

FP5TRAN **4M-R** Transforming Europe's Rail Freight

D5.4 Appendix T2 Test plan for communication system

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1 Introduction

This document defines the validation/test plan of the DAC Power and Data Communication solution (FP5-TRANS4M-R Task 5.5) and serves as a supplement (appendix [T2]) to the FP5-TRANS4M-R Deliverable 5.4 "Technical Specification of Wagon Power System and Communication System" V2.0.

One of the remaining open points of Deliverable 5.4 (D5.4) was the definition of a Test plan for the communication system. This item is closed with this document.

Keywords:

FDFT; Technical Enabler for FDFTO; Power system; Interoperable system interface; Communication system;

2 Terms & Abbreviations, acronyms and definitions

See D5.4 chapter 2.

3 Test plan for communication system

According to the FP5-TRANS4M-R Grand Agreement, WP5 Task 5.5 shall provide the specification and the related validation/test plan for the interoperable communication subsystem. WP9 shall, in collaboration with WP14, carry out “developer-tests” in order to ensure the suitable system approaches for the FDFTO communication system for locomotives and wagons. More specifically, WP9 shall (see GA, WP9 Sub-Task 9.2.2):

- setup and integrate a test system for interoperability tests
- verify the real-time data communication protocol, safety related protocol, the compatibility of the physical layer by transmitting dummy messages through real time data communication protocol and safety related protocol.
- Verify and validate full functionality in the train test lab (WP13 + WP14)

This test plan has a focus on the first two points in order to ensure that interoperable and integrable communication systems are delivered to the train test lab.

Final validation and test results shall be documented as part of D14.3: “Test and Validation Report for the energy system (Locos and wagons) and data communication system”.

3.1 System under Test (SuT)

The SuT is the communication subsystem defined in D5.4 chapter 7.3.1.

3.2 Test strategy

3.2.1 Test scope

Test scope is the Ethernet and IP based communication between end devices / end systems belonging to the consists in the train composition. This includes all the communication functions required for train wide data exchange as defined in D5.4 chapter 7.3.4.

This includes also those functions which are used for supporting train functions defined in D5.1, like:

- Passive consist detection by DC current measurement supporting the train function “train composition discovery”.
- Independent consist orientation detection by DC voltage measurement supporting the train function “train composition discovery”.
- Customer specific HELLO frame TLVs supporting the train function “automatic decoupling”.

Testing the related train functions is not in scope.

3.2.2 Test groups

Due to the time limitations for the component development and due to the fact that different tests may require a different test setup and laboratory equipment, one strategic objective is to parallelize tests where appropriate. This can best be organized by defining

test groups, where each test group uses a specific setup and laboratory equipment. An overview of the different test groups and the related test setups ("test environment") is presented in Table 1. The more detailed description is given in 3.3.

CH.	TEST GROUP	TEST ENV.	COMMENTS
3.3.2	General checks	JCTL	
3.3.3	Basic interface	Supplier	ECN/F-ETB connected devices
3.3.4	Ethernet channel	JCTL	Ethernet link between two active F-ETBN
3.3.5	ECN Test	Supplier	ECN connected devices
3.3.6	Wake-up	Supplier	Test of physical layer part. Test of train-wide wakeup belongs to train functions test (out of scope)
3.3.7	Passive consist	Supplier	Test of physical layer part Test of passive consist insertion into train composition belongs to train functions test (out of scope)
3.3.8	Consist orientation	JCTL	Support of independent consist orientation detection. Test of consist orientation detection function belongs to train functions test (out of scope)
3.3.9	Shielding&grounding	JCTL, TTL	Test of grounding concept
3.3.10	ETB inauguration	JCTL	TTDP, TND computation
3.3.11	HELLO frame TLV	JCTL	Support automatic decoupling. Test of the automatic decoupling function belongs to train functions test (out of scope)
3.3.12	Train topology detection	JCTL	TTDB computation
3.3.13	TRDP communication	JCTL	Includes IP protocol stack
3.3.14	F-ETB Line redundancy	JCTL	
3.3.15	SDT communication	JCTL	SDTv2
3.3.16	Cyber Security	TTL	
3.3.17	Performance	JCTL, TTL	

