D3.1 - Report on requirements for integration of HVAC into the Functional Distribution Framework and Simulation Framework

Project number:	826073
Project acronym:	Safe4RAIL-2
Project title:	SAFE architecture for Robust distributed Application Integration in roLling stock 2
Start date of the project:	1st October 2018
Duration:	31 months
Programme:	H2020-S2RJU-OC-2018

Deliverable type:	Report
Deliverable reference number:	ICT-826073 / D3.1
Work package	WP3
Due date:	January 2019 – M04
Actual submission date:	28th June 2019

Responsible organisation:	IKL
Editor:	Iñigo Odriozola
Dissemination level:	Public
Revision:	1.0

Abstract:	This report includes the requirements to address the integration of TCMS functions into FDF and SF. Particularly, considering the HVAC Application Profile defined by CFM members; it would be applied to the HVAC system.
Keywords:	Requirements, HVAC, Application Profile, Functional Distribution Framework, Simulation Framework

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 826073. The information and views set out in this document are those of the author(s) and do not necessarily reflect the official opinion of Shift2Rail Joint Undertaking. The JU does not guarantee the accuracy of the data included in this article. Neither the JU nor any person acting on the JU's behalf may be held responsible for the use which may be made of the information contained therein.

Editor

Iñigo Odriozola (IKL)

Contributors (ordered according to beneficiary numbers)

Xabier Mendialdua, Lorea Belategi (IKL)

Núria Mata (ETAS)

Martin Zauner, Christian Luger (LIEB)

Executive Summary

This deliverable collects the requirements for the integration of a HVAC system control application in the Functional Distribution Framework (FDF) and the Simulation Framework (SF). The FDF is a software layer that abstracts the software applications that run on top of it from the underlying hardware and communications. It provides a partition mechanism that guarantees a strict separation between different applications. On the other hand, the SF is a framework intended to enable a faster and easier integration and testing of new railway components, providing the possibility of performing Software- and Hardware-In-The-Loop (SIL/HIL) testing.

The collection of requirements contained in this document includes high-level requirements selected for both FDF and the SF frameworks in CONNECTA project, as well as additional requirements that are the result of an extension of the specification of the FDF in CONNECTA-2, the follow-up project of the formerly mentioned one. This project will have two different demonstrators: The Urban demonstrator and the Regional one. Therefore, the high-level requirements for the FDF and SF have been derived into detailed requirements for each of the demonstrators.

Besides, a set of Use Cases have been selected from the Application Profile for the HVAC system defined in CONNECTA project, which sets the baseline for the integration of HVAC systems into the TCMS. Based on these Use Cases, requirements for the HVAC application that will run on top of the FDF and SF have been identified.

Traceability matrixes have been included as annexes to this document in order to maintain the track between the requirements of CONNECTA and CONNECTA-2 projects for the FDF and the SF as well as the requirements for the HVAC system control application that will implement the functions defined in the set of use cases selected from the application profile.

Contents

List of Figures

List of Tables

Chapter 1 Introduction

The present document collects the requirements for the integration of a HVAC system control application on TCMS. They include requirements collected in CONNECTA project for the FDF (deliverable D4.4 [1]) and the SF (deliverable 6.2 [2]) as well as requirements for the HVAC system control application that will derive into additional requirements for the FDF.

1.1 Scope

The aim of this document is to gather all the necessary requirements for the implementation and integration of an application to control a HVAC system, which will run on top of different instantiations of the FDF and SF in different demonstrators.

Chapter 2 Requirements structure

The requirements of Safe4RAIL-2 project must be written according to a set of rules so that they are harmonized, consistent and of good quality. For this purpose, their characteristics, writing rules and attributes have been detailed in Safe4RAIL-2 deliverable D1.1 [3] Chapter 2.

In Work Package 3, some specific changes have been necessary to better reflect the content of the specification. The next table provides the modifications to the attributes defined as general for the project:

Name	Type	Description	Applicability
Id	ReqID	Unique identification of the requirement. Ensures that the requirement remains uniquely traceable and enables traceability to needs, solutions and documents. It shall be expressed according to the following formatting rule: “systemacronym-(componentacronym)-demoacronym-NNN”, Where: - “systemacronym” can be, for instance, “FDF”, “SF” or “HVAC” - the optional field “componentacronym” identifies the component, for instance, CM for the Communication manager in the FDF. APP for application, SIM for simulated and GW for gateway in the case of the HVAC. - “demoacronym” represents the demonstrator to which the requirement applies (either URB for Urban or REG for Regional) - N is a number between 0 and 9.	Mandatory

Table 1: Requirement attributes specific to WP3

Chapter 3 HVAC Use Cases for CONNECTA-2 demonstrators

This chapter presents the HVAC system use cases that should be implemented in Safe4RAIL-2 project for the implementation of the demonstrators defined in CONNECTA-2 project.

A complete set of use cases for the HVAC system was defined in CONNECTA project, which can be found in document D4.3 “Application profile definition guideline and example” [4] of CONNECTA project. Having this set of use cases as a starting list, a selection of the use cases related to HVAC subsystem that must be implemented in the scope of Safe4RAIL-2 project have been selected by CONNECTA partners, which are presented in the table.

Id	Name	Description
CTA-T4.3-UC-HVAC-1	Startup and manage HVAC system	After each power on of HVAC system or/and consist, a startup procedure is activated. HVAC system indicates its power need to ensure his role. Then TCMS gives available power it can deliver to the HVAC system. With the received available power value, HVAC system estimates the list of equipment it can start. For each of high energy consumers, HVAC system sends a start request to TCMS. Then, TCMS gives back a start authorization when power distribution is ready for that.
CTA-T4.3-UC-HVAC-3	Manage HVAC operational mode	Depending of environment use condition of the consist, TCMS manages operational modes of the HVAC system. HVAC system sends cyclically its actual operational mode. It can be the same as the TCMS command so TCMS can indicate this mode to dispatching staff. If the actual mode is different from the command mode, TCMS can adapt its command or, after a specific timeout, indicates an incoherency between the command mode and the HVAC system realized mode.
CTA-T4.3-UC-HVAC-16	Monitor vehicle outside temperature	HVAC system sends cyclically the outside measured temperature of the vehicle. Then, TCMS can show this information to the transportable staff. TCMS use this information to construct consist reference temperature (minimum value, maximum value, average value, depending of project choice) of all vehicle.
CTA-T4.3-UC-HVAC-11	Monitor comfort zone inside temperature	For each identified comfort zone, HVAC system sends cyclically the inside measured temperature. TCMS can show this information to the transportable staff. TCMS uses this information to construct consist reference temperature (minimum value, maximum value, average value, depending of project choice) of all comfort zone.

Id	Name	Description
CTA-T4.3-UC-HVAC-12	Monitor comfort zone HVAC functional state	Depending of actual equipment's functional behaviour in each comfort zone, HVAC system sends cyclically a status of chosen functional states to the TCMS. Then, TCMS can show to the dispatching staff each HVAC functional states or a synthesis consist HVAC functional states.
CTA-T4.3-UC-HVAC-14	Define comfort zone set point temperature	Depending of the project choice, applicable normative temperature to be set in all comfort zone can be sent by the TCMS or manage by the HVAC system. A null value for the set point temperature sent by TCMS indicates that HVAC system must use its own normative temperature curve.
CTA-T4.3-UC-HVAC-15	Adjust comfort zone temperature offset	In each defined comfort zone, dispatching staff can adjust the internal temperature (only an offset around target set point is authorized) using a specific command sent to HVAC system. In return, HVAC system gives back for each comfort zone, the specific target temperature that it has to reach (set point temperature including specific adjustment). TCMS can show this information to dispatching staff.
CTA-T4.3-UC-HVAC-17	Monitor HVAC failures	Cyclically, HVAC system evaluates failure status of its equipment's and functionality. It can send to TCMS a global failure status of its equipment's and a specific status in each comfort zone. This information can be shown to dispatching staff by TCMS.

Table 2: Use Cases for CONNECTA-2 demonstrators

Chapter 4 HVAC system integration requirements

This section collects the requirements for the integration on TCMS of a HVAC subsystem Control Application on top of an Integrated Modular Platform made up of a Functional Distribution Framework (FDF) and a Drive-by-Data communication layer.

4.1 HVAC application requirements

The requirements included in this section are requirements defined for the integration of the HVAC application on top of FDF, to fulfil the use cases defined in the HVAC Application Profile for CONNECTA-2 project demonstrators. The signals contained in this table are the ones proposed by Liebherr, which in some cases are different to the ones needed by CONNECTA-2. In future steps these requirements may need to be modified so that the signals and data-types proposed are mapped to the ones defined by the mentioned project.

Id	Name / Description	Relevant for demonstrator	Safety related	Source	Status	Notes
HVAC-APP-1	The HVAC application shall be able to use only one formally defined application programming interface (API) for the FDF.	Yes	No			
HVAC-APP-2	The HVAC application shall be able to use either signal based or service-oriented interfaces, not both.	Yes	No			Requirements are based on signal oriented implementation.
HVAC-APP-3	The HVAC application API shall be able to use clearly defined functional prototypes in order to distinguish from third party APIs	Yes	No			
HVAC-APP-4	The HVAC application shall be able to get supporting document on how to use the provided APIs in space and time.	No	No			
HVAC-APP-5	The HVAC application shall be able to register a set of variables.	Yes	No			
HVAC-APP-6	The HVAC application shall be able to get read access to variables.	Yes	No			

Id	Name / Description	Relevant for demonstrator	Safety related	Source	Status	Notes
HVAC-APP-7	The HVAC application shall be able to get write or update access to variables.	Yes	No			
HVAC-APP-8	The HVAC application shall be able to set the variables direction (e.g. depending on read/write access or explicitly).	Yes	No			
HVAC-APP-9	The HVAC application shall be able to set default values to variables.	Yes	No			
HVAC-APP-10	The HVAC application shall be able to get status access to variables.	Yes	No			
HVAC-APP-11	The HVAC application shall be able to force variables.	Yes	No			
HVAC-APP-12	The HVAC application shall be able to read from a file.	Yes	No			
HVAC-APP-13	The HVAC application shall be able to write to a file or update a file.	Yes	No			
HVAC-APP-14	The HVAC application shall be able to configure the HVAC device statically.	Yes	No			
HVAC-APP-15	The HVAC application shall be able to identify the device dynamically	No	No			
HVAC-APP-16	The HVAC application shall be able to register a device configuration file	No	No			
HVAC-APP-17	The HVAC application shall be able to register device configuration parameter.	No	No			
HVAC-APP-18	The HVAC application shall be able to register network configuration parameter.	No	No			
HVAC-APP-19	The HVAC application shall be able to identify a device instance properly.	Yes	No			
HVAC-APP-20	The HVAC application shall be able to configure process parameters.	No	No			
HVAC-APP-21	The HVAC application shall be able to configure execution parameters.	No	No			
HVAC-APP-22	The HVAC application shall be able to configure logging events and store it persistently.	No	No			
HVAC-APP-23	The HVAC application shall be able to configure monitoring events.	No	No			

Id	Name / Description	Relevant for demonstrator	Safety related	Source	Status	Notes
HVAC-APP-24	The HVAC application shall be able to configure input and output parameters according to the device configuration file.	No	No	HVAC-APP-16		
HVAC-APP-25	The HVAC application shall be able to configure parameter variables according to the device configuration file.	No	No	HVAC-APP-16		
HVAC-APP-26	The HVAC application shall be able to configure a device by one or more function calls taking device configuration and parameterization files into account.	No	No	HVAC-APP-16 HVAC-APP-17		
HVAC-APP-27	The HVAC application shall be able to be installed or updated onto the FDF.	Yes	No			
HVAC-APP-28	The HVAC application shall be able to read out its version.	No	No			
HVAC-APP-29	The HVAC application shall be able to read out it's FDF version.	No	No			
HVAC-APP-30	The HVAC application shall be able to deploy or update a device configuration file	No	No			
HVAC-APP-31	The HVAC application shall be able to read its device configuration file version.	No	No			
HVAC-APP-32	The HVAC application shall be able to delete all persisted data store when uninstalling or updating.	No	No			
HVAC-APP-33	The HVAC application shall be able to be uninstalled from FDF.	Yes	No			
HVAC-APP-34	The HVAC application shall be able to request the logging of a specific variable.	Yes	No			
HVAC-APP-35	The HVAC application shall be able to stop logging of a specific variable.	Yes	No			
HVAC-APP-36	The HVAC application shall be able to request the logging of the environment for a specified time span.	No	No			
HVAC-APP-37	The HVAC application shall be able to request different logging levels.	No	No			
HVAC-APP-38	The HVAC application shall be able to register itself or a function to be executed.	Yes	No			

