100%) capacity (see table 1). So, there was need for frequent refuelling.

Table 1. Data characterising the testing of Mulag Comet 4FC:

Date	Motor hours before	H2 level	Battery level %	Motor hours after	Motor hour difference	H2 Level after	H2 level difference	Battery level % after	Time from/to	Average volume transported (kg)
19.03.2025	651	53%	84%	653	2	1%	52%	48%	8:30-15:26	7346
21.03.2025	653	26%	87%	654	1	7%	19%	84%	09:00-12:30	1025
21.03.2025	654	41%	88%	655	1	7%	34%	85%	14:30-21:50	1330
24.03.2025	655	48%	83%	656	1	7%	41%	85%	7:30-12:15	2820
24.03.2025	656	44%	85%	656	0	15%	29%	83%	12:30-16:00	3775
24.03.2025	656	41%	83%	657	1	8%	33%	83%	16:20-20:30	4012
25.03.2025	657	43%	82%	658	1	32%	11%	81%	11:40-13:00	-
25.03.2025	658	52%	83%	658	0	48%	4%	87%	13:30-14:42	-
25.03.2025	658	47%	88%	659	1	24%	23%	82%	16:00-22:38	680
26.03.2025	659	53%	83%	659	0	47%	6%	84%	9:20-10:35	-
26.03.2025	659	45%	85%	660	1	9%	36%	85%	12:30-16:50	662
26.03.2025	660	53%	87%	661	1	22%	31%	84%	20:00-23:30	554
27.03.2025	661	50%	87%	661	0	32%	18%	81%	8:00-12:10	2825
27.03.2025	661	50%	81%	662	1	27%	23%	85%	12:30-16:30	2567
27.03.2025	662	47%	84%	663	1	15%	32%	83%	16:50-20:30	3155
28.03.2025	663	44%	83%	664	1	20%	24%	85%	11:00-18:00	1814
28.03.2025	664	42%	84%	665	1	37%	5%	85%	18:15-18:40	206
28.03.2025	665	37%	85%	665	0	22%	15%	87%	21:20-23:00	1460
29.03.2025	665	41%	87%	666	1	12%	29%	82%	9:20-21:00	5664
31.03.2025	667	38%	87%	668	1	11%	27%	82%	11:00-17:00	4193

Average working time between refuelling was 4.1 h (average 1 motor hour)

Weight transported varied: it was from 206 kg to 7346 kg on average.

While testing one time hydrogen tank was empty and the integrated (electric) battery charge was lower than 50%, the emergency shutdown has worked. Then emergency mode was initiated, and driver was able to drive the tractor to refuelling station.

When drivers got used to using the equipment they observed to have less consumption of hydrogen than in the beginning.

As the refuelling was provided by contracted experts (SIA "HySol") without constant pass, the refuelling was without any technical issues, but was frequent and required additional time consumption from RIX Riga Airport staff.

Comparing the tested equipment with an equivalent electric tractor (see table 2), it was concluded that the electric tractor currently has higher performance (longer time without refuelling/recharging) under the same conditions. All the GSE models would use environmentally friendly power (green hydrogen, electricity, biodiesel), and the CO2 emissions would be 0.

Table 2. The summary of capital costs and operational costs:

GSE model	**Cost for procurement (estimates)**	**Costs for repairs per year**	**Expected average service life (years)**	**Refuelling/ charging costs[5]**	**Total costs per year on average**
Mulag Comet 4FC (hydrogen driven)	160-199 T EUR	1800€/a at 1500h/a (estimates)	ca. 13 Years	3600,00 EUR / year[6]	16388 EUR / year
Mulag Comet 4E (electric)	ca. 70-90 T EUR (depending on the battery)	Ca. 1800€/a at 1500h/a	ca. 13 Years	322,67 EUR / year[7]	6187 EUR / year
Mulag Comet 4D (biodiesel driven)	ca. 85 T EUR	Ca. 3000€/a at 1500h/a	15 Years	2560,56EUR / year[8]	9027 EUR / year

Conclusion & Recommendations

Conclusion from comparing Mulag Comet 4FC and Charlatte T135 EVO is that electric Charlatte baggage tractor can work longer time.

Table 3. Data characterising the electric tractor alternative (please see Table 1 for Mulag Comet 4FC data):

[5] Average baggage tractor motor hours per year estimated amount is 400 (source: RIX Riga Airport, 2025)
[6] Assuming that the price for green H2 is 15 EUR/kg and 4,99 EUR costs one motor/hour
[7] Assuming current electricity price and 0,8079 EUR costs one motor/hour
[8] Assuming that the price for biodiesel commercially is 2,27 EUR/l and 6,40 EUR costs one motor/hour (Source for biodiesel price - Neste, 15.05.2025. https://www.neste.lv/lv/content/neste-my)

Date	Motor hours before	Battery level %	Motor hours after	Motor hour difference	Battery level after %	Time from/to	Average volume transported (kg)
24.04.2025	4308	100%	4311	3	45%	10:45-23:20	10825
29.04.2025	7822	49%	7823	1	25%	15:25-19:39	2235

By making average calculations and collecting data, it can be concluded that the tractor has proven itself well-functioning for certain airport operations.

To use this type of tractor improvements and additions to procedures and infrastructure are necessary at Riga Airport. The hydrogen tank capacity within the tractor should be increased or refuelling place selected closer to operations and refuelling provided by contracted experts or RIX Riga Airport specialised workers with constant pass to reduce the time when the tractor is not working.

Still for use of hydrogen for baggage towing, the price for hydrogen powered baggage tractors and the green hydrogen for refuelling should be lower. Optimal price for the baggage tractor competitiveness would be around 100 000 EUR and optimal price for about 6 EUR/kg[9], then the price for yearly costs could be below 10 000 EUR. However, there are external factors that influence these prices, including market readiness and demand, both factors currently at low levels.

Recommendations for future testing of hydrogen powered vehicles at Riga Airport:

In future hydrogen refuelling solution should be equipped with compressor or refuelling tanks with greater pressure (e.g. 450 or 500 bar tanks) to allow more efficient refuelling.

A more optimal location for the hydrogen refuelling point should be sought to shorten the time when the equipment cannot perform its primary function.

To get more valuable insights, tests for longer period and in more extreme weather conditions (snow, icy roads etc.) are necessary.

Testing during lower and higher temperatures (for longer periods) could show possible changes in performance.

Report prepared by:

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Ground Handling department

Head of Technical unit

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[9] In 2030 green hydrogen price at-the-pump could be 6,3 EUR/kg in Poland, according to Hussein Basma, Yuanrong Zhou, and Felipe Rodríguez, 2022. Fuel-Cell Hydrogen Long-Haul Trucks In Europe: A Total Cost Of Ownership Analysis, International Council on Clean Transportation https://theicct.org/wp-content/uploads/2022/09/eu-hvs-fuels-evs-fuel-cell-hdvs-europe-sep22.pdf