Table 1: Test groups

3.2.3 Test process

The testing and verification process shall follow the V model as depicted below. Base are the input requirements given within this document for the FDFT communication system with the objective of a finally 100% requirements coverage. Not in scope are tests on product and component level, but prerequisite of participating in the communication system test is a successful execution of component and product tests at supplier side. This is to prevent that immature products hinder the progress of system level tests.

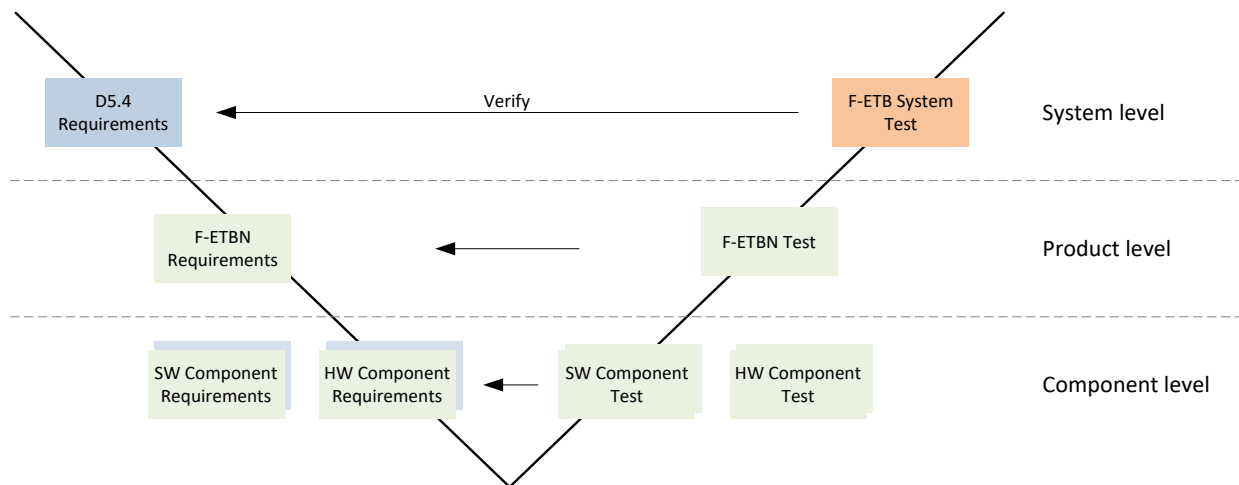


Figure 1: Overall F-ETB test strategy

3.2.4 Definition of test cases

Test cases and inspection items derived from the requirements can be categorized into verification activities, measurement activities and test activities. The characteristics of these activities are defined in Table 2.

Category	Description	Keywords	Example
Verification activities	Verification of procedures, processes and documents	verification, verify	Verify that ...
Measurement activities	Measurement and recording of physical quantities (e.g. size, distance, voltage, current, temperature, time). Does not include a pass or fail verdict.	measurement, measure	Measure the
Test activities	Check of properties or measurement results. Includes a pass or fail verdict.	test, check	Check that ... Test the ...

Table 2: Test case categories (source: D5.4 reference /62/)

3.2.5 Test documentation

Tests and test results executed at supplier and JCTL premises shall be documented within deliverable D9.3 and D9.5.

Tests and test results executed in TTL shall be documented in deliverables of WP14.

3.3 Test activities

This chapter defines the different testing activities for the execution of the system test groups, basically intended for test planning. For the test execution itself more detailed test specifications, which are derived from the requirements set out in this document, should be provided.

3.3.1 General

3.3.1.1 Test responsibility

All beneficiaries providing FDFTO communication systems shall name one test responsible. Those beneficiaries are: SMO, KB, VOI, FT, ALSTOM.

