HORIZON EUROPE PROGRAMME

TOPIC HORIZON-CL5-2022-D5-01-08

Clean and competitive solutions for all transport modes

GA No. 101084046

Zero Emission flexible vehicle platform with modular powertrains serving the long-haul Freight Eco System

ZEFES - Deliverable report

Deliverable D5.5 – Commissioning, testing and verification connectivity between BEV demonstrators and digital twin tool

Funded by the European Union

Deliverable No.	ZEFES D5.5	
Related WP	WP5	
Deliverable Title	Commissioning, testing and verification connectivity between BEV demonstrators and digital twin tool	
Deliverable Date	2025-11-28	
Deliverable Type	REPORT	
Dissemination level	Public (PU)	
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Status	Final	2025-11-21

Document History

Version	Date	Editing done by	Remarks
V1.0	30/09/2025	All 3 authors above	First draft for review
V1.1	17/11/2025	All 3 authors above	Updated deliverable for WPL
V2.0	20/11/2025	H. Wittig (FHG)	Final draft for coordinator
V2.0	21/11/2025	H. Wittig (FHG)	No changes Dates of approval and status updated

Publishable summary

Deliverable D5.5 is part of ZEFES Work Package 5, which focuses on developing modular and flexible battery-electric powertrains for long-haul heavy-duty vehicle combinations. This deliverable addresses the commissioning and testing of connectivity between Battery Electric Vehicle (BEV) demonstrators and the Digital Twin Platform developed in WP4. The goal is to enable secure, standardized, and reliable data exchange for performance and operations monitoring and optimization.

The work involves:

- Data Logger Concept Selection: A unified approach for all OEMs to ensure accountability, security, confidentiality, and integrity of data. Data loggers receive filtered CAN messages via OEM-provided gateways, using .dbc files for decoding.
- FHG Environment Set-up: Fraunhofer (FHG) manages data collection and storage. STW TCG-4 loggers capture CAN and GPS data, transmit via 4G LTE to FHG’s secured cloud, and store data in an IVImon timeseries database. Security measures include SSH keys, restricted access, and Vodafone CDA integration.
- TNO Environment Set-up: TNO retrieves data from FHG using the IVImon API and processes it through automated workflows (Argo engine). Data is stored in MinIO object storage via the ZEFES Digital Twin Platform API, with strict authentication and authorization using Ory Hydra/Keto.
- Commissioning Procedures: Verification includes correct logger installation, connectivity checks, and validation of data accessibility. TNO confirm data ingestion on the Digital Twin Platform

Delays in use case testing and in particular vehicle readiness, prevented full commissioning across any truck at the time of reporting. Full demonstration of connectivity will be reported in future deliverables (e.g. D5.6).

Further work includes completing installations, commissioning checks, and finally establishing and providing evidence of the complete system functionality from truck to platform.

	Yes	Include technical deviation if applicable	Include time related deviations if applicable
Did the deliverable attain the objectives ?	Partly		Due to delays in use case testing, the commissioning of connectivity on all trucks is not possible at the time of releasing this report. This document reports the methodology that is to be applied. Demonstration of achievements will be reported in future deliverables.

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Abbreviations & Definitions

Abbreviation	Explanation
BEV	Battery Electric Vehicle
FCEV	Fuel Cell Electric Vehicle
FMS	Fleet Management System
HSE	Health, Safety and Environment
OEM	Original Equipment Manufacturer
UC	Use Case
WP	Work Package
ZEV	Zero Emission Vehicle

Item	Definition
API	Application Programming Interface: a connection used to enable communication and data exchange between software processes
CAN	Controller area network: a vehicle bus standard
.dbc	A CAN DBC file (CAN database) is a text file that contains information for decoding raw CAN bus data to 'physical values'
HTTP	Hypertext Transfer Protocol: internet based communication protocol
HTTPS	Hypertext Transfer Protocol Secure
IVImon	FHG’s data processing application
JSON	Stands for JavaScript Object Notation, and is a lightweight format for storing and transporting data, often used when data is sent from a server to a web page
MinIO	Object storage system, particularly common in cloud environments
NMEA	Stands for National Marine Electronics Association, and is a standard for the formatting of Global Positioning System (GPS) information
Ory	Application used for identity and access management
OrientDB	OrientDB is an open source database management system written in Java
REST API	A REST API is an application programming interface (API) that conforms to the design principles of the representational state transfer (REST) architectural style
S3	Container in Amazon Web Services (AWS) used to store data as objects
SSH	Network protocol that allows for secure communication

1 Introduction

In ZEFES Work Package 5, integration of modular and flexible battery-electric powertrains is realized in vehicle demonstrators. These demonstrator vehicle combinations consist of battery-electric towing vehicles, electrified semitrailers, and one electrified converter dolly.

The work includes the development of a modular battery-electric powertrain concept for long-haul heavy-duty vehicle combinations, adaptable to daily demands of mission profiles in terms of range and power, and flexible in terms of integration of batteries and powertrains in different vehicle units. For this powertrain concept a functional safety concept is created.