Id	Name / Description	Relevant for demonstrator	Safety related	Source	Status	Notes
HVAC-APP-39	The HVAC application shall be able to define the execution period.	Yes	No			
HVAC-APP-40	The HVAC application shall be able to register a variable to be continuously monitored.	Yes	No			
HVAC-APP-41	The HVAC application shall be able to set the update rate for monitored variables.	No	No			
HVAC-APP-42	The HVAC application shall be able to read from the following binary input variables: • STATUS CONDENSOR FAN 1 • STATUS CONDENSOR FAN 2 • FEEDBACK Q50 HEATER • FEEDBACK F100 • STATUS COMPRESSOR K40 • POWER SUPPLY PFO • POWER SUPPLY PFI • COMPRESSOR F40 • FEEDBACK COMPRESSOR Q40 • STATUS SUPPLY AIR FAN • STATUS HPSWITCH B40	Yes	No			
HVAC-APP-43	The HVAC application shall be able to read from the following analog input variables: • FEEDBACK_DAMPER • SUPPLY AIR TEMPERATURE (NTC) • HIGH PRESSURE • LOW PRESSURE • COOL CYCLE TEMPERATURE	Yes	No			
HVAC-APP-44	The HVAC application shall be able to write to the following binary output variables: • COMPRESSOR Q40 • EXPANSION VALUE (4 binary outputs) • HEATER Q50 • POWER DISABLE	Yes	No			
HVAC-APP-45	The HVAC application shall be able to write to the following analog output variables: • SETPOINT COMPRESSOR • SUPPLY AIR FAN	Yes	No			

Id	Name / Description	Relevant for demonstrator	Safety related	Source	Status	Notes
	• DAMPER CONTROL • CONDENSOR FAN (PWM)					
HVAC-APP-46	The HVAC application shall be able to read the following TCMS variables: • COOL ENABLE • HEAT ENABLE • OPERATION MODE • SET POINT SHIFT • AVERAGE FRESH AIR TEMPERATURE • AVERAGE COMPARTMENT AIR TEMPERATURE • FAN SPEED • PREMODE RELEASE • STATUS MAIN ENERGY RELEASE	Yes	No			
HVAC-APP-47	The HVAC application shall be able to write the following TCMS variables: • COOLING REQUEST • HEATING REQUEST • STATUS OPERATION MODE • STATUS COMPRESSOR ON • STATUS HEATER ON • STATUS CONDENSOR FAN ON • STATUS SUPPLY AIR FAN ON • STATUS FAN SPEED • GENERAL ERROR COACH • VENTILATION ERROR COACH • COOL ERROR COACH • HEATER ERROR COACH	Yes	No			
HVAC-APP-48	The HVAC application shall be able to read the TCMS variables as the types described: • COOL ENABLE - Boolean (0 = FALSE, 1= TRUE) • HEAT ENABLE - Boolean (0 = FALSE, 1= TRUE) • OPERATION MODE - UINT8 (0 = OFF, 1 = AUTOMATIC, 2 = WAITING, 3 = STANDBY) • SET POINT SHIFT - INT8 (E.g. -3 = -3K, 0 = 0K, +3 = +3K) • AVERAGE FRESH AIR TEMPERATURE - INT16 (E.g. -400 = -40°C, 000 = 0°C, +800 = +80°C) • AVERAGE COMPARTMENT AIR TEMPERATURE - INT16 (E.g. -400 = -40°C, 000 = 0°C, +800 = +80°C)	Yes	No	HVAC-APP-46		.

Id	Name / Description	Relevant for demonstrator	Safety related	Source	Status	Notes
	• FAN SPEED - UINT8 (0 = Auto, 1 = Fan Speed 1, 2 = Fan Speed 2, 3 = Fan Speed 3) • PREMODE RELEASE - Boolean (0 = PreMode Disabled, 1 = PreMode Enabled) • STATUS MAIN ENERGY RELEASE - Boolean (0 = no energy, 1 = energy needed)					
HVAC-APP-49	The HVAC application shall be able to write the TCMS variables as the types described: • COOLING REQUEST - Boolean (0 = no cooling, 1 = cooling needed) • HEATING REQUEST - Boolean (0 = no heating, 1 = heating needed) • STATUS OPERATION MODE - UINT8 (0 means OFF, 1 = AUTOMATIC, 2 = WAITING, 3 = STANDBY) • STATUS COMPRESSOR ON - Boolean (0 = compressor off, 1 = compressor on) • STATUS HEATER ON - Boolean (0 = heater off, 1 = heater on) • STATUS CONDENSOR FAN ON - Boolean (0 = condensor fan off, 1 = condensor fan on) • STATUS SUPPLY AIR FAN ON - Boolean (0 = supply air fan off, 1 = supply air fan on) • STATUS FAN SPEED - UINT8 (0 = Auto, 1 = Fan Speed 1, 2 = Fan Speed 2, 3 = Fan Speed 3) • GENERAL ERROR COACH - Structure (uint8 coachnumber, uint8 modulnumber, boolean error), where error: 0 = no error, 1 = error active • VENTILATION ERROR COACH - Structure (uint8 coachnumber, uint8 modulnumber, boolean error), where error 0 = no fault, 1 = fault • COOL ERROR COACH - Structure (uint8 coachnumber, uint8 modulnumber, boolean error), where error: 0 = no fault, 1 = fault • HEATER ERROR COACH - Structure (uint8 coachnumber, uint8 modulnumber, boolean error), where error: 0 = no fault, 1 = fault	Yes	No	HVAC-APP-47		
HVAC-APP-50	The HVAC application shall be able to create file.	Yes	No			
HVAC-APP-51	The HVAC application shall be able to open a file.	Yes	No			
HVAC-APP-52	The HVAC application shall be able to write to file.	Yes	No			
HVAC-APP-53	The HVAC application shall be able to update a file.	Yes	No			

Id	Name / Description	Relevant for demonstrator	Safety related	Source	Status	Notes
HVAC-APP-54	The HVAC application shall be able to read from file.	Yes	No			
HVAC-APP-55	The HVAC application shall be able to close a file.	Yes	No			
HVAC-APP-56	The HVAC application shall be able to force variables externally.	Yes	No			
HVAC-APP-57	The HVAC application shall be able to retrieve global time information	Yes	No			
HVAC-APP-58	The HVAC application shall be able to register a timer with call-back function.	No	No			

Table 3: HVAC application requirements

4.2 HVAC plant model requirements

This subsection contains a specification for an HVAC plant model that will be integrated in the regional demonstrator for simulation by running on top of the SF, as described in CONNECTA-2 project.

Id	Name / Description	Relevant for demonstrator	Safety related	Source	Status	Notes
	4.2.1 Overall Purpose					
HVAC-SIM-1	The physical HVAC unit shall be substituted by an HVAC unit simulation model, while the remaining setup is changed at a minimum extent. The simulation model shall be simulated in a simulation framework.	Yes	No			
HVAC-SIM-2	The primary purpose is to demonstrate the overall concept and framework. Highly accurate results on variables such as temperature, pressure, and electric energy demand are not of relevance in the present project.	Yes	No			
	4.2.2 HVAC unit simulation model					
HVAC-SIM-3	The HVAC unit model shall represent the basic thermodynamic behaviour of the HVAC system. The model shall cover key components of the refrigerant cycle including evaporator, condenser, compressor, further on air mixing, heaters, and fans. As a simplification, actuators such as valve drives may not be modelled in detail but substituted by the physical quantity they finally modify, e.g. the mass flow rate.	Yes	No			

Id	Name / Description	Relevant for demonstrator	Safety related	Source	Status	Notes
HVAC-SIM-4	The HVAC unit model shall not represent behaviour regarding shock and vibration, acoustics, air pressure drops, impacts on the electric network, etc.	Yes	No			
HVAC-SIM-5	The HVAC unit model shall not include electronic components of e.g. the BK4 controller unit or interface components.	Yes	No			
HVAC-SIM-6	The HVAC unit simulation model does not contain the HVAC control software. The HVAC control software is separately executed on the CCU.	Yes	No			
HVAC-SIM-7	The HVAC unit model shall represent the basic operating modes with a reasonable accuracy. The model is a simplification of the real HVAC system.	Yes	No			
HVAC-SIM-8	The HVAC unit simulation model shall represent special operating modes such as start-up procedures, test and service routines of the system with a reasonable accuracy	No	No			
HVAC-SIM-9	The HVAC unit simulation model shall represent behaviour of the system under specific derating conditions or failure conditions with a reasonable accuracy.	No	No			
HVAC-SIM-10	The HVAC plant model shall allow steady-state simulations. Transient effects may be neglected for the reasons of model simplification and due to the fact that the order of magnitude of transient effects in the HVAC unit has a limited effect on the thermal comfort in the rail vehicle.	Yes	No			
HVAC-SIM-11	The model shall return plausible and close-to-reality results for typical operating points. The model may not be fully validated and calibrated based on measurement data in the scope of the present project.	Yes	No			
HVAC-SIM-12	The model shall allow real time simulation considering relevant time constants of a rail HVAC application with the thermal inertia of the vehicle as the key dynamic state.	Yes	No			
	4.2.3 Thermal vehicle simulation model					
HVAC-SIM-13	The thermal vehicle simulation model shall consider sensible and latent thermal loads associated to heat transfer through the vehicle skin, solar radiation, passenger occupancy, and heat loads of auxiliary equipment.	Yes	No			
HVAC-SIM-14	The thermal vehicle model shall provide interfaces to impose different simulation cases with respect to, e.g., profiles of meteorological data (ambient air temperature, humidity, solar radiation, etc.), train driving direction, sun position, train driving speed profile, passenger occupancy profile, etc. Additionally appropriate simulation scenarios are required.	Yes	No			
HVAC-SIM-15	The thermal vehicle model shall consider the concentration of CO2 in the air and CO2 emission of passengers.	No	No			
HVAC-SIM-16	The thermal vehicle model may be a dynamic model considering the thermal inertia of the vehicle interior and the air inside the vehicle.	Yes	No			
HVAC-SIM-17	The vehicle model shall include four sensors for inside air temperature.	Yes	No			

Id	Name / Description	Relevant for demonstrator	Safety related	Source	Status	Notes
	4.2.4 Implementation in the simulation framework					
HVAC-SIM-18	The simulation framework must provide the possibility to implement the HVAC unit simulation model.	Yes	No			
HVAC-SIM-19	The simulation framework must provide the possibility to implement a thermal vehicle simulation model.	Yes	No			
HVAC-SIM-20	The HVAC unit simulation model shall be provided as a Simulink model to be implemented into the simulation framework.	Yes	No			Test are planned to secure this design decision.
HVAC-SIM-21	VeriStand or LabVIEW of National Instruments will act as the simulation framework.	Yes	No			
	4.2.5 Interfaces					
HVAC-SIM-22	The simulation model of the HVAC unit must provide an interface (input and output) to the simulation framework to read and write signals to communicate with the HVAC control application software on the CCU. This does not include handling of a bus communication.	Yes	No			
HVAC-SIM-23	The simulation model of the HVAC unit must provide an interface (input) to read the ambient air state.	Yes	No			
HVAC-SIM-24	The simulation model of the HVAC unit must provide an interface (input) to read the return air state (state of air coming from the thermal vehicle model).	Yes	No			
HVAC-SIM-25	The simulation model of the HVAC unit must provide an interface (output) to write the supply air (state of air going to the thermal vehicle model) and supply air mass flow rate.	Yes	No			
HVAC-SIM-26	The simulation model of the HVAC unit must provide an interface (input) to read signals, which are communicated as hard-wired signals in reality such as enable bits or bits for unit encoding.	No	No			It may be a model parameter
HVAC-SIM-27	The simulation model of the HVAC unit may provide an interface (one output) to the simulation framework to communicate the simulation status (e.g. success/failure).	Yes	No			
HVAC-SIM-28	The simulation model of the HVAC unit may provide an interface (output) to the simulation framework to pass information of interest about the operation of the simulated HVAC unit. This may include virtual temperature and pressure measurements.	No	No			
HVAC-SIM-29	The simulation model of the HVAC unit may provide an interface (input) to enable the injection of faults for the simulation.	No	No			

Table 4: HVAC plant model requirements

4.3 HVAC system gateway requirements

The requirements included in this section are requirements for the integration in the urban demonstrator of the real HVAC system in a Hardware-In-the-Loop simulation with the HVAC system control application running on top Integrity based FDF.