3.3.1.2 Test location

Supplier: supplier premises

JCTL: Joint Communication Test Lab (FT Piosasco)

TTL: Train Test Lab (Berlin)

3.3.1.3 Test infrastructure

Test infrastructure is defined by the different test groups which are listed in Table 3.

Test Env.	Laboratory equipment (test laboratory)	SuT requirements (supplier)
Supplier	Supplier responsibility	F-ETBN prototype
Joint Communication Test Lab (JCTL)	- Prepared for Ethernet SPE physical layer tests (Cable meter for CAT5e cable measurements, burst generator, Ethernet frame generator and receiver for performance and FER measurements). - Provision to setup an (instrumented) Ethernet channel with maximal extension (400m) where supplier's F-ETBN can be plugged in. - Prepared for F-ETB communication tests (Wireshark, load generators, consist simulators, ...).	F-ETBN prototype with following features: - 4 10BASE-T1L Ethernet ports (for consist directions 1&2) - Bypass function (bridging the 2 Eth ports) - Sending/receiving of Ethernet frames - Controllable passive consist detection voltage source - Passive consist detection load - Wake-up signal detection - Voltage measurement - Compliant to IEC 61375-2-5 ED2 and IEC 61375-2-3 ED2
Train Test Lab (TTL)	As defined by WP13.	Integrable and interoperable F-ETBN prototypes of TRL $\geq$ 6

Table 3: Test infrastructure requirements

3.3.2 General checks

3.3.2.1 Test goals

Check some general features and availability of documentation

3.3.2.2 Test environment

JCTL

3.3.2.3 Test setup

Not relevant

3.3.2.4 Tests and measurements

- Check availability of user manual and installation manual of the DuT
- Check that supplier states conformity to Y2038 problem

3.3.3 Basic interface test

3.3.3.1 Test goals

Test the correctness of mechanical and electrical parameters of the physical layer network interface and basic IP communication capabilities.

3.3.3.2 Test environment

Supplier

3.3.3.3 Test setup

The principal test setup is depicted in Figure 2. A more detailed view on the DuT's medium interface is presented in D5.4 Figure 22. See also IEC 61375-2-8 clause 5.

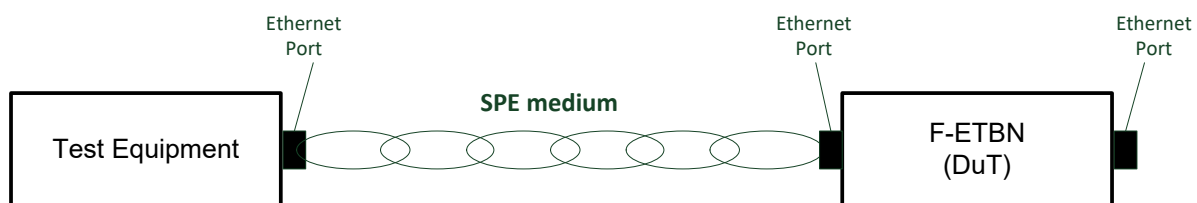


Figure 2: Test of physical layer interface (only one F-ETB line shown)

For testing bypass function the DuT may be placed between two test equipment devices.

3.3.3.4 Tests and measurements

Tests and measurements are based on IEC 61375-2-8 clause 5. Those include:

- Inspection of the Hardware Ethernet interface
 - Inspection of the mechanical Ethernet interface construction (connector type, grounding)
 - Check of electrical Ethernet interface design
- Testing of the transmitter waveform, transmitter distortion, transmitter jitter, and transmitter drop as defined in IEEE 802.3cg subclause 146.5.4.
- Testing of the receiver's capability to receive differential signals at F-ETBN Ethernet ports, that were transmitted from a remote transmitter within the specifications

of IEEE 802.3cg subclause 146.5.4 and have passed through a link segment as specified in IEEE 802.3cg subclause 146.7, with a frame error ratio less than 10^{-6} for 125 octet frames.