To realize the vehicle units, specific powertrain components, subsystems, control systems like energy and thermal management systems are adapted and integrated into the prime mover battery-electric powertrains. Development and integration efforts are also made to realize the next generation e-trailers, serving as range extender to the electric powertrain of the prime mover.

The following list shall clarify the context of deliverable D5.5:

D5.1 - System specification for ZE modular multi-powertrain concepts: In this deliverable, the system specification of the battery-electric vehicle combinations with a modular multi-powertrain is verified and evaluated. The upgraded vehicle simulation tool IVIsion is used to verify the final design specifications of each targeted BEV demo.

D5.2 – Functional Safety Concept: The deliverable investigated the functional safety concept for the vehicle combinations with a modular multi-powertrain. The concept of an additional powertrain located in a trailer is described in terms of its application area, its functional behaviour on vehicle level, the powertrain functions and a draft system architecture. Furthermore, the results of the hazard analysis and risk assessment are presented including the derived safety goals and functional safety requirements for the development of the electrified trailers and the application in the ZEFES use cases.

D5.3 - Powertrain components and control systems for next generation battery-electric trucks: Within the deliverable the innovations and system improvements for the battery-electric towing vehicles developed by SCA, VOL and REN are described. This includes results of the proof of concept.

D5.4 - Next generation battery-electric trailers: The deliverable describes the adaptations and improvements of the e-semitrailer and the e-dolly as part of the modular multi-powertrain vehicle combinations. This includes the improvement of the mechanical design for the trailer chassis, based on the existing ZF e-trailer, and the development efforts regarding the powertrain components, controls, and auxiliary systems.

D5.5 - Commissioning, testing and verification connectivity between BEV demonstrators and digital twin tool: The deliverable briefly describes the results of the commissioning and testing of the data interface between the demonstrator vehicles and the digital twin tool developed in work package 4.

D5.6 - Realization and commissioning of all BEV demonstrators: In this deliverable the commissioning and testing of the six battery-electric demonstrator vehicle combinations is presented including the results of short dry run tests. As a result of the work described in this document the vehicle combinations can be handed over to WP7 use cases.

The position of deliverable D5.5 within WP5 and the relation to other deliverables and work packages is shown in Figure 1.

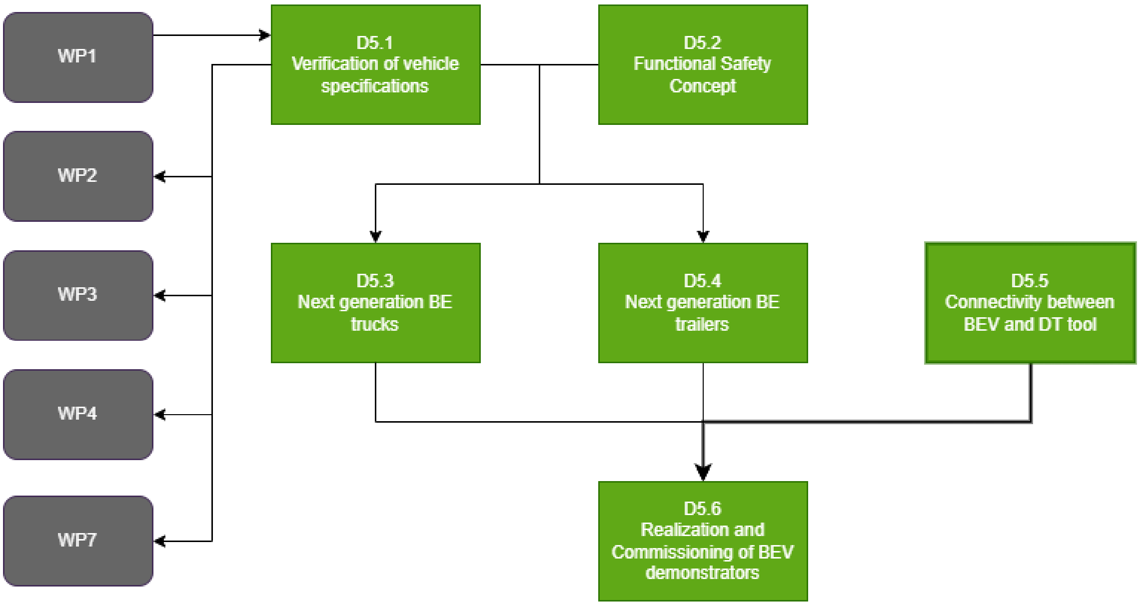

Figure 1: Relation of deliverable D5.5 to deliverables of WP5 and other WPs

2 ZEFES logging system and vehicle connectivity

2.1 Hardware and digital platform set-up

2.1.1 General architecture

Within WP4, whose aim is to develop a Digital Twin of ZEV in Logistics Operations, one of the challenges was to mitigate risks inherent to interfaces between the digital and physical environment:

- Accountability: who does what on each side of the interface and who verifies the interface functionalities
- Unification: define one single concept for all OEMs
- Connectivity: ensure hardware compatibility between truck and data logger connectors
- Safety: ensure the data logger shall only receive data, and the data logger shall not induce delay in CAN messages
- Integrity: ensure message integrity
- Confidentiality: define the data that the physical truck is allowed to provide to the platform
- Access control: given that the data has to be compartmentalized for OEMs, an access strategy has to be defined

Following discussions with the OEMs, the platform owner (TNO) and FHG, who have expertise in the installation of data loggers, the following interface concept has been agreed between all parties:

- The data is not sent directly from the standard truck CAN bus
- A gateway on the CAN bus filters the CAN messages (including signals, parameters, etc.) that are allowed by the OEM to be sent to the platform
- OEMs are responsible for providing a suitable connection in the truck CAN and connecting the FHG data logger
- OEMs are responsible for the installation of the logger into the truck, in conformity with HSE regulations, with FHG's support
- FHG ensure that the data loggers are correctly streaming to the FHG cloud where the raw CAN data are stored. FHG cloud is secured by FHG.
- CAN messages are decoded after storage using the .dbc file, provided by the OEM

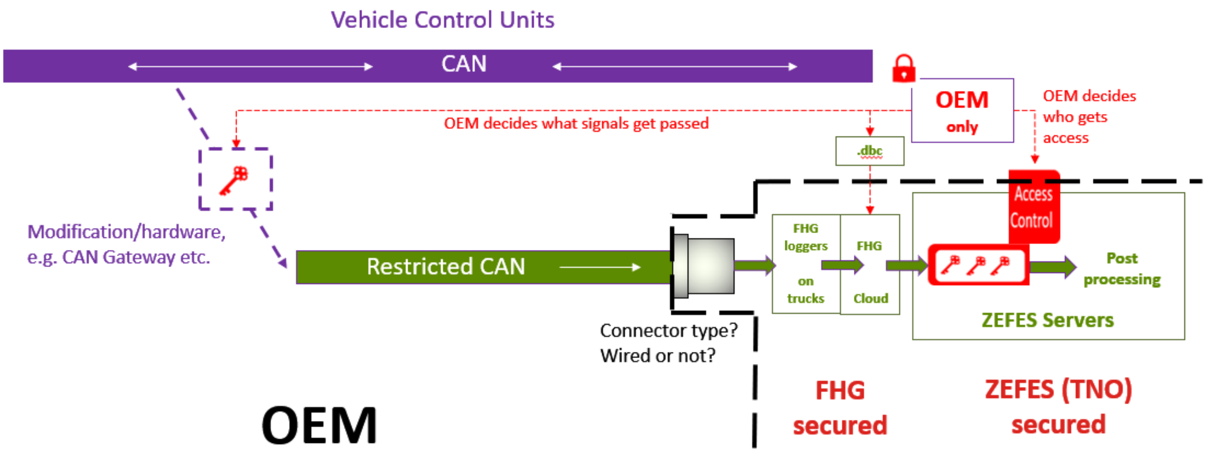

Figure 2: Interface concept

Details about the WP4 digital platform functionalities are available in the deliverable report "D4.3 – Interfaces standard and tools".

2.1.2 Description of FHG's data logging and cloud set-up

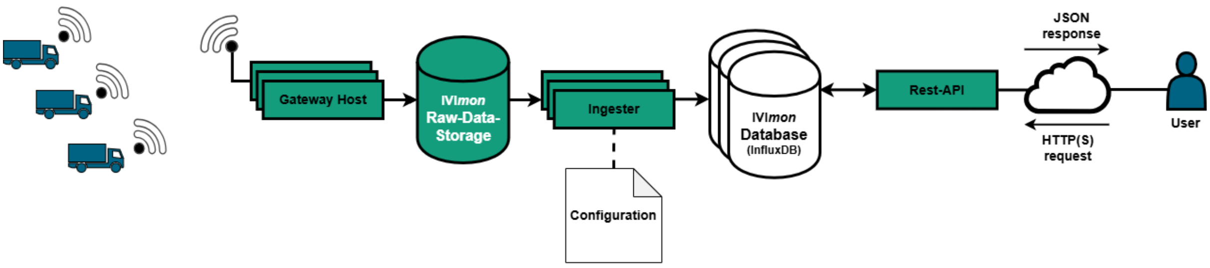

Figure 3: Relevant parts of the FHG environment

A schematic showing the relevant parts of the FHG environment is shown in Figure 3. The vehicle data is received by a Gateway Host and stored as raw data. Using a CAN DBC file provided by the vehicle OEM to interpret the CAN raw data, the data is written into the IVImon timeseries database (influxDB[1]) as physical values by the Ingester component. Via the IVImon REST-API, authorized users can access the timeseries data via an HTTPS connection. The users must authenticate with a username and a secure password and are granted access only to the vehicles and signals for which permissions have been explicitly set by FHG. In the context of ZEFES, only TNO has access to the vehicle data via the IVImon REST-API. All servers of the FHG cloud are in-house at FHG IVI.