The real HVAC system will be located at Liebherr's premises in Korneuburg while CAF's CCU running HVAC system control application will be at CAF's premises in Beasain.

Id	Name / Description	Relevant for demonstrator	Safety related	Source	Status	Notes
HVAC-GW-1	A communication bridge hardware and software shall be provided.	Yes	No			
HVAC-GW-2	The communication bridge hardware shall be deployed at the same site as the simulated component.	Yes	No			
HVAC-GW-3	The communication bridge hardware shall have at least 3 independent Ethernet interfaces.	Yes	No			
HVAC-GW-4	The communication bridge Ethernet interfaces ETH0 shall be used for Remote HVAC TRDP and the ETH1 shall be used for Environment Control TRDP communication with the BK4R1 Gateway controller.	Yes	No			
HVAC-GW-5	The communication bridge third Ethernet interface shall be used for the Internet access (Tunneling TRDP protocols over Internet).	Yes	No			
HVAC-GW-6	The communication bridge tunneling setup shall be provided.	Yes	No			
HVAC-GW-7	The communication bridge shall be able to establish a remote connection to the remote premises by initiating the tunneling activity via a software or hardware interface.	Yes	No			
HVAC-GW-8	The remote HVAC Gateway shall be implemented on Liebherr's BK4R1 communication controller.	Yes	No			
HVAC-GW-9	The remote HVAC Gateway shall be able to translate between TRDP and CANopen protocol.	Yes	No			
HVAC-GW-10	The BK4R1 ETH0 interface shall be used for remote HVAC IO communication using TRDP.	Yes	No			

Id	Name / Description	Relevant for demonstrator	Safety related	Source	Status	Notes
HVAC-GW-11	The BK4R1 ETH1 interface shall be used for remote Environment Control communication using TRDP.	Yes	No			
HVAC-GW-12	All communication interfaces (Gateway as well as Communication Bridge) shall have a a-prior statically configured IP addresses (no DHCP will be used).	Yes	No			
HVAC-GW-13	TRDP stack initialization shall be done via dedicated XML configuration files.	Yes	No			
HVAC-GW-14	Detailed system, signal, XML and data-set definitions shall be described inside the Liebherr-R01-TRDP-CANopen-Gateway-Network-ICD document.	Yes	No			
HVAC-GW-15	Only TRDP Process Data over UDP shall be used to communicate with the Gateway using cyclically transmitted intervals no less than 500ms.	Yes	No			
HVAC-GW-16	TRDP shall only use “push” communication pattern.	Yes	No			
HVAC-GW-17	The Gateway shall use the XML file devGW-IO.xml for remote HVAC IO control.	Yes	No			See Annex B
HVAC-GW-18	The Gateway shall use the XML file devGW-ENV.xml for remote environment control.	Yes	No			See Annex B
HVAC-GW-19	The Communication Bridge shall use the XML file devHVAC-IO.xml for remote HVAC IO control.	Yes	No			See Annex B
HVAC-GW-20	The Communication Bridge shall use the XML file devHVAC-ENV.xml for remote environment control.	Yes	No			See Annex B

Table 5: HVAC system gateway requirements

Further details about requirements HVAC-GW-17, HVAC-GW-18, HVAC-GW-19 and HVAC-GW-20 and description for the datasets defined for the TRDP communication between the Gateway and the Communication Bridge can be found in Annex G TRDP datasets definition.

Chapter 5 Functional Distribution Framework integration requirements

This chapter contains the requirements that the FDF must comply with for the realisation of CONNECTA-2 demonstrators. The first subsection collects the High-level requirements, based on inputs from both CONNECTA, Safe4RAIL and CONNECTA-2 projects. The next parts contain the requirements that are common to the FDFs that will run in both Urban and Regional demonstrators and those which are specific to the latter The FDF in the Regional demonstrator will be based in AUTOSAR and the extension to this platform to make it compliant CONNECTA's needs will be carried out in Safe4RAIL-2 project. However, specific requirements for the Urban demonstrator FDF have not been identified since its development is CONNECTA-2's exclusive responsibility.

5.1 High-level requirements

This section collects the high-level requirements for the Functional Distribution Framework, defined in CONNECTA project, as well as requirements related to Drive-By-Data that must be considered for the Functional Distribution Framework, which come as result of the activities carried out in WP1 of Safe4Rail2 project. Requirements defined in CONNECTA project are identified by the prefix "CTA-D4.4", as included in the deliverable D4.4, while requirements from WP1 of Safe4Rail project are identified by the "S4R-BDB" prefix. The requirements show only a short name or summary of it. Refer to deliverable D4.4 [1] for the complete information.

Id	Name / Description	Relevant for demonstrator	Safety related	Source	Status	Notes
	5.1.1 General					
CTA-D4.4-FDF-1	The FDF shall be executable in PC platform	Yes	No			
CTA-D4.4-FDF-2	The FDF shall provide hard real-time support	No	Yes			
S4R-DBD-600	FDF shall abstract the network interface from application.	Yes	Yes			
S4R-DBD-643	FDF shall provide information to system health monitoring applications.	Yes	Yes			
	5.1.2 Communication management					

Id	Name / Description	Relevant for demonstrator	Safety related	Source	Status	Notes
CTA-D4.4-CM-7	Inter-partition interface	Yes	No			
CTA-D4.4-CM-8	Interface partition and IO input	Yes	No			
CTA-D4.4-CM-9	Interface partition and IO output	Yes	No			
CTA-D4.4-CM-10	Interface partition and network	Yes	No			
CTA-D4.4-CM-11	Replicate IO inputs to consist network	TBD	Yes			
CTA-D4.4-CM-12	Control IO outputs based consist network variables	TBD	Yes			
CTA-D4.4-CM-13	Read access to variables	Yes	Yes			
CTA-D4.4-CM-14	Write access to variables	Yes	Yes			
CTA-D4.4-CM-15	Default values of variables	Yes	Yes			
CTA-D4.4-CM-16	Shared memory for processes in the same partition	Yes	Yes			
	5.1.3 Configuration management					
CTA-D4.4-CFM-2	Acquire ECU identification dynamically	Yes	Yes			
CTA-D4.4-CFM-3	Configuration parameter FDF	Yes	Yes			
CTA-D4.4-CFM-4	Configuration parameter device	Yes	Yes			
CTA-D4.4-CFM-5	Configuration parameter consist network	TBD	Yes			
CTA-D4.4-CFM-6	Configuration parameter partition	TBD	Yes			
CTA-D4.4-CFM-7	Configuration parameter process	TBD	Yes			
CTA-D4.4-CFM-8	Configuration parameter executable	TBD	Yes			

Id	Name / Description	Relevant for demonstrator	Safety related	Source	Status	Notes
CTA-D4.4-CFM-9	Configuration parameter IO unit	Yes	Yes			
CTA-D4.4-CFM-10	Configuration parameter variables	Yes	Yes			
CTA-D4.4-CFM-11	Configuration parameter service	TBD	Yes			
CTA-D4.4-CFM-12	Configuration parameter event log	TBD	Yes			
CTA-D4.4-CFM-13	Provide ECU instance identifier	TBD	Yes			
	5.1.4 Deployment management					
CTA-D4.4-DM-1	Install executable on a partition (direct connection)	No	Yes			
CTA-D4.4-DM-2	Install executable on a partition (network connection)	No	Yes			
CTA-D4.4-DM-3	Install executable on a partition (remote connection)	No	Yes			
CTA-D4.4-DM-4	Update executable on a partition (direct connection)	No	Yes			
CTA-D4.4-DM-5	Update executable on a partition (network connection)	No	Yes			
CTA-D4.4-DM-6	Update executable on a partition (remote connection)	No	Yes			
CTA-D4.4-DM-7	Uninstall executable on a partition (direct connection)	No	Yes			
CTA-D4.4-DM-8	Uninstall executable on a partition (network connection)	No	Yes			
CTA-D4.4-DM-9	Uninstall executable on a partition (remote connection)	No	Yes			
CTA-D4.4-DM-10	Provide FDF version	Yes	Yes			
CTA-D4.4-DM-11	Provide process version	Yes	Yes			
CTA-D4.4-DM-12	Security for install/update/uninstall executable	No	Yes			

Id	Name / Description	Relevant for demonstrator	Safety related	Source	Status	Notes
CTA-D4.4-DM-16	Delete persisted data stored by uninstalled software	No	Yes			
CTA-D4.4-DM-17	Validate executable before installation	No	Yes			
CTA-D4.4-DM-18	Install configuration file (direct connection)	No	Yes			
CTA-D4.4-DM-19	Install configuration file (network connection)	No	Yes			
CTA-D4.4-DM-20	Install configuration file (remote connection)	No	Yes			
CTA-D4.4-DM-21	Update configuration file (direct connection)	No	Yes			
CTA-D4.4-DM-22	Update configuration file (network connection)	No	Yes			
CTA-D4.4-DM-23	Update configuration file (remote connection)	No	Yes			
CTA-D4.4-DM-24	Uninstall configuration file (direct connection)	No	Yes			
CTA-D4.4-DM-25	Uninstall configuration file (network connection)	No	Yes			
CTA-D4.4-DM-26	Uninstall configuration file (remote connection)	No	Yes			
CTA-D4.4-DM-27	Provide configuration file version	Yes	Yes			
CTA-D4.4-DM-28	Security for install/update/uninstall configuration file	No	Yes			
CTA-D4.4-DM-29	Validate configuration file before installation	No	Yes			
CTA-D4.4-DM-30	Prevent deployment in normal operation	Yes	No			
CTA-D4.4-DM-31	Separate configuration items	Yes	No			
	5.1.5 Event logging					
CTA-D4.4-EL-1	Store event log persistently	TBD	No			

Id	Name / Description	Relevant for demonstrator	Safety related	Source	Status	Notes
CTA-D4.4-EL-2	Configure maximum size of event log	TBD	No			
CTA-D4.4-EL-3	Override old log entries if maximum size is reached	TBD	No			
CTA-D4.4-EL-4	Handling of recurrent errors	TBD	No			
CTA-D4.4-EL-5	System event entries	TBD	No			
CTA-D4.4-EL-6	Application event entries	TBD	No			
CTA-D4.4-EL-7	Logging level	TBD	No			
CTA-D4.4-EL-8	Export event log as file	TBD	No			
CTA-D4.4-EL-1	Store event log persistently	TBD	No			
CTA-D4.4-EL-2	Configure maximum size of event log	TBD	No			
CTA-D4.4-EL-3	Override old log entries if maximum size is reached	TBD	No			
	5.1.6 Execution management					
CTA-D4.4-EM-1	Authentication and authorization of executable	TBD	Yes			
CTA-D4.4-EM-2	Check integrity of executable	TBD	Yes			
CTA-D4.4-EM-3	Load executables	Yes	Yes			
CTA-D4.4-EM-4	Multiple instantiation of executables	Yes	Yes			
CTA-D4.4-EM-5	Identification of executable instances	Yes	Yes			
CTA-D4.4-EM-6	Concurrent execution of partitions	No	Yes			
CTA-D4.4-EM-7	Temporal separation of partitions	No	Yes			

Id	Name / Description	Relevant for demonstrator	Safety related	Source	Status	Notes
CTA-D4.4-EM-9	Partitions memory protection	No	Yes			
CTA-D4.4-EM-10	Partition execution period	No	Yes			
CTA-D4.4-EM-11	Partition limited execution time	No	Yes			
CTA-D4.4-EM-12	Ordered execution of partitions, processes and FDF components	TBD	Yes			
CTA-D4.4-EM-13	State of partitions	Yes	Yes			
CTA-D4.4-EM-14	Partition self-isolation	Yes	No			
CTA-D4.4-EM-15	Partition fault isolation	TBD	Yes			
CTA-D4.4-EM-16	Partition execution disable	TBD	Yes			
CTA-D4.4-EM-17	Partition and process recovery	TBD	Yes			
CTA-D4.4-EM-18	Synchronize partition execution	TBD	Yes			
CTA-D4.4-EM-19	Update of partition inputs	TBD	Yes			
CTA-D4.4-EM-20	Update of partition outputs	TBD	Yes			
CTA-D4.4-EM-21	Redundant execution of partitions and processes	TBD	Yes			
CTA-D4.4-EM-22	Leader update output	TBD	Yes			
CTA-D4.4-EM-23	Follower do not update output	TBD	Yes			
CTA-D4.4-EM-24	Synchronization of follower 1	TBD	Yes			
CTA-D4.4-EM-25	Synchronization of follower 2	TBD	Yes			
CTA-D4.4-EM-26	Redundancy switch over	TBD	Yes			