- Auto-Crossover- and Auto-Sensing-Test (only for switches)
- Simple communication test (Ethernet frames)
- UDP rising payload test (only for End Devices)
- TCP rising payload test (only for End Devices)
- UDP long term test (only for End Devices)
- Burst immunity test as defined in D5.4 reference /62/ subclause 5.6.2.2.

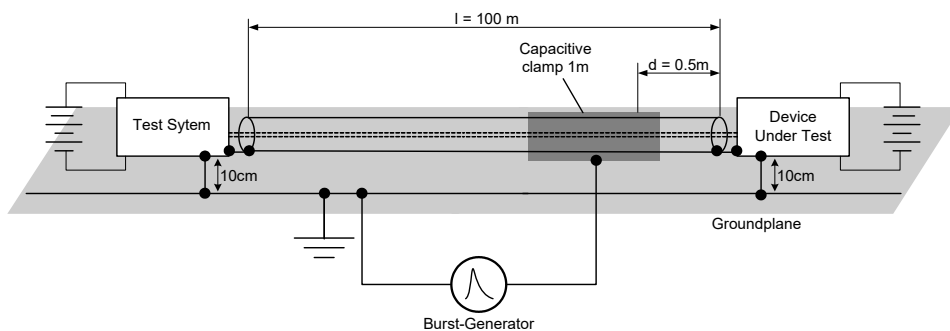


Figure 3: Setup for burst immunity test (source: D5.4 reference /62/)

- Ethernet interface isolation test

Additional checks and tests:

- Bypass functionality
- VLAN support (port based, tagged)
- Ethernet priorities
- Frame preemption
- Configuration of a monitoring port

3.3.4 Ethernet Channel assembly test (F-ETB)

3.3.4.1 Test goals

Check conformity of an Ethernet channel assembly to IEC 11801 AMD1 D5.4 reference /30/.

3.3.4.2 Test environment

JCTL

3.3.4.3 Test setup

The Ethernet channel shall be constructed with real components (SPE cable and connectors, junction boxes, E-couplers, circuitry for wake-up and passive consist detection), with real cable length and with at least 10 intermediate passive consists. (Figure 4).

The F-ETB Ethernet channel is classified in accordance to D5.4 reference /30/ as:

- Class T1-A
- Sub-class T1-A-400

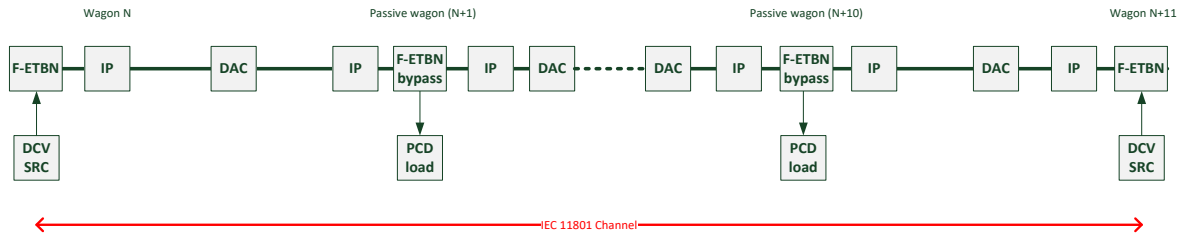


Figure 4: Ethernet channel assembly (example)

F-ETBN of the different suppliers shall both be placed at channels ends (active F-ETBN) and within the channel (passive F-ETBN in bypass).

Measurements can be done with a suitable cable meter (e.g., Fluke?)

3.3.4.4 Tests and measurements

- Measure the channel parameters as defined in D5.4 reference /30/ subclause 6.2:
 - Return loss
 - Insertion loss
 - DC loop resistance
 - DC resistance unbalance
 - Dielectric withstand
 - Propagation delay
 - Coupling attenuation
- Measure crosstalk (NEXT/FEXT) between the F-ETB lines A and B (based on IEC 61156-6).