A STW TCG-4 data module[2] is used for vehicle data logging and sending to the FHG cloud. It is installed in all vehicles and e-trailers within the ZEFES project. The initial configuration of the logger is done at FHG IVI. The logger runs a custom FHG IVI software package that manages logging of CAN and GPS data, compressing and sending it to the gateway host server of the FHG cloud via a 4G LTE connection. The loggers WiFi and Bluetooth capabilities are disabled for security reasons.
The 4G internet connection uses Vodafone Corporate Data Access (CDA)[3] to integrate the logging device into the FHG internal network. Thus, remote access is possible from within the FHG network for remote maintenance via an SSH connection. An SSH-ed25519 key pair is generated during configuration and used for remote access. The connection from the logging device to the FHG cloud is also secured by using the SSH Protocol with another set of SSH-ed25519 key pairs that are generated during the logger configuration. Each logger has a separate account on the FHG cloud with strictly limited access rights, allowing them to only read and write into the device-specific directory.

Vehicle-specific details are set during the initial configuration, like the baud rate of the CAN channels. Two CAN channels are available through gateways in all BEV vehicles within ZEFES: ZEFES CAN and FMS CAN. Along with acting as a data channel filter, the gateways ensure that the data module cannot send CAN messages to components of the vehicle.

Both the serial port and Ethernet interface require authentication with a username and secure password. The logging device is also password protected from firmware flashing. This way, access to data on the logger and manipulation attempts are prevented, even though an unauthorized person may get physical access to the logger.

Finally, the logger, a GPS/GSM dual antenna and the required cable set are sent to the project OEM partners for installation into the vehicles. The logger is connected to the vehicle via the CAN interfaces, battery positive terminal and vehicle ground (clamps 30 and 31) for power supply and, optionally, ignition plus signal (clamp 15). The CAN bus contains the vehicle data, and the ignition plus signal is

[1] https://www.influxdata.com/
[2] https://www.stw-mobile-machines.com/en/products/connectivity-gateways/tcg-data-modules/tcg-4/
[3] https://www.vodafone.de/business/digitalisierung/corporate-data-access/

used to wake the logging device. If no ignition plus signal is available, loggers are configured to wake on a CAN message received on CAN channel 1. The connector and relevant pins are shown in Figure 4 and Table 1, respectively. The ZEFES CAN is to be connected to CAN1, the FMS to CAN2 of the data logger.

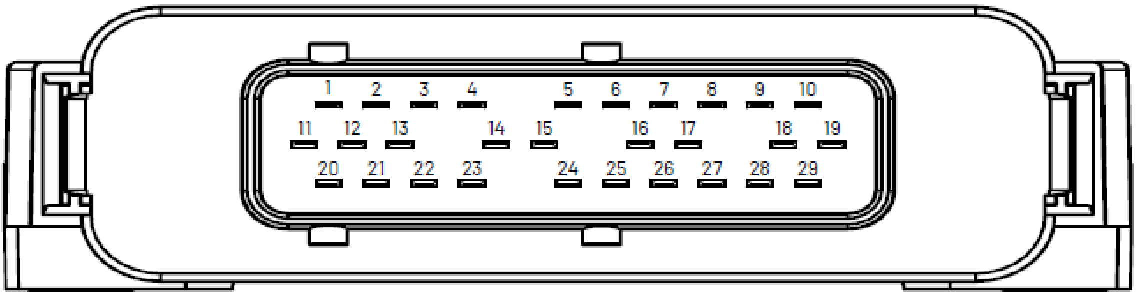

Figure 4: TCG-4 Connector side view

Table 1: Pin assignment of the TCG-4 connector

Pin Number	**Description**
8	UB+ Power supply (9-32VDC)
9	GND (shield USB & WLAN)
10	KL15 / D+ (switched power / ignition plus)
11	CAN3 low (termination required)
12	CAN3 high (termination required)
14	CAN4 low (termination required)
15	CAN4 high (termination required)
20	CAN1 low (termination required)
21	CAN1 high (termination required)
22	CAN2 low (termination required)
23	CAN2 high (termination required)

