OCORA

Open CCS On-board Reference Architecture

Testing Strategy

Guideline for Modular Testing

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Management Summary

Considering integration & testing activities, this document synthetizes the high-level requirements and related guideline applying to “OCORA compliant” CCS development and deployment projects.

This guideline defines a structured approach mirroring the OCORA modular architecture where responsibilities are defined at each level of integration.

In short, the purpose of this guideline is to propose a high-level Testing strategy that addresses the top-level requirements of the OCORA architecture up to the acceptance to:

- From a quality assurance perspective, improve industrial and operational readiness.
- From a regulatory perspective, reduce the cost and delay of compliance assessment with the regulatory framework

This strategy shall cope with the different aspects / properties of OCORA (openness, modularity, exchangeability, migration readiness, evolvability, portability and safety).

This strategy shall foresee the future ecosystem of the different stakeholders (manufacturers of building blocks, integrator, railway undertakings, …): it should aim to shape the roles and responsibilities of the different stakeholders regarding integration and testing. In that context, it should define what would be the integration / validation / acceptance process to be applied to the different constituent parts (building blocks) of OCORA (provided by different suppliers). Focus will be done on the specific approach/items induced by OCORA in a further version.

Revision history

Version	Change Description	Initial	Date of change
1.01	Official version for OCORA Delta Release	SCA	30.06.2021
2.01	Official version for OCORA Release R1	JBO	03.12.2021

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References

Reader's note: please be aware that the numbers in square brackets, e.g. [1], as per the list of referenced documents below, is used throughout this document to indicate the references to external documents. Wherever a reference to a TSI-CCS SUBSET is used, the SUBSET is referenced directly (e.g. SUBSET-026). OCORA always reference to the latest available official version of the SUBSET, unless indicated differently.

[1] OCORA-BWS01-010 – Release Notes

[2] OCORA-BWS01-020 – Glossary

[3] OCORA-BWS01-030 – Question and Answers

[4] OCORA-BWS01-040 – Feedback Form

[5] OCORA-BWS03-010 – Introduction to OCORA

[6] OCORA-BWS04-010 – Problem Statements

[7] OCORA-TWS01-030 – System Architecture

[8] OCORA-BWS08-020 – Tooling

[9] OCORA-TWS06-020 – (Cyber-) Security – Guideline

[10] OCORA-TWS07-010 – Modular Safety – Strategy

[11] OCORA-TWS04-010 – Functional Vehicle Adapter – Introduction

[12] OCORA-TWS04-011 – Functional Vehicle Adapter – Requirements

[13] OCORA-TWS04-012 – Functional Vehicle Adapter – Standard Communication Interface Specification

[14] OCORA-TWS04-013 – Functional Vehicle Adapter – Design Guideline

1 Introduction

1.1 Purpose of the document

This document is addressing the “testing strategy” as a whole (i.e. testing for integration, verification, validation and acceptance) for OCORA.

The purpose is to propose a high-level Testing strategy that addresses the top-level requirements of the OCORA architecture up to the acceptance in order to:

- From a quality assurance perspective, improve industrial and operational readiness.
- From a regulatory perspective, reduce the cost and duration of compliance assessment with the regulatory framework

This strategy shall cope with the different aspects / properties of OCORA (openness, modularity, exchangeability, migration readiness, evolvability, portability and safety).

This strategy shall foresee the future ecosystem of the different stakeholders (manufacturers of building blocks, integrator, railway undertakings, …). It should aim to shape the roles and responsibilities of the different stakeholders regarding integration and testing. In that context, it should define what would be the integration / validation / acceptance process to be applied to the different constituent parts (building blocks) of OCORA (provided by different suppliers). The focus will be on the specific approach/items induced by OCORA.

This document is addressed to experts in the CCS domain and to any other person, interested in the OCORA concepts for on-board CCS. The reader will gain insights regarding the topics listed in chapter 1.1, and is invited to provide feedback to the OCORA collaboration and can, therefore, engage in shaping OCORA. Feedback to this document and to any other OCORA documentation can be given by using the feedback form [4].

If you are a railway undertaking, you may find useful information to compile tenders for OCORA compliant CCS building blocks, for tendering complete CCS system, or also for CCS replacements for functional upgrades or for life-cycle reasons.

If you are an organization interested in developing CCS building blocks according to the OCORA standard, information provided in this document can be used as input for your development.

Before reading this document, it is recommended to read the Release Notes [1]. If you are interested in the context and the motivation that drives OCORA we recommend to read the Introduction to OCORA [5], and the Problem Statements [6]. The reader should also be aware of the Glossary [2] and the Question and Answers [3].

1.2 Applicability of the document

The document is currently considered informative but may become a standard at a later stage for OCORA compliant on-board CCS solutions.

1.3 Context of the document

This document is published as part of the OCORA Delta release, together with the documents listed in the release notes [1]. Before reading this document, it is recommended to read the Release Notes [1]. If you are interested in the context and the motivation that drives OCORA we recommend to read the Introduction to OCORA [5], and the Problem Statements [6]. The reader should also be aware of the Glossary [2] and the Question and Answers [3].

2 High level integration and testing requirements

2.1 Scope and Capabilities of the Integration and Testing

The Integration & Testing Strategy shall allow to integrate, verify and validate the system under consideration of the OCORA collaboration which is CCS Onboard subsystem (CCS-OB), as well as its internal and external interfaces. The Testing Strategy shall particularly focus on the parts of the CCS-OB for which OCORA gives a high level of specification including for the functional requirements ("OCORA core" scope).