Id	Name / Description	Relevant for demonstrator	Safety related	Source	Status	Notes
CTA-D4.4-EM-27	One leader	TBD	Yes			
CTA-D4.4-EM-28	Partition decomposition into processes	TBD	Yes			
CTA-D4.4-EM-29	Process execution	TBD	Yes			
CTA-D4.4-EM-30	Process consecutive execution	TBD	Yes			
CTA-D4.4-EM-31	Process concurrent execution 1	TBD	Yes			
CTA-D4.4-EM-32	Process concurrent execution 2	TBD	Yes			
CTA-D4.4-EM-33	Configuration of partition and process execution	TBD	Yes			
CTA-D4.4-EM-34	Service protection	TBD	Yes			
CTA-D4.4-EM-35	Service discovery and announcement	TBD	Yes			
CTA-D4.4-EM-36	Access to internal variables	TBD	Yes			
CTA-D4.4-EM-38	Suspend execution	Yes	Yes			
CTA-D4.4-EM-39	Cyclic triggering of processes	TBD	Yes			
CTA-D4.4-EM-40	Execution time of processes	TBD	Yes			
CTA-D4.4-EM-41	Provide FDF operation mode	TBD	No			
	5.1.7 External monitoring					
CTA-D4.4-MO-1	Register variable	TBD	No			
CTA-D4.4-MO-2	Receive request for list of variables	TBD	No			
CTA-D4.4-MO-3	Provide list of variables	TBD	No			

Id	Name / Description	Relevant for demonstrator	Safety related	Source	Status	Notes
CTA-D4.4-MO-4	Secure transmission	TBD	No			
CTA-D4.4-MO-5	Update frequency	TBD	No			
CTA-D4.4-MO-6	Transmission frequency	TBD	No			
	5.1.8 Health management					
CTA-D4.4-HM-1	Monitor temperature	No	Yes			
CTA-D4.4-HM-2	Monitor load	No	Yes			
CTA-D4.4-HM-3	Software Watchdog	No	Yes			
CTA-D4.4-HM-4	Hardware watchdog	No	Yes			
CTA-D4.4-HM-5	Refresh watchdog	No	Yes			
CTA-D4.4-HM-6	Integrity check of hardware	No	Yes			
CTA-D4.4-HM-7	Check partition and process	No	Yes			
CTA-D4.4-HM-8	Error handling 1	TBD	Yes			
CTA-D4.4-HM-9	Error handling 2	TBD	Yes			
	5.1.9 IO management					
CTA-D4.4-IO-1	Get digital input	TBD	Yes			
CTA-D4.4-IO-2	Get analog input	TBD	Yes			
CTA-D4.4-IO-3	Set digital output	TBD	Yes			

Id	Name / Description	Relevant for demonstrator	Safety related	Source	Status	Notes
CTA-D4.4-IO-4	Set analog output	TBD	Yes			
CTA-D4.4-IO-5	Set default values for inputs	TBD	Yes			
CTA-D4.4-IO-6	Set default values for outputs	TBD	Yes			
CTA-D4.4-IO-7	Decode encoder signals	TBD	Yes			
	5.1.10 Network management					
CTA-D4.4-NM-1	ETB	TBD	Yes			
CTA-D4.4-NM-2	ECN	TBD	Yes			
CTA-D4.4-NM-3	Safety layer	TBD	Yes			
CTA-D4.4-NM-7	Obtain data from TTDB	TBD	Yes			
CTA-D4.4-NM-8	Update data from TTDB	TBD	Yes			
CTA-D4.4-NM-9	Provide data from TTDB	TBD	Yes			
	5.1.11 Persistency					
CTA-D4.4-PS-1	Create file	TBD	Yes			
CTA-D4.4-PS-2	Open file	TBD	Yes			
CTA-D4.4-PS-3	Opening mode of file	TBD	Yes			
CTA-D4.4-PS-4	Write data to file	TBD	Yes			
CTA-D4.4-PS-5	Read from file	TBD	Yes			

Id	Name / Description	Relevant for demonstrator	Safety related	Source	Status	Notes
CTA-D4.4-PS-6	Close file	TBD	Yes			
CTA-D4.4-PS-7	Store files persistent	TBD	Yes			
CTA-D4.4-PS-8	Remove file	TBD	Yes			
CTA-D4.4-PS-9	Store variables persistently	TBD	Yes			
CTA-D4.4-PS-10	Access persistently stored variables	TBD	Yes			
CTA-D4.4-PS-11	Identify persistently stored variables	TBD	Yes			
CTA-D4.4-PS-12	Prevent data corruption	TBD	Yes			
	5.1.12 Security management					
CTA-D4.4-SEC-1	Identify and authenticate users	No	No			
CTA-D4.4-SEC-2	Authorize users	No	No			
CTA-D4.4-SEC-3	Identify and authenticate executables	No	No			
CTA-D4.4-SEC-4	Authorize executables	No	No			
CTA-D4.4-SEC-5	Manage authentication	No	No			
CTA-D4.4-SEC-6	Manage identifier	No	No			
CTA-D4.4-SEC-7	Strength of password-based authentication	No	No			
CTA-D4.4-SEC-8	Public key infrastructure (PKI) certificates	No	No			
CTA-D4.4-SEC-9	Validate certificates	No	No			
CTA-D4.4-SEC-10	Feedback authentication result	No	No			

Id	Name / Description	Relevant for demonstrator	Safety related	Source	Status	Notes
CTA-D4.4-SEC-11	React on unsuccessful login attempts	No	No			
CTA-D4.4-SEC-12	Display system use notification message before authenticating	No	No			
CTA-D4.4-SEC-13	Support cryptography	No	No			
CTA-D4.4-SEC-14	Encrypt data	No	No			
CTA-D4.4-SEC-15	Decrypt data	No	No			
CTA-D4.4-SEC-16	Sign data	No	No			
CTA-D4.4-SEC-17	Check data signature	No	No			
CTA-D4.4-SEC-18	Provide user access right management	No	No			
	5.1.13 Simulation					
CTA-D4.4-SM-1	Force variables externally	No	Yes			
CTA-D4.4-SM-2	Register variables	No	Yes			
CTA-D4.4-SM-3	Secure connection	No	Yes			
CTA-D4.4-SM-4	List of variables	No	No			
CTA-D4.4-SM-5	Value of variables	No	Yes			
CTA-D4.4-SM-6	Operation mode simulation	No	Yes			
	5.1.14 Time management					
CTA-D4.4-TM-1	Get global time	Yes	Yes			

Id	Name / Description	Relevant for demonstrator	Safety related	Source	Status	Notes
CTA-D4.4-TM-2	Set global time	Yes	Yes			
CTA-D4.4-TM-4	Timer	Yes	Yes			
CTA-D4.4-TM-5	Network Time Protocol (NTP)	Yes	Yes			

Table 6: FDF High level requirements

5.2 Common detailed requirements

The requirements included in this section are detailed requirements that have been derived from high level requirements or HVAC Application requirements and are common for both the urban and the regional demonstrator.

Id	Name / Description	Relevant for demonstrator	Safety related	Source	Status	Notes
	5.2.1 General					
FDF-1	The platform shall be POSIX PSE51 compliant towards the lower OS layer.	Yes	No	CTA-D4.4-FDF-1, CTA-D4.4-FDF-2		Interface POSIX definitions are given in IEEE 1003.13.
FDF-2	Each application programming interface (API) towards the upper application layer shall be specified.	Yes	No	S4R2-D3.1-HVAC-2		
FDF-3	The namespace **'fdf'** shall be used to define the specified APIs.	Yes	No	S4R2-D3.1-HVAC-2		
FDF-4	The APIs shall be specified in both C and C++.	Yes	No	S4R2-D3.1-HVAC-2		
FDF-5	The 'fdf' namespace in C++ shall be used as 'ara' namespace alias if the FDF is an AUTOSAR Adaptive Platform.	Yes	No	S4R2-D3.1-HVAC-2		namespace fdf = ara; 'ara' stands for Runtime for Adaptive applications
	5.2.2 Communication					
FDF-CM-1	Service interfaces shall define the variables to be exchanged between partitions, with IO devices and with the network, as events.	Yes	No	CTA-D4.4-CM-7 CTA-D4.4-CM-8 CTA-D4.4-CM-9		

Id	Name / Description	Relevant for demonstrator	Safety related	Source	Status	Notes
				CTA-D4.4-CM-10		
FDF-CM-2	An application reading a variable included in a service interface shall define a required port (RPort) typed by the service interface.	Yes	No	CTA-D4.4-CM-13		
FDF-CM-3	An application writing a variable included in a service interface shall define a providing port (PPort) typed by the service interface.	Yes	No	CTA-D4.4-CM-14		
FDF-CM-4	A change of the service interface deployment shall be possible without re-compiling the involved application software.	Yes	No	CTA-D4.4-CM-7 CTA-D4.4-CM-8 CTA-D4.4-CM-9 CTA-D4.4-CM-10		
FDF-CM-5	Processes inside one partition shall communicate via shared memory.	Yes	Yes	CTA-D4.4-CM-16		
FDF-CM-6	The FDF shall provide an C-API to the application to read the value for the variable(s) of a required port typed by an interface using a C struct.	Yes	No	FDF-COM-3		The namespace 'fdf' shall be used to define the specified APIs.
FDF-CM-7	The FDF shall provide a C-API to the application to write the value for the variable(s) of a providing port typed by an interface using a C struct.	Yes	No	FDF-COM-3		The namespace 'fdf' shall be used to define the specified APIs.
	5.2.3 Configuration					
FDF-CFM-1	The C-API `fdf_get_device_identifier()` shall provide the ECU instance the	Yes	Yes	CTA-D4.4-CFM-2		

Id	Name / Description	Relevant for demonstrator	Safety related	Source	Status	Notes
	requesting process is running on.					
	5.2.4 Logging					
FDF-EL-1	The C-API `fdf_writeEntry()` shall write a log entry in the current event log including time, level and text.	Yes	No	CTA-D4.4-EL-6		
	5.2.5 Execution					
FDF-EM-1	The C-API `fdf_sleep(int time_s)` shall suspends the execution of the calling process for the given time period in seconds.	Yes	Yes			
FDF-EM-2	The C-API `fdf_usleep(int time_ms)` shall suspends the execution of the calling process for the given time period in microseconds.	Yes	Yes			
FDF-EM-3	The C-API `fdf_setOperationMode(int requestedMode)` shall set a new FDF operation mode.	Yes	Yes			
FDF-EM-4	The C-API `fdf_getOperationMode()` shall get the current FDF operation mode.	Yes	Yes	CTA-D4.4-EM-41		
FDF-EM-5	The C-API `fdf_ReportExecutionState` shall report the current state of a process to the execution management.	Yes	Yes	CTA-D4.4-EM-5		Application state management.
	5.2.6 IO					
FDF-IOM-1	Service interfaces shall be defined for the inputs of a device and for the outputs of a device according to the configured pins.	Yes	No	CTA-D4.4-IO-1 CTA-D4.4-IO-2 CTA-D4.4-IO-3 CTA-D4.4-IO-4		

Table 7: Common FDF detailed requirements

5.3 Regional demonstrator detailed requirements

The requirements included in this section are detailed requirements, derived from high level requirements, specific for the regional demonstrator.