2.1.3 Description of TNO's digital platform

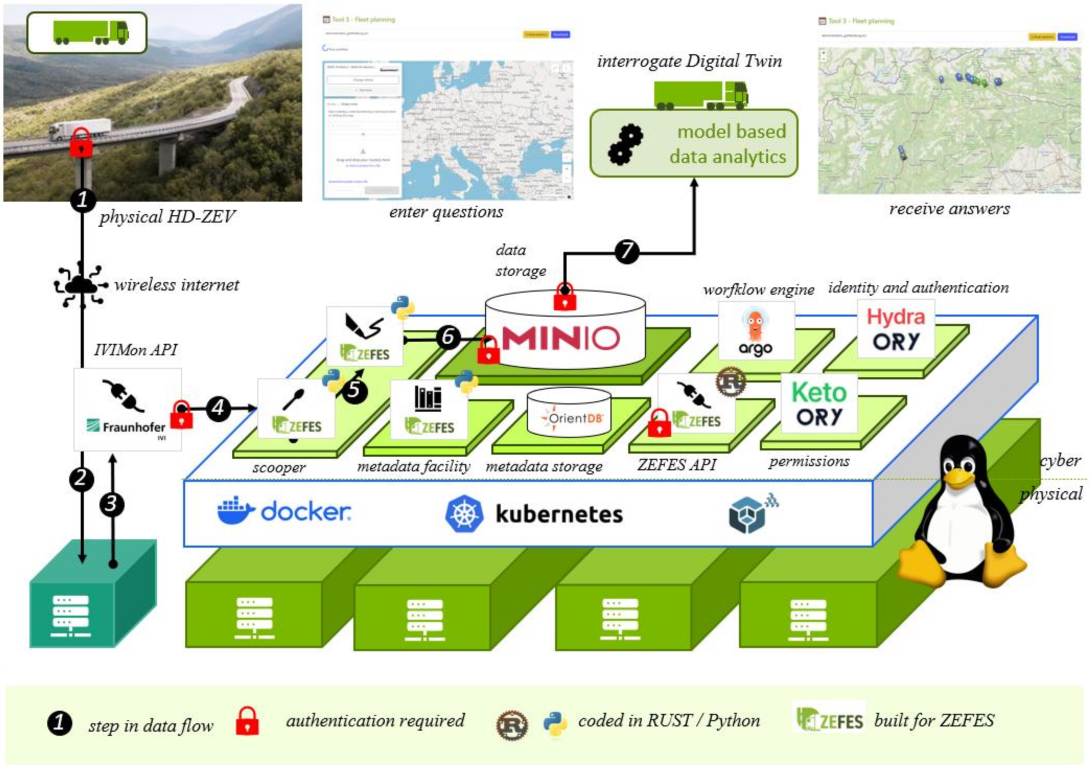

Figure 5: Dataflow from Heavy Duty Zero Emission Vehicle (HD-ZEV) to data analytics on the ZEFES Digital Twin Platform

Once the logged data is stored on FHG's cloud system, TNO (and TNO only) is provided access to retrieve the data using the HTTP REST-based IVImon API.

In the TNO environment, there is a dedicated workflow for each vehicle and/or combination, implemented using the Argo[4] workflow engine. At a regular time interval (e.g., half an hour), a vehicle specific workflow is launched, which consists of the following two main tasks:

Task 'retrieve data' *(carried out by the 'scooper' component in Figure 5: Dataflow from Heavy Duty Zero Emission Vehicle (HD-ZEV) to data analytics on the ZEFES Digital Twin Platform*

). Data from Fraunhofer for a specific named CAN bus device is retrieved, using the GET signals functionality in the IVImon API. This is the data that has been collected and stored by Fraunhofer in a database at Fraunhofer (step 4 in Figure 5: Dataflow from Heavy Duty Zero Emission Vehicle (HD-ZEV) to data analytics on the ZEFES Digital Twin Platform

1.). The IVImon API first requires identification and authentication to connect. After that, there is extra authorization needed to access specific signals for specific vehicles. The scooper component on the platform has an HTTPS connection with the IVImon API at Fraunhofer IVI, so no third parties can eavesdrop on what is exchanged. The scooper component runs temporarily during the workflow in its own Docker container, so other components cannot see what happens inside that component.

Task 'store received data' *(also carried out by the 'scooper' component in Figure 5: Dataflow from Heavy Duty Zero Emission Vehicle (HD-ZEV) to data analytics on the ZEFES Digital Twin Platform*

[4] https://argoproj.github.io/workflows/

2.). The retrieved data is stored (step 6) on the MinIO platform using the 'upload file' functionality from the HTTPS/REST based ZEFES Digital Twin Platform (DTP) API component. This provides a so-called *presigned* Uniform Resource Locator (URL) to an S3 compliant bucket on the MinIO[5] hyperscale object store platform. Presigned means that it contains information regarding the identification and authentication of the party requesting the storage platform to store that information. The URL is only valid for a relatively short amount of time (e.g., less than a minute). After that, the URL becomes useless, closing the access window again.

   The ZEFES API uses the Ory Hydra[6] platform to *identify* and *authenticate* the identity of the components (in the workflow). It then uses the Ory Keto[7] platform to check permissions and *authorize* the workflow to store data in a specific place on the MinIO platform. Finally, the metadata facility component is provided with metadata (which vehicle, what begin time, what end time, what signals, etc.) regarding the data that was scooped from the Fraunhofer IVImon API and stored in the MinIO storage. The metadata facility component uses the OrientDB product to store the metadata as connected graph data.