The Integration & Testing Strategy shall also consider the peripheral devices and connectivity devices which are part of the CCS-OB for which OCORA only provides interface specifications, high-level functional requirements, and non-functional requirements (basically, all requirements and specifications needed to ensure "plug & play"-like exchangeability).

The Integration & Testing Strategy shall also allow to integrate, verify and validate the part of the Train Adapter (TA, which is itself a part of the Physical Train Unit) for which OCORA aims at providing requirements, a standardized interface specification, and design guidelines. Currently, OCORA works on the specifications of the Functional Vehicle Adapter (FVA), which is a central part of the TA (refer to [11], [12], [13] and [14] for more details).

The Integration & Testing Strategy shall allow to verify and validate the modularity properties of the CCS-OB and the TA as defined in [7].

The Integration & Testing Strategy shall allow to verify and validate that the building blocks within CCS-OB and the TA support the whole functional scope of OCORA, for all grades of automation.

The Integration & Testing Strategy shall address cybersecurity issues: depending on the security category of the application, building block or subsystem, Testing activities may be needed to check that the cybersecurity requirements have been correctly fulfilled (refer to [9] for more details).

The Integration & Testing Strategy shall take into account that the configuration for a specific implementation is open and may include only a subset of the building blocks or components: Testing Strategy shall be able to address these different scopes of functionality, while remaining consistent and complete in regards with the building blocks and components implemented.

The Integration &Testing Strategy shall take into account that the functionality of some of the hardware components may vary.

Note: the number and the functional behavior of the CCUs can differ for the various implementations, depending on the RU's need. For migration reasons, multiple CCUs may be needed, or certain functions can be deployed on one node (e.g. safe functions) while others (e.g. non-safe) are deployed on a separate node. In some projects, additional CCUs may be used to increase availability and reliability by defining one or multiple CCU nodes as fail over or standby units.

The Integration &Testing Strategy shall define system tests that are composed of several test types that are used to verify different categories of requirements:

- Functional tests: these tests shall demonstrate that the test object fulfills the functional requirements and interface specifications assigned to this test object. These tests include ERTMS tests (e.g. Subset 76).
- Safety tests
- Non-functional tests: performance tests, Maintainability tests, Environmental (climate, EMC) tests, Load tests, Stress tests, Endurance tests
- User tests: testing by end users who perform specific tasks under real-life conditions
- Cybersecurity tests

Note: the need for environmental (climate, EMC) system tests is induced by the fact that the integrated pieces of equipment are only individually validated in terms of environmental requirements.

The Integration &Testing Strategy shall consider degraded modes for each kind of test type defined above.

The Integration &Testing Strategy shall allow system tests to be classified into two categories, depending on where and how they can be performed:

- Factory Acceptance Tests
- Site Acceptance Tests

The Integration &Testing Strategy shall define the different levels of integration, verification and validation (like system test, sub-system test, component test…).

Beside other topics addressed by other workstreams (e.g. safety activities also requiring verification, cyber security requiring analysis and technical/architectural solutions…see [9] and [10]), the scope of the current "Testing strategy" document is to address integration and testing either in factory or on site as depicted on the sketch below.

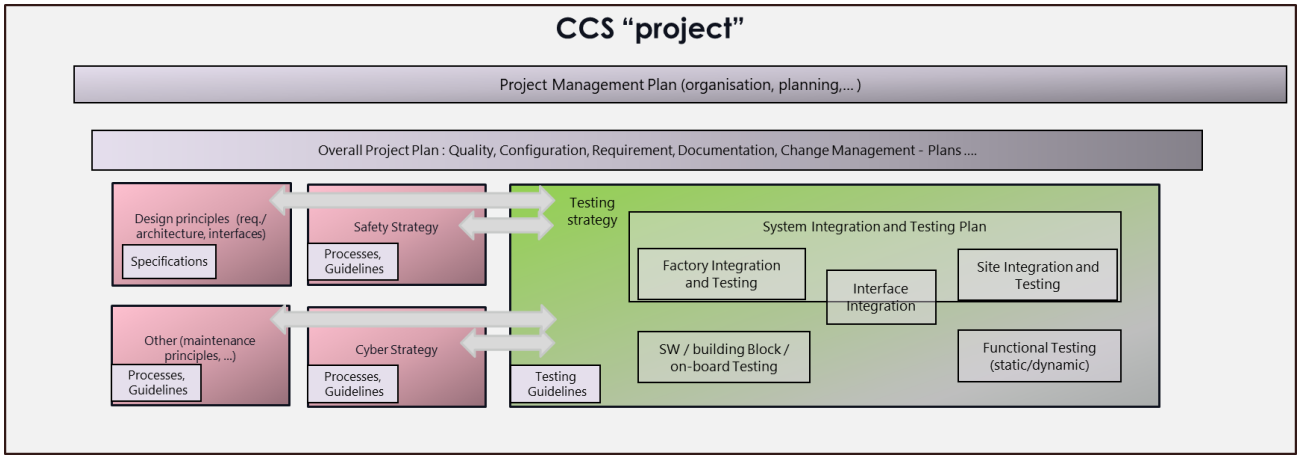

Figure 1: Scope of the Testing Strategy and interaction with other workstreams

2.2 Actors, Process and Methods

In this section of the present guideline, the aim is to clarify the "who", the "what" and the "how".