Id	Name / Description	Relevant for demonstrator	Safety related	Source	Status	Notes
	5.3.1 General					
FDF-REG-1	The FDF shall be executable on Windows for testing purposes.	Yes	No	CTA-D4.4-FDF-1		Virtual machines can be used.
	5.3.2 Communication					
FDF-CM-REG-1	The `'fdf::com'` namespace in C++ shall be used as `'ara::com'` namespace alias if the FDF is an AUTOSAR Adaptive Platform.	Yes	No			
FDF-CM-REG-2	Service interfaces shall be instantiated for inter-partition communication to a specific network protocol binding, i.e. TRDP.	Yes	No	CTA-D4.4-CM-7 CTA-D4.4-CM-8 CTA-D4.4-CM-9 CTA-D4.4-CM-10	Currently SOME/IP network binding supported.	
FDF-CM-REG-3	The application subscribing to a service shall define a default behaviour in case the service cannot be reached.	Yes	Yes	CTA-D4.4-CM-15		
FDF-CM-REG-4	Service instances shall be able to be bound statically.	TBD	TBD			
FDF-CM-REG-5	Service instances shall be able to be offered, discovered and subscribed.	TBD	TBD			
	5.3.3 Configuration					
FDF-CFM-REG-1	The C-API `fdf_get_device_identifier()` shall provide the ECU instance the requesting process is running on.	Yes	Yes	CTA-D4.4-CFM-2		
FDF-CFM-REG-2	The FDF shall provide the ability to differentiate between a simulated, virtual and real ECU.	Yes	TBD	CTA-D4.4-CFM-1 CTA-D4.4-CFM-2		

Id	Name / Description	Relevant for demonstrator	Safety related	Source	Status	Notes
FDF-CFM-REG-3	The FDF shall provide the ability to dynamically identify a service.	Yes	TBD			
	5.3.4 Logging					
FDF-EL-REG-1	The `'fdf::log'` namespace in C++ shall be used as `'ara::log'` namespace alias if the FDF is an AUTOSAR Adaptive Platform.	Yes	No			'namespace fdf = ara; 'ara' stands for Runtime for Adaptive applications
	5.3.5 Execution					
FDF-EM-REG-1	The `'fdf::exec'` namespace in C++ shall be used as `'ara::exec'` namespace alias if the FDF is an AUTOSAR Adaptive Platform.	Yes	No			'namespace fdf = ara; 'ara' stands for Runtime for Adaptive applications
FDF-EM-REG-2	The `'fdf::sm'` namespace in C++ shall be used as `'ara::sm'` namespace alias if the FDF is an AUTOSAR Adaptive Platform.	Yes	No			'namespace fdf = ara; 'ara' stands for Runtime for Adaptive applications The State Management services in the Adaptive Platform are defined in ara::sm.
	5.3.6 Monitoring					
FDF-MO-REG-1	The C-API `fdf_setVarToMonitor` adds the given variable to the list of variables that can be monitored externally.	TBD	TBD			
	5.3.7 Health					

Id	Name / Description	Relevant for demonstrator	Safety related	Source	Status	Notes
FDF-HM-REG-1	The `'fdf::phm'` namespace in C++ shall be used as `'ara::phm'` namespace alias if the FDF is an AUTOSAR Adaptive Platform.	Yes	No			
	5.3.8 IO					
FDF-IOM-REG-1	Services in input devices are service providers and Rports for the application.	TBD	TBD	CTA-D4.4-IO-1, CTA-D4.4-IO-2		
FDF-IOM-REG-2	Services in output devices are service subscribers and Pports for the application.	TBD	TBD	CTA-D4.4-IO-3, CTA-D4.4-IO-4		
FDF-IOM-REG-3	Service oriented communication between application and IO shall be statically configured (no service discovery).	TBD	Yes			
	5.3.9 Persistency					
FDF-PM-REG-1	The `'fdf::per'` namespace in C++ shall be used as `'ara::per'` namespace alias if the FDF is an AUTOSAR Adaptive Platform.	Yes	No			'namespace fdf = ara; 'ara' stands for Runtime for Adaptive applications
FDF-PM-REG-2	The Persistency functional cluster shall be used to manage files.	Yes	Yes	CTA-D4.4-PS-2, CTA-D4.4-PS-4, CTA-D4.4-PS-5, CTA-D4.4-PS-6, CTA-D4.4-PS-8, CTA-D4.4-PS-9		It is not allowed in the AP that the application creates and manage files.
	5.3.10 Security					
FDF-SEC-REG-1	The `'fdf::crypto'` namespace in C++ shall be used as `'ara::crypto'` namespace alias if the FDF is an AUTOSAR Adaptive Platform.	Yes	No			'namespace fdf = ara; 'ara' stands for Runtime for Adaptive applications

Id	Name / Description	Relevant for demonstrator	Safety related	Source	Status	Notes
	5.3.11 Simulation					
FDF-SM-REG-1	The C-API `fdf_setVarToForcea` dds the given variable to the list of variables that can be forced externally.	TBD	TBD			
	5.3.12 Time					
FDF-TM-REG-1	The `'fdf::time'` namespace in C++ shall be used as `'ara::time'` namespace alias if the FDF is an AUTOSAR Adaptive Platform.	Yes	No			namespace fdf = ara; 'ara' stands for Runtime for Adaptive applications
FDF-TM-REG-2	The C-API `fdf_getTime()` provides the actual calendar time.	Yes	Yes	CTA-D4.4-TM-1		
FDF-TM-REG-3	The C-API `fdf_setDateTime(time time_s)` sets the actual time.	Yes	Yes	CTA-D4.4-TM-2		
FDF-TM-REG-4	The C-API `fdf_startTimer()` starts a new timer.	Yes	Yes	CTA-D4.4-TM-4		
FDF-TM-REG-5	The C-API `fdf_getTimer(int time_ms)` returns the number of milliseconds elapsed since the last start or restart.	Yes	Yes	CTA-D4.4-TM-4		
FDF-TM-REG-6	The C-API `fdf_restartTimer(int time_ms)` restarts a timer and returns the time elapsed since the previous start or restart.	Yes	Yes	CTA-D4.4-TM-4		
FDF-TM-REG-7	The C-API `fdf_stopTimer(int time_ms)` stops a timer and returns the time elapsed since the last start or restart.	Yes	Yes	CTA-D4.4-TM-4		
FDF-TM-REG-8	The C-API `fdf_terminateTimer(int timer_id)` terminates a timer.	Yes	Yes	CTA-D4.4-TM-4		

Table 8: FDF detailed requirements for regional demonstrator

Chapter 6 Simulation Framework integration requirements

6.1 High-level requirements

The requirements included in this section are high level requirements for the Simulation Framework, which have been collected from the results of CONNECTA project. The requirements which are relevant for the Simulation Framework demonstrators and need a lower level of detail for the integration of the HVAC control application in the Simulation Framework will be derived into detailed requirements that will be collected in upcoming Safe4RAIL-2 deliverable D3.4 “Conclusions on integration of subsystems into FDF and SF”. On the other hand, in section 6.2, there are requirements exported from the HVAC plant model requirements to the Simulation Framework.

Id	Name / Description	Relevant for demonstrator	Safety related	Source	Status	Notes
	6.1.1 Configuration					
CTA-D6.2-SF-1.1	The Simulation Framework (SF) shall read all application settings from settings files.	Yes	No			
CTA-D6.2-SF-1.2	The Simulation Framework (SF) shall be able to load following configuration files exported by the Software Tool Set (SWTS): - global configuration file containing list of devices and signals this file may also contain a list of configured bus interfaces - bus interface specific configuration files (one for each interface) containing all telegrams and communication settings - test system configuration file containing test support settings, test control communication settings and similar	Yes	No			
CTA-D6.2-SF-1.3	The Simulation Framework (SF) shall not implement any artificial limitations for configuration items. This includes the number of configurable devices or signals, telegram lengths or number of signals per telegram.	No	No			
CTA-D6.2-SF-1.4	If any limitations are required, they shall not be hard-coded, but configurable in one of the configuration files.	No	No			
CTA-D6.2-SF-1.5	The Simulation Framework (SF) shall detect if a configuration file is missing or not loadable.	Yes	No			
CTA-D6.2-SF-1.6	The Simulation Framework (SF) shall detect if a configuration file is not well-formed. *The detailed format of the configuration files will be defined in accordance with the*	Yes	No			

Id	Name / Description	Relevant for demonstrator	Safety related	Source	Status	Notes
	Software Tool Set (SWTS).					
CTA-D6.2-SF-1.7	The Simulation Framework (SF) shall detect if a configuration file is not complete or not consistent.	Yes	No			
CTA-D6.2-SF-1.8	The Simulation Framework (SF) shall implement the functionality to return configuration data information on request, like signal or device information, telegram information and similar. The Simulation Framework (SF) shall also be able to return meta information about the configuration, like validity, completeness and consistency of the configuration.	Yes	No			
CTA-D6.2-SF-1.9	The Simulation Framework (SF) shall support switching from a real End Device (ED) to an accordant End Device Simulation (EDS) or vice versa without the need of stopping other simulations. Depending on the requested change, there might be more limitations, for example due to the complexity of a specific sub system a special state might be required before exchanging it by its simulation.	No	No			
	6.1.2 Communication					
CTA-D6.2-SF-2.1	The Simulation Framework (SF) shall embed and use a Communications Emulator (CE) for external communication. The embedded Communications Emulator (CE) shall be used for all external links like System-under-Test (SUT) communication, test support communication and test control and monitoring communication. *External communication includes network and bus communication, serial communication and similar between the SF and any other device or system.*	Yes	No			
CTA-D6.2-SF-2.2	The Simulation Framework (SF) shall support interfacing multiple Communications Emulator (CE) instances.	No	No			
CTA-D6.2-SF-2.3	The Simulation Framework (SF) shall provide high-level data representation like telegrams and data signals for System-under-Test (SUT) communication.	Yes	No			
CTA-D6.2-SF-2.4	The Simulation Framework (SF) shall handle higher communication levels. This includes telegram and data signal handling, life sign simulation and monitoring, safe data transmission, cycle time supervision and redundancy. Low-level communication will be handled by the embedded Communications Emulator (CE), see above.	No	No			

Id	Name / Description	Relevant for demonstrator	Safety related	Source	Status	Notes
CTA-D6.2-SF-2.5	The Simulation Framework (SF) shall provide additional control and monitoring signals for System-under-Test (SUT) communication. *Those additional signals will for example support deactivating single telegrams sent to the System-under-Test (SUT) or monitoring the telegram data received from the System-under-Test (SUT).*	No	No			
CTA-D6.2-SF-2.6	The Simulation Framework (SF) shall support process data and message data for System-under-Test (SUT) communication.	Yes	No			
CTA-D6.2-SF-2.7	The Simulation Framework (SF) shall provide all required functionality for communicating to the System-under-Test (SUT) via TRDP and other high-level protocols (e.g. safe data transmission).	Yes	No			
	6.1.3 Simulation					
CTA-D6.2-SF-3.1	The Simulation Framework (SF) shall provide an internal interface as software API for simulations (SIM). The same interface will be used by End Device Simulations (EDS) and Electro-Mechanical Simulations (EMS).	Yes	No			
CTA-D6.2-SF-3.2	The simulation API shall support accessing communication items like telegrams, data signals and also control and monitoring signals and data.	No	No			
CTA-D6.2-SF-3.3	The Simulation Framework (SF) shall support loading multiple simulations (SIM).	No	No			
CTA-D6.2-SF-3.4	The simulation API shall provide initialising, running, stopping, pausing and resuming simulations.	No	No			
CTA-D6.2-SF-3.5	The simulation API shall implement synchronisation between multiple simulations.	No	No			
CTA-D6.2-SF-3.6	The simulation API of the Simulation Framework (SF) shall provide information about the Simulation Framework (SF) itself, so that the simulation model can check for prerequisites like specific interfaces.	No	No			
	6.1.4 Test Control Interface					

Id	Name / Description	Relevant for demonstrator	Safety related	Source	Status	Notes
CTA-D6.2-SF-4.1	The test control interface of the Simulation Framework (SF) shall provide full access to simulation control commands (like load, start, stop, unload).	No	No			
CTA-D6.2-SF-4.2	The test control interface of the Simulation Framework (SF) shall provide signal monitoring and manipulation commands like reading and writing signals.	Yes	No			
CTA-D6.2-SF-4.3	The test control interface of the Simulation Framework (SF) shall support forcing and unforcing signals values.	Yes	No			
CTA-D6.2-SF-4.4	The Simulation Framework (SF) shall support a validation mode, in which only the active test control interface is allowed to manipulate signal values or to manipulate end device simulations of the accordant Simulation Framework (SF) instance. Read-only access (like reading or monitoring) shall still be available for other clients without any restriction.	No	No			
	6.1.5 Internal Supervision					
CTA-D6.2-SF-5.1	The Simulation Framework (SF) shall supervise its own internal state.	No	No			
CTA-D6.2-SF-5.2	The Simulation Framework (SF) shall provide a monitoring interface for its own internal state and health. This shall at least include: - information about task overruns - communication errors - simulation failures	No	No			
	6.1.6 Data Monitoring					
CTA-D6.2-SF-6.1	The Simulation Framework (SF) shall provide a configurable data monitoring interface.	No	No			
CTA-D6.2-SF-6.2	The data monitoring interface shall support uploading signal value or simulation model state changes to a configured monitoring client.	No	No			
CTA-D6.2-SF-6.3	The data monitoring interface shall support adding or removing monitored items while the monitoring is in progress.	No	No			