   After the workflow ends, the instance of the required scooper component and the temporarily stored data are removed. The data that was scooped and written is now only present in the MinIO storage, which can only be accessed through the ZEFES API component (that requires identification, authentication and authorization rules).

2.2 Procedures

Commissioning and verification of BEV logging system consists of two main items:

- The data loggers are correctly installed on the truck, and all signals are correctly collected on the FHG server
- The data collected is accessible only by authorized personnel via TNO platform access.

2.2.1 Verification of FHG's data logging and cloud set-up

After the initial configuration of the STW TCG-4 data logger at FHG IVI, connectivity to the FHG cloud via a 4G LTE connection is verified by checking for a logger status file being sent to the FHG cloud server. If the connectivity test is successful, the logger, cable set for connection to the vehicle, a GPS/GSM dual antenna and a short installation manual are sent to the project partners.

The cables are labelled accordingly to ensure easy installation. When testing the logger after installation, typically by starting the vehicle, a LED indicator on the logging device gives direct feedback. If everything is working as intended, the LED starts blinking in green shortly after starting, which indicates successful GPS and Internet connection as well as incoming CAN traffic being detected. In case the installation is done at a place without GPS reception, the logger will blink pink. All states and their description are given in Table 1 and described in the installation manual supplied with the logger.

Since no data loggers had been installed at the time the deliverable was created, it was not yet possible to perform a final check of correct functionality.

The plan for this is as follows:

[5] https://min.io/docs/minio/linux/reference/s3-api-compatibility.html
[6] https://www.ory.sh/hydra/
[7] https://www.ory.sh/keto/

1. Installation of the loggers and functional testing by the OEM in accordance with the supplied manual and Table 2
2. Test activation and test drives of the vehicle (incl. Periods with ignition on and off) to generate data
3. Checking the data input at FHG (in normal operation and logger follow-up)
4. Verification of correct data processing and interpretation using the provided DBC based on existing function test routines and visual inspection of the physical values in a dashboard
5. Verification of the completeness of the data set in accordance with the agreed signal list.

During the installation process, FHG IVI provides support via telephone and can change configurations remotely if necessary.

Table 2: STW TCG-4 Status LED Reference

LED-colour	state	Description
Yellow	Power ON	active when the TCG-4 has booted and none of the other states are active
Blue	GPS	active when a valid NMEA string is received and the internet-state is not active
Pink	Internet	active when a valid connection to the internet exists and the GPS state is not active
Green	GPS + Internet	active when the GPS state and the Internet state are both active
Red	Error	active if an internal error occurred
Blinking (any colour)	CAN-traffic	active when traffic on any CAN interface is detected

In case the logger loses connectivity to the FHG gateway server, e.g. if the server is undergoing maintenance, the modem of the logging device is restarted, and another authentication attempt is made. This is repeated once every hour until a connection has successfully been established. In the meantime, the logger saves the CAN data locally to ensure no data is lost until the buffer storage of 2488 MB is full. In case a logger has not sent a status message to the FHG cloud for more than 7 days, an Email is sent to a service Email address that responsible FHG employees have access to. Additionally, if the data logger storage reaches more than 50% occupation signalling the prolonged use of the buffer storage, an SMS is sent also resulting in an Email to the service address.

2.2.2 Verification of the TNO Platform Access

After it has been established that the logger is able to send data to the FHG gateway server, FHG will inform TNO that a new source for signals is available and provide TNO with an identifier (e.g. ‘device name’) and the access rights to programmatically access the data through the IVImon API. TNO will then add this device to the configuration of the TNO Platform. The platform operator at TNO will check if the data can be retrieved automatically by starting a workflow on the platform to ingest the data, using a ‘file listing only’ service account that can see the creation of new files on the platform, but cannot investigate the content of the files. Once these new data files are visible, it is confirmed that the flow of data is functioning as expected. If this is not the case, the platform operator at TNO will look at the logs of the data ingestion components in the workflow. The remainder of this section lists cases where the ingestion and access to data can fail.

The first case is where the workflow cannot be started, this is signalled at the console of the workflow engine. Secondly the scooper component might fail to launch, this will also be signalled by the workflow engine. Following a successful scooper component launch, there can be failure within the scooper component. These can be at the level of the:

1. **IP connection.** If it is not possible to connect at the IP-level with Fraunhofer, this is detected by the scooper component that will write this to logs, based on a 'cannot connect' error response from a lower-level Python library on the ZEFES Digital Twin Platform.

2. **webserver IVImon application connection**. If it is not possible to connect to the HTTP/REST API, the scooper component will get a response from the HTTPS-server of Fraunhofer saying that there is something wrong with the application. The TNO scooper software can distinguish this response from the 'no IP connection' response.

3. **requesting party identification/authentication.** If the scooper component cannot be identified and/or authenticated by the Fraunhofer IVImon API, it will get a response that explicitly tells this.