Therefore, a particular focus is proposed on the Actors ("who is in charge of what"), the process (which activities, in which sequence…) and the methods (how it shall be done). Specific requirements are proposed on these items:

- The Testing activity shall start as early as possible in the process.
- Early testing steps shall be proposed.
- The requirements shall be mastered (and their releases) during the whole cycle of development and validation.
- The Testing documentation shall be well structured down to test cases.
- The Interface Integration Plans for each interface shall be well structured (according to each interface) and mastered with clear steps (what/how/who…).
- The Interface Integration Plans shall be converged between all stakeholders involved.
- Each milestone of the Integration & Testing process shall be clearly defined.
- The Integration & Testing effort shall be adapted accordingly to the needs of each step.

- The risk of having many actors /many tools… shall be reduced by having a common environment (e.g. MBSE and its Testing) where specific tools are limited to stakeholders' specific activities.
- A system integrator (or system integrators but with an overall system integrator above) shall be designated.
- A clear process for bugs/anomaly tracing until corrections are made (among the different stakeholders) supported by ad hoc tools shall be proposed.
- When possible, safety demonstration shall also rely on additional and complementary methods, other than test and validation (use of formal method for instance).
- The Integration & Testing Strategy shall lead to a minimal effort in case of an update of a component:
    - Software update
    - Addition of a new CCS-OB – vehicle interface
    - Addition of a new building block (e.g. AV for ATO)
    - Replacement of a building block (e.g. replacement of LOC-OB due to a change of localization sensors – VLSs - or localization component - VL)
    - Replacement of an adapter (e.g. FVA replaced)
    - Addition of a new peripheral device (e.g. BTM, LTM…)
    - Hardware exchange (e.g. new processor)
    - Cybersecurity upgrade
    - (…)
- The Integration & Testing Strategy shall be organized in well-defined successive and complementary steps.
  An example is given below:
    - Integration and testing of the HW (operating system test cases, bus communication test cases: load and performance tests)
    - Integration of the runtime environment (testing of the interfaces between OCORA runtime environment and vehicle apps by using vehicle app simulators)
    - Integration of CCS-OB building blocks (overall and operational use cases with trackside simulated), with simulated peripheral/connectivity devices and then real devices
    - Integration of a CCS-OB to a reference vehicle with trackside simulated, real balises and run basic ERTMS functions on a test track and a set of operational use cases
    - CCS-OB and Interoperability with Trackside in Lab
    - Test Reference Vehicle on Reference Track: interoperability on reference track with real trackside

  Note: the example given above has to be confirmed and defined later. The integration levels described may not always be performed sequentially. Parallel execution is allowed.
- The Integration & Testing Strategy shall define for every level of integration, verification and validation the appropriate verification and validation methods (e.g. review, inspection, black-box testing…) to be used.
- For each level of integration, verification and validation, a report containing the proofs that the required testing activities have been correctly carried out shall be provided by the actor in charge of this level.

2.3 Tools and Environment

In this section of the present guideline, the aim is to specify high level requirements on “tooling” and testing environment. Particular tools will be chosen within the corresponding Integration and Testing plans.

- The Testing Strategy shall rely on a test environment automized as far as possible.

  Note: especially in the first steps of integration (then manual testing may be needed in case of use of real peripheral devices).
- A powerful test environment allowing configuration testing, degraded modes…shall be available.
- A “reference” test environment shall be proposed and mastered.
- The Testing Strategy shall rely on a flexible line representation, where all particular and relevant configurations can be added.
- Early verification and validation using model-in-the-loop simulation shall be foreseen.
- The test environment shall support model-in-the-loop (1), software-in-the-loop and hardware-in-the-loop testing.

  (1) This also depends highly on the tools/methods used for system/subsystem definition (see [8]): the usage of formal or semi-formal language in specification and design phase shall help to reduce the overall test and safety demonstration effort.
- The test environment shall support easy re-use of test-cases between model-in-the-loop, software-in-the-loop, hardware-in-the-loop and vehicle testing.
- A common reusable set of scenarios shall be maintained with an incremental approach at each system release.

3 Integration and testing strategy guidelines

3.1 CCS Integration Verification Validation (IVV) activities

Each of the IVV activities contains technical and non-technical activities.

Technical activities of the IVV steps are the “Testing” activities: tests are needed during each of the IVV steps to prove that the system under test fulfils the objectives of this IVV step. On one hand, tests should confirm the correctness of the tested functions and properties, and on the other hand, possible errors should be detected. For this purpose, test cases are to be defined in such a way that as many errors as possible can be found and tests can be carried out as efficiently and automatically as possible. Nature and specification of these tests differ depending on the IVV step (Integration, Verification or Validation for a given life cycle phase) to which they are associated. Checks performed during the tests can be automatic or manual and are the checks associated to the “T” (Test), the “D” (Demonstration) and some of the “I” (Inspection: the ones that require a test scenario) of the IADT classification.

Non-technical activities are related to quality management, review of documentation, process compliance checking, safety activities, proof by analysis (“A” of the IADT classification) or inspection (“I” of the IADT classification that do not require any test scenario).

A full definition of the IVV activities can be found in the CENELEC documentation EN 50126-1 as well as in CCS TSI. Some basics are reminded hereunder. More details will be given in the OCORA Safety Plan (provided after the Delta release).

Verification tasks are included within each life cycle phase, whereas validation tasks are only undertaken in Phase 4 “Specification of system requirements” and Phase 9 “System validation”.