Id	Name / Description	Relevant for demonstrator	Safety related	Source	Status	Notes
	6.1.7 Fault Injection					
CTA-D6.2-SF-7.1	The Simulation Framework (SF) shall support injecting faults into System-underTest (SUT) communication protocols. This includes fault injection into higher protocol levels in the Simulation Framework (SF) itself, and also injecting faults into lower protocol levels in the accordant Communications Emulator (CE) instance.	No	No			
CTA-D6.2-SF-7.2	The Simulation Framework (SF) shall support injecting faults into simulations.	No	No			
	6.1.8 Co-Simulation					
CTA-D6.2-SF-8.1	The Simulation Framework (SF) shall support co-simulation by providing a communication interface to other Simulation Framework (SF) instances. This interface shall be separated from the System-under-Test (SUT) communication interface.	No	No			
CTA-D6.2-SF-8.2	The Simulation Framework (SF) shall support co-simulation by providing a communication interface to other third-party simulation hosts. This interface shall be separated from the System-under-Test (SUT) communication interface.	No	No			
	6.1.9 Target System					
CTA-D6.2-SF-9.1	The Simulation Framework (SF) base application shall be portable to common hardware and software platforms. *This requires splitting logic from system functions, so that the system specific part can be easily replaced.*	No	No			
CTA-D6.2-SF-9.2	The supported host operating systems shall include at least one real-time operating system for testing real devices. *The Simulation Framework (SF) base application should first be implemented for Windows and real-time Linux targets.*	No	No			

Id	Name / Description	Relevant for demonstrator	Safety related	Source	Status	Notes
	6.1.10 Software-in-the-Loop					
CTA-D6.2-SF-10.1	The Simulation Framework (SF) shall support running in a Software-in-the-Loop (SWIL) setup.	No	No			
CTA-D6.2-SF-10.2	The Software-in-the-Loop (SWIL) approach shall support faster than real-time execution for speeding up long lasting test cases.	No	No			
CTA-D6.2-SF-10.3	The Software-in-the-Loop (SWIL) approach shall support slow-down and step mode for debugging and development (of System-under-Test (SUT) applications, simulations and more), or for slowing down quick-respond test cases.	No	No			

Table 9: SF high level requirements

6.2 Requirements exported from HVAC plant model

Id	Name / Description	Relevant for demonstrator	Safety related	Source	Status	Notes
HVAC-SIM-30	The simulation framework must handle the communication between HVAC unit model and HVAC control application software running on the CCU. This includes packing/unpacking bus messages and reading/writing signals transferred via the bus from/to the HVAC unit model.	Yes	No			
HVAC-SIM-31	The simulation framework must handle the communication between HVAC unit model and thermal vehicle model.	Yes	No			
HVAC-SIM-32	The simulation framework must provide an interface to communicate the ambient air state to the HVAC unit model.	Yes	No			
HVAC-SIM-33	The simulation framework shall provide an interface to read the simulation status from the HVAC unit model and interpret results appropriately.	Yes	No			
HVAC-SIM-34	The simulation framework may provide an interface to read information of interest about the operation of the simulated HVAC unit. This may include virtual temperature and pressure measurements.	No	No			
HVAC-SIM-35	The simulation framework may provide an interface to inject faults for the simulation of the HVAC unit.	No	No			
HVAC-SIM-36	The simulation framework must provide an interface to write signals such as enable bits or	No	No			May be a

Id	Name / Description	Relevant for demonstrator	Safety related	Source	Status	Notes
	bits for unit encoding.					model parameter
HVAC-SIM-37	The simulation framework must provide means to configure different operating scenarios and parameters for simulation cases, e.g. set ambient temperature profiles.	Yes	No			
HVAC-SIM-38	A detailed interface definition shall be provided by the HVAC system manufacturer to ensure proper interface implementation.	Yes	No			An initial version was sent to Mr. Grund end of March 2019.

Table 10: HVAC plant model exported requirements

Chapter 7 Definitions and Abbreviations

7.1 Definitions

HVAC	Heating, ventilation and air conditioning is the technology of indoor and vehicular environmental comfort. Its goal is to provide thermal comfort and acceptable indoor air quality.
Application Profile	An Application Profile, according to CONNECTA project goal, describes a functional interface between the TCMS and a subsystem.

Table 11: List of definitions.

7.2 Abbreviations

API	Application Programming Interface
WP	Work Package
FDF	Functional Distribution Framework
SF	Simulation Framework
DBD	Drive-By-Data
AP	Application Profile
TCMS	Train Control and Management System
HVAC	Heating, Ventilation and Air Conditioning subsystem

Table 12: List of Abbreviations

Chapter 8 Bibliography

[1] CONNECTA, D4.4 - Report on technology evaluation for application distribution, 2018.
[2] CONNECTA, D6.2 - Specification of the Simulation Framework and Train Virtualisation, 2018. Available: https://projects.shift2rail.org/s2r_ip1_n.aspx?p=CONNECTA
[3] Safe4RAIL-2, D1.1 - Drive-by-Data Requirements Specification, 2019.
[4] CONNECTA, D4.3 - Application Profile Definition Guideline and Example, 2018. Available: https://projects.shift2rail.org/s2r_ip1_n.aspx?p=CONNECTA

Annex A HVAC application vs. FDF High-Level integration requirements traceability matrix

HVAC application requirement	FDF High level requirement
HVAC-APP-1	
HVAC-APP-2	
HVAC-APP-3	
HVAC-APP-4	
HVAC-APP-5	
HVAC-APP-6	CTA-D4.4-CM-13
HVAC-APP-7	CTA-D4.4-CM-14
HVAC-APP-8	
HVAC-APP-9	CTA-D4.4-CM-15
HVAC-APP-10	
HVAC-APP-11	
HVAC-APP-12	
HVAC-APP-13	
HVAC-APP-14	CTA-D4.4-CFM-3 CTA-D4.4-CFM-4 CTA-D4.4-CFM-5 CTA-D4.4-CFM-7

HVAC application requirement	FDF High level requirement
	CTA-D4.4-CFM-13
HVAC-APP-15	CTA-D4.4-CFM-2 CTA-D4.4-CFM-13
HVAC-APP-16	
HVAC-APP-17	
HVAC-APP-18	
HVAC-APP-19	CTA-D4.4-CFM-1
HVAC-APP-20	CTA-D4.4-CFM-7
HVAC-APP-21	CTA-D4.4-CFM-8
HVAC-APP-22	CTA-D4.4-CFM-12
HVAC-APP-23	
HVAC-APP-24	CTA-D4.4-CFM-8
HVAC-APP-25	CTA-D4.4-CFM-3
HVAC-APP-26	CTA-D4.4-CFM-4
HVAC-APP-27	CTA-D4.4-DM-1 CTA-D4.4-DM-2 CTA-D4.4-DM-3 CTA-D4.4-DM-4 CTA-D4.4-DM-5 CTA-D4.4-DM-6
HVAC-APP-28	
HVAC-APP-29	CTA-D4.4-DM-10

HVAC application requirement	FDF High level requirement
HVAC-APP-30	CTA-D4.4-DM-18 CTA-D4.4-DM-19 CTA-D4.4-DM-20 CTA-D4.4-DM-21 CTA-D4.4-DM-22 CTA-D4.4-DM-23
HVAC-APP-31	CTA-D4.4-DM-27
HVAC-APP-32	
HVAC-APP-33	CTA-D4.4-DM-7 CTA-D4.4-DM-8 CTA-D4.4-DM-9
HVAC-APP-34	CTA-D4.4-EL-1 CTA-D4.4-EL-6
HVAC-APP-35	
HVAC-APP-36	
HVAC-APP-37	CTA-D4.4-EL-7
HVAC-APP-38	
HVAC-APP-39	
HVAC-APP-40	CTA-D4.4-MO-1 CTA-D4.4-MO-5
HVAC-APP-41	
HVAC-APP-42	CTA-D4.4-CM-13
HVAC-APP-43	CTA-D4.4-CM-13
HVAC-APP-44	CTA-D4.4-CM-14

HVAC application requirement	FDF High level requirement
HVAC-APP-45	CTA-D4.4-CM-14
HVAC-APP-46	CTA-D4.4-CM-13
HVAC-APP-47	CTA-D4.4-CM-14
HVAC-APP-48	CTA-D4.4-CM-13
HVAC-APP-49	CTA-D4.4-CM-14
HVAC-APP-50	CTA-D4.4-PS-1
HVAC-APP-51	CTA-D4.4-PS-2
HVAC-APP-52	CTA-D4.4-PS-4 CTA-D4.4-PS-3
HVAC-APP-53	CTA-D4.4-PS-4
HVAC-APP-54	CTA-D4.4-PS-5
HVAC-APP-55	CTA-D4.4-PS-6
HVAC-APP-56	CTA-D4.4-SM-1 CTA-D4.4-SM-2
HVAC-APP-57	CTA-D4.4-TM-1
HVAC-APP-58	

Table 13: HVAC application requirements vs high level requirements

Annex B TRDP data sets definition

Four different datasets are defined to specify the configuration of the TRDP communication between the Gateway and the Communication Bridge for the simulation scenario in the urban demonstrator. An XML file has been defined for each data set description:

- devGW-IO.xml: gateway HVAC IO dataset.
- devGW-ENV.xml: gateway environment dataset.
- devHVAC-IO.xml: HVAC application IO dataset.
- devHVAC-ENV.xml: HVAC environment dataset.

The detail of each dataset's specification is described following.