4. **requesting party authorization**. If the scooper component is not allowed to receive data regarding a specific signal by the Fraunhofer IVImon API, it will get a response that explicitly tells this. There is a clear difference between the response for non-identification and non-authorization.

5. **data integrity.** If the response message with data is malformed, the scooper component will not be able to process the JSON formatted response. This is signaled, and the scooper component will try again once. If it still fails, a message will be written to the logs. The scooper component cannot determine if the data is correct; there is no checksum or error correcting code used for retrieving the data.

When one of these failures occurs, it is an indication that a problem exists in the connection between TNO and FHG. This will therefore be the point of investigation to resolve the issue. Note that if the JSON response from IVImon has been parsed successfully by the scooper component, there is no way for the scooper component to determine if the response contained the corrected measurement data. It relies on the Fraunhofer part of the chain (steps 1, 2 and 3) to verify this. Also note that the scooper component relies on the IVImon service to determine if data is available for a vehicle at a certain point in time. If no data is available for the period that the scooper component requested from the IVImon API, the scooper component will get an empty response.

After retrieving the data from IVIMon (step 4), the received data is written as a temporary file, and the location of this file is handed over for writing (step 5). This next step can fail due to:

1. **Temporary file corruption or loss**. Part of this failure is detected by the scooper component, which will receive something like a 'file could not be written successfully' error, and this will be written to the logs.

After successfully completing step 5, the scooper component has to write the data to the MinIO system (step 6), using the ZEFES API component (to get access to the MinIO system). This can fail in different ways:

1. **Temporary file corruption or loss**. Part of this failure is detected by the Scooper component, which will receive a notification that an 'object could not be stored successfully' error and write this to the logs.

2. **Failure of the ZEFES API component** in different ways. The scooper component should write this to the logs:

    a. The scooper component would not get a response in time from the ZEFES API.
    b. The ZEFES API responds with:

i. 'not identified'. This means that the identity of the ZEFES API client could not be found within the ZEFES valid identities (Ory components). A ZEFES Digital Twin Platform administrator needs to be notified.
ii. 'not authenticated'. This means that the identity could not be authenticated.
iii. 'not authorized' This means that the authenticated identity has no rights to write to the bucket in the MinIO file system.

3. Failure of the MinIO system:
   a. The MinIO server does not provide a pre-signed URL to store.
   b. The pre-signed URL is not recognized and/or seen as valid.

Correct writing of the vehicle data on the TNO Digital Twin platform will be checked on completion of steps 5 and 6, and any errors that occur will be noted in the logs, which will be inspected by TNO platform operators at regular intervals. If they encounter any of the above error conditions, they will attempt to restore the data ingestion and storage process based on consultation and intervention by Fraunhofer operators and/or TNO engineers.

3 Results & Discussion

3.1 Results

The connectivity commissioning process will be repeated on all BEV vehicles and e-trailers (and FCEV vehicles for WP6) taking part in the Use Case demonstration testing. At the time of releasing this report, it has not yet been possible to demonstrate the vehicle-to-platform connectivity, due to delays in the vehicle preparation and deployment.

This work will be completed upon availability of demonstration vehicles and reported in D5.6.

3.2 Contribution to project (linked) Objectives

This work and deliverable contribute to:

- Objective 3 of the Project: provide digital and fleet management tools specifically for HD ZEVs, fleet integration with remote operational optimization of vehicle performance.
- Sub-objective 3.2: create accessible data for zero emission impact assessment generated by demonstrations. (The goal of this sub-objective is to make the data usable for assessing the demonstrator vehicles against the baseline vehicles. […])
- VC 18: findable and accessible data from the Digital Twin models with the purpose of assessing the demonstrator vehicles against the baseline vehicles.

3.3 Contribution to major project exploitable result

The establishment of effective connectivity between the test vehicles and the digital platform is a vital part for the collection, storage and analysis of vehicle performance, and the processing of metrics and KPI's planned within WP8. These are key to provide a factual, data-based assessment of the opportunities and challenges for the future adoption of Zero Emission Vehicles in the long haul freight sector.

4 Conclusion and Recommendation

This section will be finalised and reported in D5.6 when at least one test vehicle has been commissioned.

The hardware and general process used to log and store the truck data have been trialled successfully on 2 Diesel vehicles, already operating on the Gruber Logistics and Gebrüder Weiss use case routes. These activities were for the purpose of gathering reference data for the analysis work of Work Package 8. This allowed the validation of the hardware suitability, the installation, the collection of data, and the streaming and storage onto the platform. This will be reconfirmed and reported once the system has been deployed and tested on the demonstrator vehicles.

5 Risks and interconnections

5.1 Risks/problems encountered

This section will be finalised and reported in D5.6 when at least one test vehicle has been commissioned. For now, the following list of risks has been established.