3.1.1 [Prerequisite] Traceability

A fundamental prerequisite for checks is the identifiability and traceability of relevant elements and units of all abstraction levels in all phases of the development process. This starts with the classification and identification of relevant elements and units as well as their change and configuration management. This leads to the mapping of classifiable relationships between relevant elements and entities. They exist in the context of application development and variants, in the context of versioning as well as in the context of generic developments. Without the implementation of identifiability and traceability in the development process, the application of checks in the sense of the standards is hardly possible.

3.1.2 Integration

The subsystems or components are specified or designed according to the top-down principle and integrated according to the bottom-up principle. During the integration activities, subsystems or components are assembled and installed to form an integrated system of higher level. Tested software components are to be combined step by step and systematically into larger units or with their target hardware and tested as a composite in each case. Finally, the embedded system is to be integrated into its target environment at common interfaces.

Integration activities shall demonstrate that these subsystems or components work correctly together as defined by the interfaces: they interact correctly as specified in the interface specifications to perform their intended function.

3.1.3 Verification

Verification activities provide inputs to the validation activities. They intend to demonstrate that the specified requirements have been correctly implemented and are fulfilled.

Verification determines the correctness of individual development steps. This involves assessing whether the task of the higher-level abstraction has been developed correctly and consistently. The evaluation of the results must be carried out phase by phase, up to the design of the software components. After implementation or code generation, the freedom from errors of the developed software must be demonstrated by testing the components, from step-by-step integrated software to the fully integrated system.

Verification means to answer the question **“have we built it correctly?”**

Depending on the required safety integrity level, the methods to be used are specified by the EN50657 resp. EN50128 standard. Different methods, tools and techniques may be used, including testing.

Testing activities are under the responsibility of the Testing team TWS09 whereas non-technical verification activities are under the responsibility of the CENELEC documentation team TWS01-WP09.

3.1.4 Validation

Validation activities intend to demonstrate that the system under consideration meets the needs of the customer and other identified stakeholders for the intended use or application.

First, the results of the verifications as well as the component tests and integration must be checked. The conformity of the development results with the requirements specification must be traced and evaluated. The focus is on functions and properties according to the assigned safety integrity level. This includes additional tests that include complex scenarios for stressing the system and reflect the actual requirements of the application in the target environment.

Validation means to answer the question **“have we built the correct thing?”**

Depending on the required safety integrity level, the methods to be used are specified by the EN50657 resp. EN50128 standard. Different methods, tools and techniques may be used, including testing.

Validation activities address functionalities related to safety and not related to safety.

Testing activities are under the responsibility of the Testing team TWS09 whereas non-technical validation activities are under the responsibility of the Modular Safety team TWS07.