Gateway IO dataset

The Gateway IO data-set-list XML definition is described in the following figure.

```
<data-set-list>
    <!-- Specific Telegram Datasets -->
    <data-set name="BK4_IO_PD" id="1640">
            <element name="Status Power Good Reset Info Ext Int" type="UINT8" id="1" />
            <element name="Spare" type="UINT8" id="2" />
            <element name="Internal MCU Temperature Sensor" type="INT16" id="3"/>
            <element name="Main Power Supply Voltage" type="UINT16" id="4"/>
            <element name="Power Supply Heat Sink Temperature" type="INT16" id="5"/>
            <element name="Binary Inputs" type="UINT32" id="6"/>
            <element name="Binary Output Current Sense 00" type="UINT16" id="7"/>
            <element name="Binary Output Current Sense 01" type="UINT16" id="8"/>
            <element name="Binary Output Current Sense 02" type="UINT16" id="9"/>
            <element name="Binary Output Current Sense 04" type="UINT16" id="10"/>
            <element name="Binary Output Current Sense 05" type="UINT16" id="11"/>
            <element name="Binary Output Current Sense 06" type="UINT16" id="12"/>
            <element name="Binary Output Current Sense 07" type="UINT16" id="13"/>
            <element name="Binary Output Current Sense 08" type="UINT16" id="14"/>
            <element name="Binary Output Current Sense 09" type="UINT16" id="15"/>
            <element name="Binary Output Current Sense 10" type="UINT16" id="16"/>
            <element name="Binary Output Current Sense 11" type="UINT16" id="17"/>
            <element name="Binary Output Analog Feedback 00" type="UINT16" id="18"/>
            <element name="Binary Output Analog Feedback 01" type="UINT16" id="19"/>
            <element name="Binary Output Analog Feedback 02" type="UINT16" id="20"/>
            <element name="Binary Output Analog Feedback 03" type="UINT16" id="21"/>
            <element name="Binary Output Analog Feedback 04" type="UINT16" id="22"/>
            <element name="Binary Output Analog Feedback 05" type="UINT16" id="23"/>
            <element name="Binary Output Analog Feedback 06" type="UINT16" id="24"/>
            <element name="Binary Output Analog Feedback 07" type="UINT16" id="25"/>
            <element name="Binary Output Analog Feedback 08" type="UINT16" id="26"/>
            <element name="Binary Output Analog Feedback 09" type="UINT16" id="27"/>
            <element name="Binary Output Analog Feedback 10" type="UINT16" id="28"/>
            <element name="Binary Output Analog Feedback 11" type="UINT16" id="29"/>
            <element name="Power Supply Binary Output Feedback 0" type="UINT16" id="30"/>
            <element name="Power Supply Binary Output Feedback 1" type="UINT16" id="31"/>
            <element name="Power Supply Binary Output Feedback 2" type="UINT16" id="32"/>
            <element name="Power Supply Binary Output Feedback 3" type="UINT16" id="33"/>
            <element name="Power Supply Binary Output Feedback 4|5" type="UINT16" id="34"/>
            <element name="1-Wire Mean Temperature Sensor 00" type="INT16" id="35"/>
            <element name="1-Wire Mean Temperature Sensor 01" type="INT16" id="36"/>
            <element name="1-Wire Mean Temperature Sensor 02" type="INT16" id="37"/>
            <element name="1-Wire Mean Temperature Sensor 03" type="INT16" id="38"/>
            <element name="1-Wire Mean Temperature Sensor 04" type="INT16" id="39"/>
            <element name="1-Wire Mean Temperature Sensor 05" type="INT16" id="40"/>
            <element name="1-Wire Mean Temperature Sensor 06" type="INT16" id="41"/>
            <element name="1-Wire Mean Temperature Sensor 07" type="INT16" id="42"/>
            <element name="1-Wire Mean Temperature Sensor 08" type="INT16" id="43"/>
            <element name="1-Wire Mean Temperature Sensor 09" type="INT16" id="44"/>
            <element name="1-Wire Mean Temperature Sensor 10" type="INT16" id="45"/>
            <element name="1-Wire Mean Temperature Sensor 11" type="INT16" id="46"/>
            <element name="Spare" type="UINT16" id="47" />
            <element name="1-Wire Diagnostics" type="UINT8" id="48"/>
            <element name="1-Wire Bus Status" type="UINT8" id="49"/>
            <element name="Analog Input/Output 00" type="UINT16" id="50"/>
            <element name="Analog Input/Output 01" type="UINT16" id="51"/>
            <element name="Analog Input/Output 02" type="UINT16" id="52"/>
            <element name="Analog Input/Output 03" type="UINT16" id="53"/>
            <element name="Analog Input/Output 04" type="UINT16" id="54"/>
            <element name="Analog Input/Output 05" type="UINT16" id="55"/>
            <element name="Analog Input/Output 06" type="UINT16" id="56"/>
            <element name="Analog Input/Output 07" type="UINT16" id="57"/>
            <element name="External DAC7718 Feedback" type="UINT16" id="58"/>
            <element name="DAC Reference Feedback" type="UINT16" id="59"/>
            <element name="Analog Current Output Error" type="UINT8" id="60"/>
            <element name="Spare" type="UINT8" id="61" />
    </data-set>
    <data-set name="HVAC_IO_PD" id="1540">
            <element name="General Signals" type="UINT8" id="1"/>
            <element name="General Commands" type="UINT8" id="2"/>
            <element name="Binary Outputs" type="UINT16" id="3"/>
            <element name="Duty Cycle Binary Output 00" type="UINT8" id="4"/>
            <element name="Duty Cycle Binary Output 01" type="UINT8" id="5"/>
            <element name="Duty Cycle Binary Output 02" type="UINT8" id="6"/>
            <element name="Duty Cycle Binary Output 03" type="UINT8" id="7"/>
            <element name="Duty Cycle Binary Output 04" type="UINT8" id="8"/>
            <element name="Duty Cycle Binary Output 05" type="UINT8" id="9"/>
            <element name="Duty Cycle Binary Output 06" type="UINT8" id="10"/>
            <element name="Duty Cycle Binary Output 07" type="UINT8" id="11"/>
            <element name="Duty Cycle Binary Output 08" type="UINT8" id="12"/>
            <element name="Duty Cycle Binary Output 09" type="UINT8" id="13"/>
            <element name="Duty Cycle Binary Output 10" type="UINT8" id="14"/>
            <element name="Duty Cycle Binary Output 11" type="UINT8" id="15"/>
            <element name="DAC Output Value 00" type="UINT16" id="16"/>
            <element name="DAC Output Value 01" type="UINT16" id="17"/>
            <element name="DAC Output Value 02" type="UINT16" id="18"/>
            <element name="DAC Output Value 03" type="UINT16" id="19"/>
            <element name="DAC Output Value 04" type="UINT16" id="20"/>
            <element name="DAC Output Value 05" type="UINT16" id="21"/>
            <element name="DAC Output Value 06" type="UINT16" id="22"/>
            <element name="DAC Output Value 07" type="UINT16" id="23"/>
    </data-set>
</data-set-list>
```

Figure 1: Gateway IO data-set-list XML definition

HVAC application IO dataset

The HVAC application IO data-set-list XML definition is the same as for the Gateway IO. However, the bus-interface list differs since data such as the telegram name or source and destination ids are different.

```
<data-set-list>
    <!-- Specific Telegram Datasets -->
    <data-set name="BK4_IO_PD" id="1640">
            <element name="Status Power Good Reset Info Ext Int" type="UINT8" id="1" />
            <element name="Spare" type="UINT8" id="2" />
            <element name="Internal MCU Temperature Sensor" type="INT16" id="3"/>
            <element name="Main Power Supply Voltage" type="UINT16" id="4"/>
            <element name="Power Supply Heat Sink Temperature" type="INT16" id="5"/>
            <element name="Binary Inputs" type="UINT32" id="6"/>
            <element name="Binary Output Current Sense 00" type="UINT16" id="7"/>
            <element name="Binary Output Current Sense 01" type="UINT16" id="8"/>
            <element name="Binary Output Current Sense 02" type="UINT16" id="9"/>
            <element name="Binary Output Current Sense 04" type="UINT16" id="10"/>
            <element name="Binary Output Current Sense 05" type="UINT16" id="11"/>
            <element name="Binary Output Current Sense 06" type="UINT16" id="12"/>
            <element name="Binary Output Current Sense 07" type="UINT16" id="13"/>
            <element name="Binary Output Current Sense 08" type="UINT16" id="14"/>
            <element name="Binary Output Current Sense 09" type="UINT16" id="15"/>
            <element name="Binary Output Current Sense 10" type="UINT16" id="16"/>
            <element name="Binary Output Current Sense 11" type="UINT16" id="17"/>
            <element name="Binary Output Analog Feedback 00" type="UINT16" id="18"/>
            <element name="Binary Output Analog Feedback 01" type="UINT16" id="19"/>
            <element name="Binary Output Analog Feedback 02" type="UINT16" id="20"/>
            <element name="Binary Output Analog Feedback 03" type="UINT16" id="21"/>
            <element name="Binary Output Analog Feedback 04" type="UINT16" id="22"/>
            <element name="Binary Output Analog Feedback 05" type="UINT16" id="23"/>
            <element name="Binary Output Analog Feedback 06" type="UINT16" id="24"/>
            <element name="Binary Output Analog Feedback 07" type="UINT16" id="25"/>
            <element name="Binary Output Analog Feedback 08" type="UINT16" id="26"/>
            <element name="Binary Output Analog Feedback 09" type="UINT16" id="27"/>
            <element name="Binary Output Analog Feedback 10" type="UINT16" id="28"/>
            <element name="Binary Output Analog Feedback 11" type="UINT16" id="29"/>
            <element name="Power Supply Binary Output Feedback 0" type="UINT16" id="30"/>
            <element name="Power Supply Binary Output Feedback 1" type="UINT16" id="31"/>
            <element name="Power Supply Binary Output Feedback 2" type="UINT16" id="32"/>
            <element name="Power Supply Binary Output Feedback 3" type="UINT16" id="33"/>
            <element name="Power Supply Binary Output Feedback 4|5" type="UINT16" id="34"/>
            <element name="1-Wire Mean Temperature Sensor 00" type="INT16" id="35"/>
            <element name="1-Wire Mean Temperature Sensor 01" type="INT16" id="36"/>
            <element name="1-Wire Mean Temperature Sensor 02" type="INT16" id="37"/>
            <element name="1-Wire Mean Temperature Sensor 03" type="INT16" id="38"/>
            <element name="1-Wire Mean Temperature Sensor 04" type="INT16" id="39"/>
            <element name="1-Wire Mean Temperature Sensor 05" type="INT16" id="40"/>
            <element name="1-Wire Mean Temperature Sensor 06" type="INT16" id="41"/>
            <element name="1-Wire Mean Temperature Sensor 07" type="INT16" id="42"/>
            <element name="1-Wire Mean Temperature Sensor 08" type="INT16" id="43"/>
            <element name="1-Wire Mean Temperature Sensor 09" type="INT16" id="44"/>
            <element name="1-Wire Mean Temperature Sensor 10" type="INT16" id="45"/>
            <element name="1-Wire Mean Temperature Sensor 11" type="INT16" id="46"/>
            <element name="Spare" type="UINT16" id="47" />
            <element name="1-Wire Diagnostics" type="UINT8" id="48"/>
            <element name="1-Wire Bus Status" type="UINT8" id="49"/>
            <element name="Analog Input/Output 00" type="UINT16" id="50"/>
            <element name="Analog Input/Output 01" type="UINT16" id="51"/>
            <element name="Analog Input/Output 02" type="UINT16" id="52"/>
            <element name="Analog Input/Output 03" type="UINT16" id="53"/>
            <element name="Analog Input/Output 04" type="UINT16" id="54"/>
            <element name="Analog Input/Output 05" type="UINT16" id="55"/>
            <element name="Analog Input/Output 06" type="UINT16" id="56"/>
            <element name="Analog Input/Output 07" type="UINT16" id="57"/>
            <element name="External DAC7718 Feedback" type="UINT16" id="58"/>
            <element name="DAC Reference Feedback" type="UINT16" id="59"/>
            <element name="Analog Current Output Error" type="UINT8" id="60"/>
            <element name="Spare" type="UINT8" id="61" />
    </data-set>
    <data-set name="HVAC_IO_PD" id="1540">
            <element name="General Signals" type="UINT8" id="1"/>
            <element name="General Commands" type="UINT8" id="2"/>
            <element name="Binary Outputs" type="UINT16" id="3"/>
            <element name="Duty Cycle Binary Output 00" type="UINT8" id="4"/>
            <element name="Duty Cycle Binary Output 01" type="UINT8" id="5"/>
            <element name="Duty Cycle Binary Output 02" type="UINT8" id="6"/>
            <element name="Duty Cycle Binary Output 03" type="UINT8" id="7"/>
            <element name="Duty Cycle Binary Output 04" type="UINT8" id="8"/>
            <element name="Duty Cycle Binary Output 05" type="UINT8" id="9"/>
            <element name="Duty Cycle Binary Output 06" type="UINT8" id="10"/>
            <element name="Duty Cycle Binary Output 07" type="UINT8" id="11"/>
            <element name="Duty Cycle Binary Output 08" type="UINT8" id="12"/>
            <element name="Duty Cycle Binary Output 09" type="UINT8" id="13"/>
            <element name="Duty Cycle Binary Output 10" type="UINT8" id="14"/>
            <element name="Duty Cycle Binary Output 11" type="UINT8" id="15"/>
            <element name="DAC Output Value 00" type="UINT16" id="16"/>
            <element name="DAC Output Value 01" type="UINT16" id="17"/>
            <element name="DAC Output Value 02" type="UINT16" id="18"/>
            <element name="DAC Output Value 03" type="UINT16" id="19"/>
            <element name="DAC Output Value 04" type="UINT16" id="20"/>
            <element name="DAC Output Value 05" type="UINT16" id="21"/>
            <element name="DAC Output Value 06" type="UINT16" id="22"/>
            <element name="DAC Output Value 07" type="UINT16" id="23"/>
    </data-set>
</data-set-list>
```