3.3.5 ECN Test

3.3.5.1 Test goals

Test of ECN network devices.

3.3.5.2 Test environment

Supplier

3.3.5.3 Test setup

As defined in IEC 61375-2-8 clause 7.

3.3.5.4 Tests and measurements

Tests and measurements are defined in IEC 61375-2-8 clause 7. Those include:

- Recovery in case of network failure
- IP address assignment via DHCP
- Name (TCN-URI address) resolution via DNS
- Switch basic functions
- Priority levels

- Ingress rate limiting
- Egress rate shaping
- Untagged/tagged frames
- Switching and routing performance (optional)
- NTP support
- Switch management
- Network management via SNMP
- ECSP Interface (optional)
- TTDB manager interface (optional)
- DNS TCN interface (optional)
- ETBN control interface (optional)

3.3.6 Wake-up test

3.3.6.1 Test goals

Test train wake-up function.

3.3.6.2 Test environment

JCTL

3.3.6.3 Test setup

Two connected F-ETBN acting as DuT.

3.3.6.4 Tests and measurements

- Test for consists with wake-up source that a wake-up DC signal is applied as specified on demand.
- Measure disturbances created by the wake-up DC signal source on the F-ETB line (ripple voltage and transients, see D5.4 reference /16/ clause 104.4.6.3)
- Test remote consist wake-up when DC voltage is applied to the ETB link
- Measure the time from wake-up signal applied until F-ETBN is operational

3.3.7 Passive consist detection test

3.3.7.1 Test goals

Test the ability to detect passive consists between two active F-ETBN.

3.3.7.2 Test environment

Supplier

3.3.7.3 Test setup

F-ETBN as DuT.

3.3.7.4 Tests and measurements

- Measure the load current of unpowered F-ETBN and check that the load current is in accordance to D5.1 requirement IPTRANS-6773. Measure with different input voltage in the range of 8.0 V ... 26.4 V.
- Connect a number $N = 10$ of unpowered F-ETBN (or load substitutions) to the active F-ETBN and check that the active F-ETBN is able to measure the load current correctly. Measurement should be (sequentially) done on both F-ETB lines A and B and in both directions 1 and 2.

3.3.8 Consist orientation detection test

3.3.8.1 Test goals

Test the ability to detect (relative) consist orientation between two active F-ETBN by voltage measurement.

3.3.8.2 Test environment

Supplier

3.3.8.3 Test setup

Two connected active F-ETBN, one acting as DC voltage source and the other acting as DuT.

3.3.8.4 Tests and measurements

- Check that a DC voltage applied to one of the F-ETB lines A and B is correctly detected by the DuT.
- Repeat the test with DuT reversed.

3.3.9 Shielding & grounding test

3.3.9.1 Test goals

Test the impact of external electromagnetic interference and of stray currents to the data communication.

Use the measurement results to optimize the shielding/grounding concept.

3.3.9.2 Test environment

JCTL, TTL

3.3.9.3 Test setup

DuT: Ethernet channel as defined in 3.3.4. Test setup as defined in EN 50121-3-2 for immunity tests.

3.3.9.4 Tests and measurements

- Test immunity against radio frequency common mode as defined in EN 50121-3-2 (Table 4)
- Test immunity against fast transients (bursts) as defined in EN 50121-3-2 (Table 4)

- Measure quantity, distribution and duration of data communication interruptions occurring during lab immunity tests and during train trials

3.3.10 ETB Inauguration test

3.3.10.1 Test goals

Test that F-ETB is correctly configured after power-up and train composition changes.

3.3.10.2 Test environment

JCTL

3.3.10.3 Test setup

F-ETB with at least 3 F-ETBN (from different suppliers).