3.2 CCS Integration and Testing activities sequencing

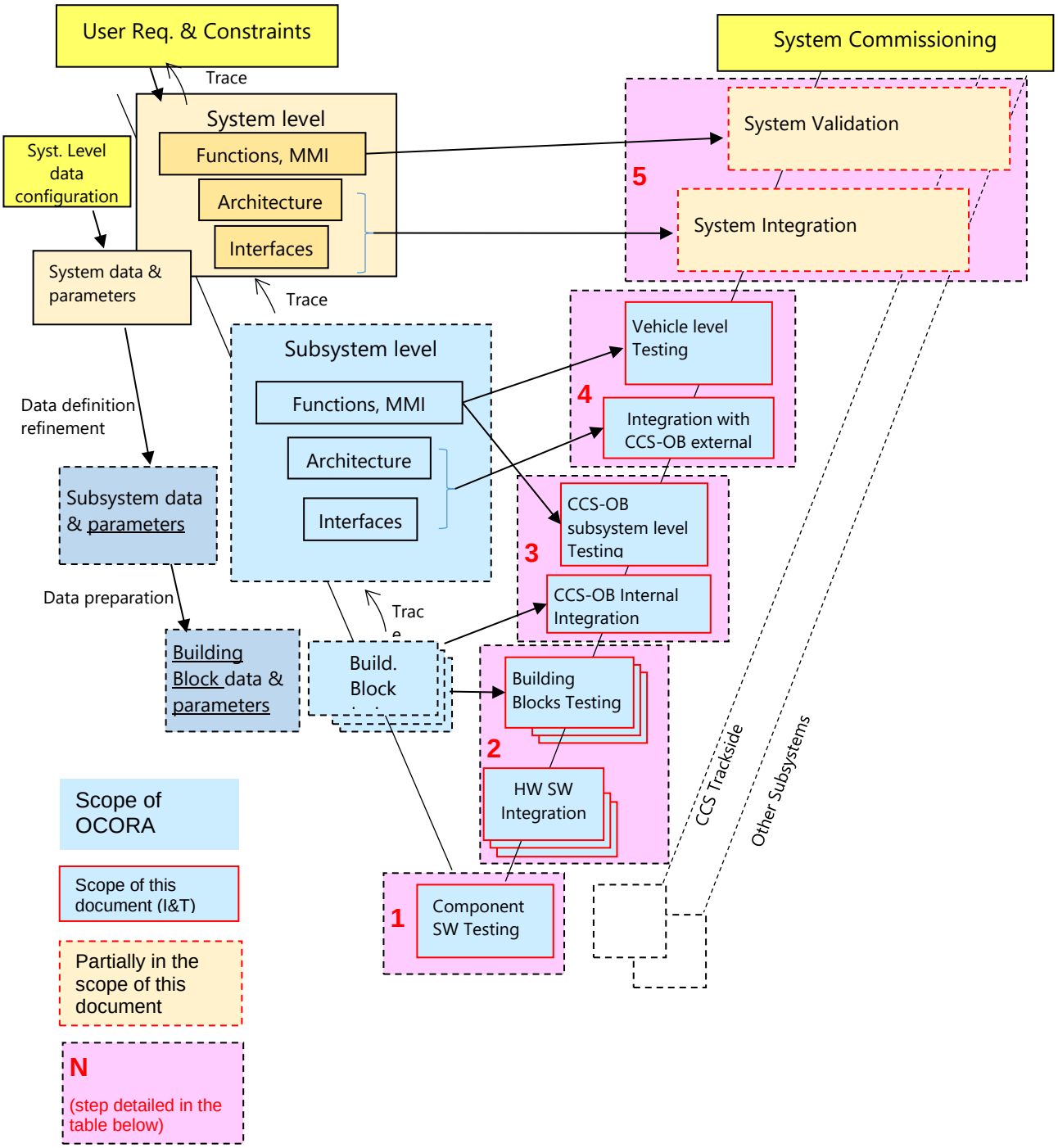

Figure 2: Integration and Testing activities sequencing

Integration, Verification and Validation steps for the Testing activities are detailed below:

Note: in following section, “Factory” is equivalent to “Laboratory”: factory tests are all the tests that are not performed on site.

Level	Activity	Scope	Documentation	Factory /Site	Responsible
0 - Platform Level	Qualification (HW/low SW level)	*Not further addressed in this document and not displayed on the figure above.*	Qualification plan	Factory	Platform Supplier (HW)
1 - Component Level	SW Testing	Component SW (configured applications) are tested individually (Verification and Validation).	Component SW Test Plan	Factory	Component Supplier (SW)
2 – OCORA Core Building Block level	Integration	SW of the n Component(s) that are part of one same OCORA Core Building Block are integrated together. Integration with one or several HW is also performed at this step.	OCORA Core Building Block Integration Plan	Factory	Component Supplier (which is also the Platform Supplier for ETCS Core) or On-board CCS Integrator (if n>1 and several Component Suppliers) NB: Component Supplier can be different from Platform Supplier for non ETCS Core (e.g. Digital Map, AV…)
	Testing	OCORA Core Building Blocks (configured) are tested individually (Verification and Validation).	OCORA Core Building Block Test Plan		
2 – Peripheral or Connectivity Block level	Integration	SW of the n Component(s) that are part of one same Peripheral or Connectivity Block are integrated together. Integration with one or several HW is also performed at this step.	Peripheral/Connectivity Block Integration Plan	Factory	Peripheral/Connectivity Device Supplier
	Testing	Peripheral and Connectivity Blocks are tested individually (Verification and Validation).	Peripheral/Connectivity Block Test Plan		
2 – Train Adapter Block level	Integration	SW of the n Component(s) that are part of one same Train Adapter Block are integrated together. Integration with one or several HW is also performed at this step.	Train Adapter Block Integration Plan	Factory	Train Adapter Block Supplier
	Testing	Train Adapter Blocks are tested individually (Verification and Validation).	Train Adapter Block Test Plan		
3 – CCS-OB Level	Integration	Building Blocks and Peripheral/Connectivity Blocks are integrated together to build the CCS-OB equipment.	Factory CCS-OB Integration Plan	Factory	CCS-OB Integrator

Level	Activity	Scope	Documentation	Factory /Site	Responsible
		CCS-OB internal interfaces (Building Block ⇔ Building Block; Building Block ⇔ Peripheral Block; Building Block ⇔ Connectivity Block; Peripheral Block ⇔ Connectivity Block) are checked. At this step, Rolling Stock and other external interfaces are not integrated.			
	Testing	The whole CCS-OB equipment is tested in factory (Verification and Validation) without testing the external interfaces.	Factory CCS-OB Test Plan		Factory CCS-OB Tester (can be the CCS-OB Integrator)
4 - Vehicle Level	Integration	The CCS-OB equipment is integrated in the vehicle. Interfaces with the Rolling Stock via the Train Adapter and some other CCS-OB external interfaces (e.g. external STM) are checked.	Site CCS-OB Integration Plan	Site (vehicle)	Vehicle Integrator (can be the CCS-OB Integrator)
	Testing	The CCS-OB equipment is tested in the vehicle (Verification and Validation) including the interfaces with the vehicle via the Train Adapter and some other external interfaces (e.g. external STM).	Site CCS-OB Test Plan		Site CCS-OB Tester (can be the CCS-OB Integrator)
5 - System Level	Integration	The CCS-OB equipment and the CCS trackside equipment are integrated together. CCS-OB external interfaces with the trackside with real (Factory/Site) or simulated (Factory) radio transmission are checked.	CCS Integration Plan	Factory/Site	System Integrator (can be the CCS-OB Integrator)
	Testing	The CCS-OB equipment and trackside equipment are tested (Verification and Validation) together.	CCS Test Plan		System Tester (can be the CCS-OB Integrator)

Table 1: Integration and Testing steps

These steps do not necessarily occur in chronological order. For instance, the CCS-OB equipment and the CCS trackside equipment can be integrated together in factory (step 5) before the CCS-OB equipment is integrated in the vehicle (step 4).

Note: Depending on the projects' particularities and the countries in which they are deployed, the actors which are responsible of some steps may differ. For instance, the Vehicle Integrator may be the Vehicle Keeper or the CCS-OB Integrator.