Figure 2: HVAC application IO data-set-list XML definition

Gateway environment dataset

The GW Environment data-set-list XML definition is described in the following figure.

```
<data-set-list>
    <!-- Specific Telegram Datasets -->
            <element name="Status Power Good Reset Info Ext Int" type="UINT8" id="1" />
            <element name="Spare" type="UINT8" id="2" />
            <element name="Internal MCU Temperature Sensor" type="INT16" id="3"/>
            <element name="Main Power Supply Voltage" type="UINT16" id="4"/>
            <element name="Power Supply Heat Sink Temperature" type="INT16" id="5"/>
            <element name="Binary Inputs" type="UINT32" id="6"/>
            <element name="Binary Output Current Sense 00" type="UINT16" id="7"/>
            <element name="Binary Output Current Sense 01" type="UINT16" id="8"/>
            <element name="Binary Output Current Sense 02" type="UINT16" id="9"/>
            <element name="Binary Output Current Sense 04" type="UINT16" id="10"/>
            <element name="Binary Output Current Sense 05" type="UINT16" id="11"/>
            <element name="Binary Output Current Sense 06" type="UINT16" id="12"/>
            <element name="Binary Output Current Sense 07" type="UINT16" id="13"/>
            <element name="Binary Output Current Sense 08" type="UINT16" id="14"/>
            <element name="Binary Output Current Sense 09" type="UINT16" id="15"/>
            <element name="Binary Output Current Sense 10" type="UINT16" id="16"/>
            <element name="Binary Output Current Sense 11" type="UINT16" id="17"/>
            <element name="Binary Output Analog Feedback 00" type="UINT16" id="18"/>
            <element name="Binary Output Analog Feedback 01" type="UINT16" id="19"/>
            <element name="Binary Output Analog Feedback 02" type="UINT16" id="20"/>
            <element name="Binary Output Analog Feedback 03" type="UINT16" id="21"/>
            <element name="Binary Output Analog Feedback 04" type="UINT16" id="22"/>
            <element name="Binary Output Analog Feedback 05" type="UINT16" id="23"/>
            <element name="Binary Output Analog Feedback 06" type="UINT16" id="24"/>
            <element name="Binary Output Analog Feedback 07" type="UINT16" id="25"/>
            <element name="Binary Output Analog Feedback 08" type="UINT16" id="26"/>
            <element name="Binary Output Analog Feedback 09" type="UINT16" id="27"/>
            <element name="Binary Output Analog Feedback 10" type="UINT16" id="28"/>
            <element name="Binary Output Analog Feedback 11" type="UINT16" id="29"/>
            <element name="Power Supply Binary Output Feedback 0" type="UINT16" id="30"/>
            <element name="Power Supply Binary Output Feedback 1" type="UINT16" id="31"/>
            <element name="Power Supply Binary Output Feedback 2" type="UINT16" id="32"/>
            <element name="Power Supply Binary Output Feedback 3" type="UINT16" id="33"/>
            <element name="Power Supply Binary Output Feedback 4|5" type="UINT16" id="34"/>
            <element name="1-Wire Mean Temperature Sensor 00" type="INT16" id="35"/>
            <element name="1-Wire Mean Temperature Sensor 01" type="INT16" id="36"/>
            <element name="1-Wire Mean Temperature Sensor 02" type="INT16" id="37"/>
            <element name="1-Wire Mean Temperature Sensor 03" type="INT16" id="38"/>
            <element name="1-Wire Mean Temperature Sensor 04" type="INT16" id="39"/>
            <element name="1-Wire Mean Temperature Sensor 05" type="INT16" id="40"/>
            <element name="1-Wire Mean Temperature Sensor 06" type="INT16" id="41"/>
            <element name="1-Wire Mean Temperature Sensor 07" type="INT16" id="42"/>
            <element name="1-Wire Mean Temperature Sensor 08" type="INT16" id="43"/>
            <element name="1-Wire Mean Temperature Sensor 09" type="INT16" id="44"/>
            <element name="1-Wire Mean Temperature Sensor 10" type="INT16" id="45"/>
            <element name="1-Wire Mean Temperature Sensor 11" type="INT16" id="46"/>
            <element name="Spare" type="UINT16" id="47" />
            <element name="1-Wire Diagnostics" type="UINT8" id="48"/>
            <element name="1-Wire Bus Status" type="UINT8" id="49"/>
            <element name="Analog Input/Output 00" type="UINT16" id="50"/>
            <element name="Analog Input/Output 01" type="UINT16" id="51"/>
            <element name="Analog Input/Output 02" type="UINT16" id="52"/>
            <element name="Analog Input/Output 03" type="UINT16" id="53"/>
            <element name="Analog Input/Output 04" type="UINT16" id="54"/>
            <element name="Analog Input/Output 05" type="UINT16" id="55"/>
            <element name="Analog Input/Output 06" type="UINT16" id="56"/>
            <element name="Analog Input/Output 07" type="UINT16" id="57"/>
            <element name="External DAC7718 Feedback" type="UINT16" id="58"/>
            <element name="DAC Reference Feedback" type="UINT16" id="59"/>
            <element name="Analog Current Output Error" type="UINT8" id="60"/>
            <element name="Spare" type="UINT8" id="61" />
    </data-set>
    <data-set name="HVAC_ENV_PD" id="1541">
            <element name="General Signals" type="UINT8" id="1"/>
            <element name="General Commands" type="UINT8" id="2"/>
            <element name="Binary Outputs" type="UINT16" id="3"/>
            <element name="Duty Cycle Binary Output 00" type="UINT8" id="4"/>
            <element name="Duty Cycle Binary Output 01" type="UINT8" id="5"/>
            <element name="Duty Cycle Binary Output 02" type="UINT8" id="6"/>
            <element name="Duty Cycle Binary Output 03" type="UINT8" id="7"/>
            <element name="Duty Cycle Binary Output 04" type="UINT8" id="8"/>
            <element name="Duty Cycle Binary Output 05" type="UINT8" id="9"/>
            <element name="Duty Cycle Binary Output 06" type="UINT8" id="10"/>
            <element name="Duty Cycle Binary Output 07" type="UINT8" id="11"/>
            <element name="Duty Cycle Binary Output 08" type="UINT8" id="12"/>
            <element name="Duty Cycle Binary Output 09" type="UINT8" id="13"/>
            <element name="Duty Cycle Binary Output 10" type="UINT8" id="14"/>
            <element name="Duty Cycle Binary Output 11" type="UINT8" id="15"/>
            <element name="DAC Output Value 00" type="UINT16" id="16"/>
            <element name="DAC Output Value 01" type="UINT16" id="17"/>
            <element name="DAC Output Value 02" type="UINT16" id="18"/>
            <element name="DAC Output Value 03" type="UINT16" id="19"/>
            <element name="DAC Output Value 04" type="UINT16" id="20"/>
            <element name="DAC Output Value 05" type="UINT16" id="21"/>
            <element name="DAC Output Value 06" type="UINT16" id="22"/>
            <element name="DAC Output Value 07" type="UINT16" id="23"/>
    </data-set>
</data-set-list>
```

Figure 3: Gateway Environment data-set-list XML definition

HVAC environment dataset

The HVAC Environment data-set-list XML definition is the same as for the Gateway environment. However, the bus-interface list differs since data such as the telegram name or source and destination ids are different.

```
<data-set-list>
    <!-- Specific Telegram Datasets -->
            <element name="Status Power Good Reset Info Ext Int" type="UINT8" id="1" />
            <element name="Spare" type="UINT8" id="2" />
            <element name="Internal MCU Temperature Sensor" type="INT16" id="3"/>
            <element name="Main Power Supply Voltage" type="UINT16" id="4"/>
            <element name="Power Supply Heat Sink Temperature" type="INT16" id="5"/>
            <element name="Binary Inputs" type="UINT32" id="6"/>
            <element name="Binary Output Current Sense 00" type="UINT16" id="7"/>
            <element name="Binary Output Current Sense 01" type="UINT16" id="8"/>
            <element name="Binary Output Current Sense 02" type="UINT16" id="9"/>
            <element name="Binary Output Current Sense 04" type="UINT16" id="10"/>
            <element name="Binary Output Current Sense 05" type="UINT16" id="11"/>
            <element name="Binary Output Current Sense 06" type="UINT16" id="12"/>
            <element name="Binary Output Current Sense 07" type="UINT16" id="13"/>
            <element name="Binary Output Current Sense 08" type="UINT16" id="14"/>
            <element name="Binary Output Current Sense 09" type="UINT16" id="15"/>
            <element name="Binary Output Current Sense 10" type="UINT16" id="16"/>
            <element name="Binary Output Current Sense 11" type="UINT16" id="17"/>
            <element name="Binary Output Analog Feedback 00" type="UINT16" id="18"/>
            <element name="Binary Output Analog Feedback 01" type="UINT16" id="19"/>
            <element name="Binary Output Analog Feedback 02" type="UINT16" id="20"/>
            <element name="Binary Output Analog Feedback 03" type="UINT16" id="21"/>
            <element name="Binary Output Analog Feedback 04" type="UINT16" id="22"/>
            <element name="Binary Output Analog Feedback 05" type="UINT16" id="23"/>
            <element name="Binary Output Analog Feedback 06" type="UINT16" id="24"/>
            <element name="Binary Output Analog Feedback 07" type="UINT16" id="25"/>
            <element name="Binary Output Analog Feedback 08" type="UINT16" id="26"/>
            <element name="Binary Output Analog Feedback 09" type="UINT16" id="27"/>
            <element name="Binary Output Analog Feedback 10" type="UINT16" id="28"/>
            <element name="Binary Output Analog Feedback 11" type="UINT16" id="29"/>
            <element name="Power Supply Binary Output Feedback 0" type="UINT16" id="30"/>
            <element name="Power Supply Binary Output Feedback 1" type="UINT16" id="31"/>
            <element name="Power Supply Binary Output Feedback 2" type="UINT16" id="32"/>
            <element name="Power Supply Binary Output Feedback 3" type="UINT16" id="33"/>
            <element name="Power Supply Binary Output Feedback 4|5" type="UINT16" id="34"/>
            <element name="1-Wire Mean Temperature Sensor 00" type="INT16" id="35"/>
            <element name="1-Wire Mean Temperature Sensor 01" type="INT16" id="36"/>
            <element name="1-Wire Mean Temperature Sensor 02" type="INT16" id="37"/>
            <element name="1-Wire Mean Temperature Sensor 03" type="INT16" id="38"/>
            <element name="1-Wire Mean Temperature Sensor 04" type="INT16" id="39"/>
            <element name="1-Wire Mean Temperature Sensor 05" type="INT16" id="40"/>
            <element name="1-Wire Mean Temperature Sensor 06" type="INT16" id="41"/>
            <element name="1-Wire Mean Temperature Sensor 07" type="INT16" id="42"/>
            <element name="1-Wire Mean Temperature Sensor 08" type="INT16" id="43"/>
            <element name="1-Wire Mean Temperature Sensor 09" type="INT16" id="44"/>
            <element name="1-Wire Mean Temperature Sensor 10" type="INT16" id="45"/>
            <element name="1-Wire Mean Temperature Sensor 11" type="INT16" id="46"/>
            <element name="Spare" type="UINT16" id="47" />
            <element name="1-Wire Diagnostics" type="UINT8" id="48"/>
            <element name="1-Wire Bus Status" type="UINT8" id="49"/>
            <element name="Analog Input/Output 00" type="UINT16" id="50"/>
            <element name="Analog Input/Output 01" type="UINT16" id="51"/>
            <element name="Analog Input/Output 02" type="UINT16" id="52"/>
            <element name="Analog Input/Output 03" type="UINT16" id="53"/>
            <element name="Analog Input/Output 04" type="UINT16" id="54"/>
            <element name="Analog Input/Output 05" type="UINT16" id="55"/>
            <element name="Analog Input/Output 06" type="UINT16" id="56"/>
            <element name="Analog Input/Output 07" type="UINT16" id="57"/>
            <element name="External DAC7718 Feedback" type="UINT16" id="58"/>
            <element name="DAC Reference Feedback" type="UINT16" id="59"/>
            <element name="Analog Current Output Error" type="UINT8" id="60"/>
            <element name="Spare" type="UINT8" id="61" />
    </data-set>
    <data-set name="HVAC_ENV_PD" id="1541">
            <element name="General Signals" type="UINT8" id="1"/>
            <element name="General Commands" type="UINT8" id="2"/>
            <element name="Binary Outputs" type="UINT16" id="3"/>
            <element name="Duty Cycle Binary Output 00" type="UINT8" id="4"/>
            <element name="Duty Cycle Binary Output 01" type="UINT8" id="5"/>
            <element name="Duty Cycle Binary Output 02" type="UINT8" id="6"/>
            <element name="Duty Cycle Binary Output 03" type="UINT8" id="7"/>
            <element name="Duty Cycle Binary Output 04" type="UINT8" id="8"/>
            <element name="Duty Cycle Binary Output 05" type="UINT8" id="9"/>
            <element name="Duty Cycle Binary Output 06" type="UINT8" id="10"/>
            <element name="Duty Cycle Binary Output 07" type="UINT8" id="11"/>
            <element name="Duty Cycle Binary Output 08" type="UINT8" id="12"/>
            <element name="Duty Cycle Binary Output 09" type="UINT8" id="13"/>
            <element name="Duty Cycle Binary Output 10" type="UINT8" id="14"/>
            <element name="Duty Cycle Binary Output 11" type="UINT8" id="15"/>
            <element name="DAC Output Value 00" type="UINT16" id="16"/>
            <element name="DAC Output Value 01" type="UINT16" id="17"/>
            <element name="DAC Output Value 02" type="UINT16" id="18"/>
            <element name="DAC Output Value 03" type="UINT16" id="19"/>
            <element name="DAC Output Value 04" type="UINT16" id="20"/>
            <element name="DAC Output Value 05" type="UINT16" id="21"/>
            <element name="DAC Output Value 06" type="UINT16" id="22"/>
            <element name="DAC Output Value 07" type="UINT16" id="23"/>
    </data-set>
</data-set-list>
```

Figure 4: HVAC Environment data-set-list XML definition