Risk No.	What is the risk	Probability of risk occurrence[1]	Effect of risk[1]	Solutions to overcome the risk
WP5.5.1	OEM's provide limited or no access to truck in-use performance data	Low	High	Continue engagement with OEM's to assure them that their requirements for data protection and access are met
WP5.5.2	Data is not received onto the platform as expected	Low	High	There will be regular human checks that data is received as expected. Also, automated alerts will activate if/when no data is received for 7 days. For each truck.
WP5.5.3	No 4G network connectivity	Medium	Medium	When the lack of data received by the platform is due to network access issues, the data collected by the loggers is automatically stored on memory cards, and transmitted when network connection resumes.

1) Probability risk will occur: 1 = high, 2 = medium, 3 = Low

5.2 Interconnections with other deliverables

The content of this deliverable is similar to that of D6.2, which regards the commissioning of the connectivity of ZEFES fuel cell demonstrator vehicles. The logging hardware and approach used are the same across all ZEFES vehicles.

D5.5 may also be regarded as a sub-set of D5.6, Realization and Commissioning of all BEV demonstrators.

6 Deviations from Annex 1

Due to the delays within the preparation process of the BEVs, FCEVs and e-trailers, data loggers could not be installed in the vehicles and the connectivity between demonstrators and the digital twin platform could not be tested. Thus, in month 24 it was decided to postpone submission of the deliverable to month 35. Nonetheless, at the time of releasing this deliverable no vehicle could be provided for the commissioning process. To avoid further delay of publication of this document, full demonstration of connectivity will be reported in deliverable D5.6.

7 References

None.

8 Acknowledgement

The author(s) would like to thank the partners in the project for their valuable comments on previous drafts and for performing the review.

Project partners:

#	Partner short name	Partner Full Name
1	VUB	VRIJE UNIVERSITEIT BRUSSEL
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4	KAE	KASSBOHRER FAHRZEUGWERKE GMBH
5	REN	RENAULT TRUCKS SAS
6	SCA	SCANIA CV AB
7	VET	VAN ECK TRAILERS BV
8	VOL	VOLVO TECHNOLOGY AB
8.1	CPA	CPAC SYSTEMS AB
9	ABB	ABB E-MOBILITY BV
9.1	ABP	ABB E-MOBILITY SPOLKA Z OGRANICZONAODPOWIEDZIALNOSCIA
9.2	ABG	ABB E-MOBILITY GMBH
10	AVL	AVL LIST GMBH
11	CM	SOCIEDAD ESPANOLA DE CARBUROS METALICOS SA
11.1	APG	AIR PRODUCTS GMBH
12	HEPL	HITACHI ENERGY POLAND SPOLKA Z OGRANICZONA ODPOWIEDZIALNOSCIA
13	MIC	MANUFACTURE FRANCAISE DES PNEUMATIQUES MICHELIN
14	POW	OPmobility
15	RIC-CZ	RICARDO PRAGUE S.R.O.
15.1	RIC-DE	RICARDO GMBH
16	UNR	UNIRESEARCH BV
17	ZF	ZF CV SYSTEMS HANNOVER GMBH
18	ALI	ALLIANCE FOR LOGISTICS INNOVATION THROUGH COLLABORATION IN EUROPE
19	DPD	DPD (NEDERLAND) B.V.
20	COL	ETABLISSEMENTEN FRANZ COLRUYT NV
21	GRU	GRUBER LOGISTICS S.P.A.
22	GBW	GEBRUEDER WEISS GESELLSCHAFT M.B.H.
23	PG	PROCTER & GAMBLE SERVICES COMPANY NV
23.1	PGP	PROCTER AND GAMBLE POLSKA SPOLKA Z OGRANICZONA ODPOWIEDZIALNOSCIA
23.2	PGA	PROCTER & GAMBLE AMIENS
23.3	PGG	PROCTER & GAMBLE SERVICE GMBH
24	PRI	PRIMAFRIO CORPORACION, S.A.
25	PTV	PTV PLANUNG TRANSPORT VERKEHR GmbH
26	Fraunhofer	FRAUNHOFER GESELLSCHAFT ZUR FORDERUNG DER ANGEWANDTEN FORSCHUNG EV
27	HAN	STICHTING HOGESCHOOL VAN ARNHEM ENNIJMEGEN HAN
28	IDI	IDIADA AUTOMOTIVE TECHNOLOGY SA
29	TNO	NEDERLANDSE ORGANISATIE VOOR TOEGEPAST NATUURWETENSCHAPPELIJK ONDERZOEK TNO

30	UIC	UNION INTERNATIONALE DES CHEMINS DE FER
31	CFL	CFL MULTIMODAL S.A.
32	GSS	Grupo Logistico Sese
33	HIT	Hitachi ABB Power Grids Ltd.
34	IRU	UNION INTERNATIONALE DES TRANSPORTS ROUTIERS (IRU)
35	RIC-UK	RICARDO CONSULTING ENGINEERS LIMITED

Disclaimer/ Acknowledgment

Funded by
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