3.2.1 Documentation content activities

Documentation	Activities
The CCS Test Plan shall…	- Define CCS acceptation strategy: identify means (simulators, real hardware…) and location (factory or site). - Identify roles and responsibilities. - Identify deliverables (test specifications and test reports). - Describe the acceptation process regarding testing. Note: a different plan shall address the overall CCS acceptation process on top of it (also outside testing).
The CCS Integration Plan shall…	- Define CCS integration strategy and related process (steps identification) for the whole CCS-OB <=> CCS trackside integration (TMS, ATO wayside, digital register...). - Identify activities for each step. - Identify roles and responsibilities for each step. - Identify deliverables for each step (test specifications and test reports). - Identify means and tools for each step. Note: if needed, dedicated documents (Integration Plan and associated Site and/or Factory Test Specifications) can be created for specific interfaces. In this case, the CCS Integration can be used as a framework document that contains and references these dedicated documents.
The Site CCS-OB Test Plan shall…	- Define CCS test strategy (for on-site testing), while aiming to minimize the number of test cases to be performed on site (as they are costly and hard to set-up). - Identify roles and responsibilities. - Identify deliverables (test specifications and test reports). - Identify means. - Identify actors.
The Site CCS-OB Integration Plan shall…	- Define CCS-OB integration strategy and related process (steps identification) for the CCS-OB integration with the vehicle (TCMS and other Rolling Stock interfaces) and other CCS-OB external interfaces (e.g., STM if any). Note: this applies to the whole CCS-OB but also to specific modules, e.g., ATO with vehicle. - Identify activities for each step. - Identify roles and responsibilities for each step. - Identify deliverables for each step (test specifications and test reports for each interface). - Identify means and tools for each step. Note: if needed, dedicated documents (Integration Plan and associated Site and/or Factory Test

Documentation	Activities
	Specifications) can be created for specific interfaces. In this case, the Site CCS-OB Integration Plan can be used as a framework document that contains and references these dedicated documents.
The Factory CCS-OB Test Plan shall…	*Refer to CCS Test Plan requirements (but focus on CCS-OB).*
The Factory CCS-OB Integration Plan shall…	- Define CCS-OB integration strategy and related process (steps identification) for the several CCS-OB building blocks (ETCS Core, AV, LOC-OB...). - Identify activities for each step. - Identify roles and responsibilities for each step. - Identify deliverables for each step (e.g., Integration Report, test specifications and test reports for each interface). - Identify means and tools for each step.
The Peripheral/Connectivity/Train Adapter Block Test Plan shall…	- Define Peripheral/Connectivity/Train Adapter Block test strategy (for Factory testing). *For instance, at this level, the test strategy shall include more complex validation scenarios than at Component level.* Note: the test cases are specified in the Test Specification.
The Peripheral/Connectivity/Train Adapter Block Integration Plan shall…	*Refer to the OCORA Core Building Block Integration Plan.*
The OCORA Core Building Block Test Plan shall…	- Define Building Block test strategy (for Factory testing). *For instance, at this level, the test strategy shall include more complex validation scenarios than at Component level.* Note: the test cases are specified in the Test Specification.

Documentation	Activities
The OCORA Core Building Block Integration Plan shall…	- Define Building Block integration process (steps identification) for each OCORA Core Building Block (ETCS Core, AV...). - Identify activities for each step. - Identify roles and responsibilities for each step. - Identify means and tools for each step. - Identify deliverables for each step (e.g., Integration Report).
The Component SW Test Plan shall…	- Define SW test strategy. *For instance, at this level, the test strategy shall include unit-testing and code coverage testing.* Note: the test cases are specified in the Test Specification.
At all levels, Test Specifications shall…	- Define goals, actions and expected results. - Identify needed configurations (for type testing and the additional configurations when requested from evolutions). - Identify means, tools and actors.

Table 2: Documentation content activities

3.2.2 Level specific activities

Specific activities related to the Integration and Testing strategy that apply to particular levels among the ones defined in Table 1 are indicated in the Table 3 below.

Level	Activity	Description
0 - Platform Level	Qualification (HW/low SW level)	None. *The Platform Qualification (in accordance with the associated Qualification plan) shall fully be under the responsibility of the Platform supplier.*
1 - Component Level	SW Testing	None. *The Component SW Testing (in accordance with the associated Component SW Test Plan) shall fully be under the responsibility of the Component Supplier.*
2 – OCORA Core Building Block level	Integration	The OCORA Core Building Block Integration activity shall ensure that the functional interfaces of the Components contained in the OCORA Core Building Block are consistent with their definition and therefore these Components are compatible with each other. The OCORA Core Building Block Integration activity shall ensure that the Components contained in the OCORA Core Building Block can be integrated with the expected hardware component (possibly several hardware components). *An OCORA compliant project shall provide the tests objectives*