3.3.10.4 Tests and measurements

- Check exchange of HELLO-frames, TOPOLOGY-frames and the computation of the train network directory (TND)
- Test with different topology scenarios:
 - Train lengthening (coupling F-ETBNs)
 - Train shortening (de-coupling end F-ETBNs)
 - Late insertion (intermediate F-ETBN is activated delayed)
 - Different orientations of the F-ETBN
- Test with different failure scenarios (single failures):
 - Loss of end F-ETBN (= train shortening)
 - Loss of intermediate F-ETBN
 - Loss of Ethernet link
- Test train inauguration inhibit function
- Check correct IP router configuration

3.3.11 HELLO TLV test

3.3.11.1 Test goals

A custom specific LLDP TLV (Type/Length/Value) is inserted into HELLO frames (parameter 'otherTlvsX') as defined in IEC 61375-2-5 in order to exchange information point-to-point between two adjacent active F-ETBN. This information may be used to support the automatic decoupling function.

3.3.11.2 Test environment

JCTL

3.3.11.3 Test setup

Two coupled F-ETBN (from different suppliers) with connected end device (e.g., WCU, LCU or test PC).

3.3.11.4 Tests and measurements

- Test that each end device is able to request its F-ETBN to send a custom TLV with dummy content to the coupled F-ETBN.

- Check the correct reception of the custom TLV and the forwarding of its content to the connected end device.

3.3.12 Train topology detection test

3.3.12.1 Test goals

Test that the TTDB is correctly computed after power-up and train composition changes.

3.3.12.2 Test environment

JCTL

3.3.12.3 Test setup

F-ETB with at least 3 F-ETBN (from different suppliers).

3.3.12.4 Tests and measurements

- Check the computation of the train network directory (TTDB)
- Test with different topology scenarios:
 - Train lengthening (coupling F-ETBNs)
 - Train shortening (de-coupling end F-ETBNs)
 - Late insertion (intermediate F-ETBN is activated delayed)
 - Different orientations of the F-ETBN
- Test with different operational scenarios:
 - No leading consist
 - Leading consist at different positions
 - Coupling of 2 trains with each having a leading consist (leading conflict)
- Test with different failure scenarios:
 - Loss of end F-ETBN (= train shortening)
 - Loss of intermediate F-ETBN
 - Attempt to set a second leading consist

3.3.13 TRDP communication test

3.3.13.1 Test goals

Test the ability of end devices (e.g., LCU or WCU) to exchange data over F-ETB with TRDP as defined in IEC 61375-2-3:

- Process data (mandatory)
- Message data (optional)

3.3.13.2 Test environment

JCTL

3.3.13.3 Test setup

At least 3 F-ETBN with connected end device(s)

3.3.13.4 Tests and measurements

Tests and measurements shall follow the requirements of TRDP conformance test as defined in IEC 61375-2-8.

3.3.14 ETB Line redundancy test

3.3.14.1 Test goals

Test the behaviour in case of F-ETB line failures.

3.3.14.2 Test environment

JCTL

3.3.14.3 Test setup

Redundancy performance is tested on dual (A+B) F-ETB Line with at least 3 F-ETBN.

3.3.14.4 Tests and measurements

- Measuring data communication interruption time if one F-ETB link segment is interrupted.
- Measuring data communication interruption time if two F-ETB link segments belonging to different F-ETB lines are interrupted at different locations.
- Measuring data communication interruption time if one F-ETBN is switched off.
- Measuring data communication interruption time if one F-ETBN is switched on again.

3.3.15 SDT communication test

3.3.15.1 Test goals

Test the ability of end devices (e.g., LCU or WCU) to exchange data over F-ETB with SDTv2 over TRDP as defined in IEC 61375-2-3.

3.3.15.2 Test environment

JCTL

3.3.15.3 Test setup

At least 3 F-ETBN with connected end device(s).

3.3.15.4 Tests and measurements

Tests and measurements shall follow the requirements of SDTv2 conformance test as defined in IEC 61375-2-8.

3.3.16 Cyber security test

Cyber security feature tests will be planned once cyber security requirements are defined by the cyber security group.

3.3.17 Performance test

3.3.17.1 Test goals

Measure typical performance values of the network in real environment.

3.3.17.2 Test environment

JCTL

3.3.17.3 Test setup

At least 3 connected F-ETBN.

3.3.17.4 Tests and measurements

- Check that communication system is able to run with a maximum of 104 consists
- Measuring end-to-end latency of critical data (high priority) under heavy low priority data traffic load on F-ETB.
- Measure Frame Error Rate (FER)

3.4 Traceability Matrix

The traceability matrix maps the FDFT communication system requirements to the different test groups which can be used as input for a detailed test specification.

Requ.ID	Title	Test group
IPTRANS-7391	DC Orientation - voltage threshold	3.3.8
IPTRANS-7390	DC Orientation	3.3.8
IPTRANS-7389	DC Orientation	3.3.8
IPTRANS-6789	The e-coupler shall provide 4 electrical contacts for use by F-ETB	3.3.4
IPTRANS-6788	Communication standard for the F-TCN: IEEE 10BASE-T1L	3.3.3
IPTRANS-6783	ETB PCD Wagon	3.3.7
IPTRANS-6782	ETB CM layout	3.3.7
IPTRANS-6781	ETB Current Measure (CM)	3.3.7
IPTRANS-6774	CS circuit galvanic isolated	3.3.7
IPTRANS-6773	CS resolution	3.3.7
IPTRANS-6772	CS circuit layout	3.3.7
IPTRANS-6771	CCU wake-up input signals	3.3.6
IPTRANS-6770	ETB wake-up - CS circuit	3.3.6
IPTRANS-6769	ETB wake-up CCU wake-up	3.3.6
IPTRANS-6768	ETB wake-up ETB port protection	3.3.6
IPTRANS-6767	ETB wake-up	3.3.6
IPTRANS-6766	ETB wake-up power supply filter to tap	3.3.6
IPTRANS-6765	ETB wake-up power supply output current	3.3.6
IPTRANS-6764	F-ETB wake-up power supply control	3.3.6
IPTRANS-6763	F-ETB wake-up power supply diagnostic	3.3.6
IPTRANS-6762	F-ETB wake-up power supply overcurrent protection	3.3.6
IPTRANS-6761	F-ETB wake-up power supply	3.3.6
IPTRANS-6760	F-ETB wake-up power supply tap to network lines	3.3.6
IPTRANS-6524	The consist wake-up shall be based on a 24 V DC signal	3.3.6
IPTRANS-415	Year 2038 problem	3.3.2
IPTRANS-414	NTP synchronization mechanism relies on the equity of Request transmission delay...	3.3.5
IPTRANS-413	NTP priority	3.3.5

Requ.ID	Title	Test group
IPTRANS-412	UTC time distribution	3.3.5
IPTRANS-410	DNS service	3.3.5
IPTRANS-408	Inauguration inhibit	3.3.10
IPTRANS-407	Inauguration confirmation/correction	3.3.12
IPTRANS-406	Leading consist	3.3.12
IPTRANS-405	TTDB computation	3.3.12
IPTRANS-402	IP-routing priority	3.3.13
IPTRANS-401	Multicast IP datagram routing	3.3.13
IPTRANS-400	Unicast IP datagram routing	3.3.13
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IPTRANS-386	Bypass control	3.3.3
IPTRANS-385	Bypass deactivation	3.3.3
IPTRANS-384	Bypass operation	3.3.3
IPTRANS-383	Bypass function	3.3.3
IPTRANS-382	F-TCN shall support frame preemption in the F-ETBN as defined in [IEEE802.3br].	3.3.3
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IPTRANS-379	Transmission of mixed criticality data	3.3.13
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IPTRANS-376	IP DSCP priority configuration	3.3.3
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4 References

References are listed in D5.4.