Level	Activity	Description
		related to the "requirements" from TWS01 which should focus on the interfaces and therefore shall have the OCORA Core Building Block Integration activity under its responsibility (for OCORA Core Building Blocks with n>1 Components).
		<u>From a standard perspective:</u> For the specification of software integration tests, the requirements are the same as for the specification of software component test (refer to the row below). For the specification of the software/hardware integration, tests shall be specified according to EN50657 resp. EN50128 Chapter 7 Paragraph 7.3.4.33 to .39. Chapter 7.3.4.39 of EN50657 resp. EN50128 requires the use of methods from Table A.5 and Table A.6: - Dynamic Analysis and Testing (A.13) including Equivalence Classes and Input Partition Testing (D.18), Performance Modelling (D.39), Structure-based Testing (D.50) and Test Case Execution from Boundary Value Analysis (D.4). - Functional and Black-box Testing (A.14) including Equivalence Classes and Input Partition Testing (D.18) and Boundary Value Analysis (D.4).
	Testing	The OCORA Core Building Block Testing activity shall define the tests mentioned in §2.1 which are relevant at the OCORA Core Building Block level: functional tests, safety tests, non-functional tests (including performance tests), cybersecurity tests. The OCORA Core Building Block Testing activity shall also contain preliminary checks regarding the interfaces of the OCORA Core Building Block in order to facilitate the integration at CCS-OB level (next step) and identify potential issues at an early stage: functional, mechanical and electric compatibilities shall be checked. The OCORA Core Building Blocks can be tested on computer host or on test bench, depending on the type of test to perform. *The OCORA Core Building Block Testing (in accordance with the associated OCORA Core Building Block Test Plan) shall fully be under the responsibility of the Component Supplier for OCORA Core Building Block with only one Component.* *However, the OCORA Core Building Block Testing (in accordance with the associated OCORA Core Building Block Test Plan) shall fully be in the scope of an "OCORA compliant" project for OCORA Core Building Block with several (n>1) Components and therefore the OCORA compliant project shall define the related test objectives.*
		<u>From a standard perspective:</u> For the specification of software component tests, Chapter 7.3.4.32 and Chapter 7.4.4.10 of EN50657 resp. EN50128 require the use of methods from Table A.5: - Dynamic Analysis and Testing (A.13) including Equivalence Classes and Input Partition Testing (D.18), Performance

Level	Activity	Description
		Modelling (D.39), Structure-based Testing (D.50) [including Test Coverage: Statement (D.50) and Test Coverage: Path (D.50)] and Test Case Execution from Boundary Value Analysis (D.4). - Functional and Black-box Testing (A.14) including Equivalence Classes and Input Partition Testing (D.18) and Boundary Value Analysis (D.4).
2 – Peripheral or Connectivity Block level	Integration Testing	Tests with both software and hardware must be performed (simple computer host tests are not sufficient). It shall also be checked that Connectivity Blocks related to radio transmission are working correctly at this early stage, even if the radio transmission itself is only checked in the next integration levels (especially at level 5 – System level). *The Peripheral/Connectivity Block Integration & Testing (in accordance with the associated Peripheral/Connectivity Block Integration & Test Plans) shall fully be under the responsibility of the Peripheral/Connectivity Block Supplier.*
2 – Train Adapter Block level	Integration Testing	Tests with both software and hardware must be performed (simple computer host tests are not sufficient). It shall be checked that Train Adapter Blocks are working correctly at this early stage, even if the complete correct behavior can only be checked in the next integration levels (especially at level 4 – Vehicle level). *The Train Adapter Block Integration & Testing (in accordance with the associated Train Adapter Block Integration & Test Plans) shall fully be under the responsibility of the Train Adapter Block Supplier.*
3 - CCS-OB Level	Integration	The Factory CCS-OB Integration activity shall ensure that the functional, mechanical and electric interfaces of the OCORA Core Building Blocks and Peripheral/Connectivity Blocks are consistent with their definition and therefore these OCORA Core Building Blocks and Peripheral/Connectivity Blocks are compatible with each other. The Factory CCS-OB Integration activity shall ensure that the OCORA Core Building Blocks and Peripheral/Connectivity Blocks can communicate with each other by the means of the CCN (CCS Communication Network) and its associated messaging protocol. *The CCS-OB Integration activity shall fully be in the scope of an "OCORA compliant" project and therefore the OCORA compliant project shall define the related integration objectives.*
		<u>From a standard perspective:</u> For the specification of software integration tests, the requirements are the same as for the **Level 2.**
	Testing	The Factory CCS-OB Testing activity shall define the tests

Level	Activity	Description
		mentioned in §2.1 which are relevant at the CCS on-board level: functional tests, safety tests, non-functional tests (including performance tests), user tests, cybersecurity tests. The Factory CCS-OB Testing activity shall also contain preliminary checks regarding the interfaces of the CCS-OB in order to facilitate the integration at Vehicle and System levels (next steps) and identify potential issues at an early stage: functional, mechanical, electric and messaging protocol compatibilities shall be checked. *The CCS-OB Testing shall fully be in the scope of an "OCORA compliant" project and therefore the OCORA compliant project shall define the related test objectives.*
		From a standard perspective: Test of the overall software shall be specified according to EN50657 resp. EN50128 Chapter 7 Paragraph 7.2.4.16 to .19. For the specification of tests of the overall software, Chapter 7.2.4.18 of EN50657 resp. EN50128 requires the use of methods from Table A.7: - Functional and Black-box Testing (A.14), including Equivalence Classes and Input Partition Testing (D.18) and Boundary Value Analysis (D.4). - Performance Testing (A.18) including Response Timing and Memory Constraints (D.45), Avalanche-/Stress Testing (D.3) and Performance Requirements (D.40). Within the scope of the overall software test, the validator must define additional tests according to Chapter 7.7.4.3. These must stress the system with **complex scenarios** and reflect the actual requirements of the application.
4 - Vehicle Level	Integration	The Site CCS-OB Integration activity shall ensure that the functional, mechanical and electric interfaces between the CCS-OB and the vehicle are compatible. One part of the integration tests shall be static tests which check that all the functional information (I/O) defined on its interface are correctly exchanged between the CCS-OB and the vehicle via the Train Adapter. The Vehicle Integrator shall be able to activate the I/O manually by the means of a dedicated tool. *The CCS-OB Integration in the Vehicle shall fully be in the scope of an "OCORA compliant" project and therefore the OCORA compliant project shall define the related integration objectives.*
	Testing	The Site CCS-OB Testing activity shall define the tests mentioned in §2.1 which are relevant at the Vehicle level: functional tests, safety tests, non-functional tests (including performance tests), user tests, cybersecurity tests. These tests can be static or dynamic tests, depending on the target of test. *The CCS-OB Testing at Vehicle level shall fully be in the scope of*

Level	Activity	Description
		an "OCORA compliant" project and therefore the OCORA compliant project shall define the related test objectives.
5 - System Level	Integration	The CCS Integration activity shall ensure that the CCS-OB external interfaces with the trackside (balise, CCS trackside equipment) are compatible from a functional and messaging protocol point of view. The integration tests can be performed with real airgap transmission (mainly in Factory and with a limited number of tests on Site) or simulated airgap transmission (in Factory). *The CCS-OB Integration at System level shall fully be in the scope of an "OCORA compliant" project and therefore the OCORA compliant project shall define the related integration objectives.*
	Testing	The CCS Testing activity shall define the tests mentioned in §2.1 which are relevant at the System level: functional tests, safety tests, non-functional tests (including performance tests), user tests, cybersecurity tests. These tests can be static or dynamic tests and can be performed in Factory and on Site, depending on the target of test (the number of Site tests shall remain as limited as possible). These tests shall particularly focus on functionalities which involve both on-board and trackside equipment, which require synchronization between equipment and which can suffer from performance and communication issues due to time delays (e.g. trackside equipment handover, trackside order: pantograph to be lowered…). *The CCS-OB Testing at System level shall fully be in the scope of an "OCORA compliant" project and therefore the OCORA compliant project shall define the related test objectives.*

Table 3: Levels specific activities

3.2.3 Building Blocks specific activities

This section is still being drafted and has not been fully reviewed.

So far, OCORA project has only defined a list of candidates for Building Blocks. This list is just a proposal and is not frozen yet. Currently, OCORA project is still focusing on defining the logical and physical components that will, at the end, be grouped into OCORA building blocks.

Based on this current list of Building Blocks, specific activities related to the Integration and Testing strategy that apply to particular Building Blocks are indicated in the Table 4 below.

Building Block	Activity	Description
OCORA Core Building Block		
ETCS Core (components European	Testing	Subset 76 tests related to ETCS Core functionalities shall be performed.

Building Block	Activity	Description
Train Protection – ETP + Mode & Level Manager – MLM + STM Controler - STMC)		
ATO Vehicle (AV)	Testing	Testing of the AV BB shall start at Level 2. The test environment used at Level 2 shall allow to interface the AV BB with a simulated and configurable vehicle that moves on a virtual test track according to the ATO commands received in order to perform functional tests as early as possible (before Level 4). The train model shall be as representative as possible of the real vehicle in which the AV BB will be used in order to adjust the maximum number of parameters' values or at least have an initial rough idea about their setting. It shall also be possible to use a generic train model (if no information is available regarding the vehicle for instance) in order to test some of the functionalities of the AV BB. The virtual test track shall be representative of all the possible configurations that can be encountered in "real life", especially in terms of speed limits and topology. Dynamic tests shall be performed in various track configurations (speed limit, topology…) to check that the outputs of the AV BB allow the vehicle to: - Start moving without unintentional rollback movement - Move at the authorized speed (ceiling speed, speed profile restriction, speed profile increase) - Accelerate/brake while ensuring passengers' comfort - Stop in the acceptable window around the targeted stopping point - Respect movement authorities associated to static or dynamic targets (e.g., downstream moving train, movement authority restriction or extension…) - … At Level 4, first the static integration of the AV BB in the vehicle shall take place. Then, train characterization tests shall be performed in order to identify the brake/traction/cruising patterns and behavior of the vehicle and be able to build a set of parameters for the AV BB that is well adapted to the vehicle. Finally, the dynamic integration of the AV BB in the vehicle shall take place. As many as possible dynamic tests shall be performed again at Level 4 with the real vehicle on a real track. Note: at Level 4, it may be impossible to perform some tests due to unavailable specific track configurations or vehicle limitations.
Driver Advisory System On-Board (DAS-		

Building Block	Activity	Description
OB)		
Virtual ETCS Transponder Service (VETS)		
Physical ETCS Transponder Service (PETS)		
Peripheral Building Block		
Localisation On-Board (LOC-OB)	Testing	Subset 76 tests related to on-board localisation functionalities shall be performed.
Movement Detection On-Board (MD-OB)		
Automated Train Protection Extension On-Board (ATPE-OB)		
Cabin Voice Radio (CVR)		
Human Machine Interface On-Board (HMI-OB)		
Connectivity Building Block		
FRMCS On-board subsystem 1 Radio		
Train Adapter Building Block		
Functional Vehicle Adapter (FVA)		Waiting for input for next release. [Subset 119 but not only]
Wired I/O Control – SIL4 (WIOC-S4)		

Building Block	Activity	Description
Wired I/O Control (WIOC)		
Passenger Info System Adapter (PISA)		

Table 4: Building Blocks specific activities