OCORA

Open CCS On-board Reference Architecture

Business Objective and Economic Model
Beta Release

Document ID: OCORA-30-004-Beta

Version: 1.02

Date: 26.06.2020

Status: final

Revision history

Version	Change Description	Name (Initials)	Date of change
0.01	Initial release	NPT/JBS	2020-06-11
0.02	Final draft for review	NPT/JBS	2020-06-24
1.00	Final	RM	2020-06-25
1.01	Solving comments	JBS	2020-06-25
1.02	Final version for Beta Release	NPT	2020-06-26

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References

The following references are used in this document:

[1] OCORA-10-001-Beta – Release Notes

[2] OCORA-30-001-Beta – Introduction to OCORA

[3] OCORA-30-010-Beta – Set of Requirements

[4] ERTMS Coordinator Work Plan, May 2020

[5] The ERTMS business case on the 9 core network corridors – Second release", European Commission, June 2019

[6] Decision authorising the use of unit contributions to support ERTMS deployment under the Connecting Europe Facility (CEF) - Transport sector, Ref. Ares(2019)1025126 - 19/02/2019

1 Introduction

1.1 Document context and purpose

This document is published as part of the OCORA Beta release, together with the documents listed in the release notes [1]. It is the first release of this document and it is still in a preliminary state.

This document aims at providing to the reader a first introduction to the economic evaluation of OCORA members on how the CCS On-board can be developed in the next decade to satisfy the needs and requirements of railway companies engaged in the transportation of passengers and goods. Indeed, OCORA targets the development of an economic evaluation from a fleet owner point of view, while taking into account business and industrial feasibility.

This document introduces the economic evaluation of OCORA, for both qualitative perspective by an assessment of the benefits, and quantitative perspective by an assessment of typical business case.

This document consists in the four following parts:

- Scope of OCORA economic evaluation using a business model canvas
- Building of the economic model: scenarios to be considered in OCORA business models
- Preliminary Assessment of Benefits: a qualitative perspective
- Preliminary Assessment of Business Case: a quantitative perspective

1.2 Why should I read this document?

The economic model for OCORA should help fleet owners and suppliers to build good business cases for CCS On-board migrations with OCORA. It should also help the TSI revision process by providing quantitative and qualitative assessment.

This document set the ground for a collaborative economic modelling roadmap. It lays down the main hypothesis and objectives for an economic evaluation. It proposes an approach on economic values to be modelled and a first empirical evaluation of expected results.

2 Building OCORA economic model

2.1 Scope of OCORA economic evaluation: OCORA business model canvas

Key Partners	**Key Activities:**	**Value Propositions:**	**Customer Relationships**	**Customer Segments**
Key contributors: - OpenETCS with its technical solutions and organization - Alliance Partners such as RCA/EUG/UIC/S2R for achieving a coherent CCS system definition - CER to ensure political acceptance and support Key suppliers: - Manufacturers in order to gain constructive advice and feedbacks. - S2R/S2R2 in order to fund activities - ERA in order to enhance acceptance regimes - Engineering companies to support architecture modeling and demonstrations Projects driven by OCORA members to deliver proof of OCORA concepts	Requirement design from strategic objectives (e.g. rail transport business), down to technical constraints (e.g. interfaces) Coordinated demonstration roadmap for early and advanced solutions, including a MVP Exploration of new solutions for CCS ON-BOARD building blocks (technology, migration…) **Key Resources** OCORA Organization: SteeCo, core team and topic based workstreams. Experts and budget from OCORA members Expertise from any stakeholders (RU, IM, manufacturer, NoBo, institution)	Reduce risks with a commonly understood **reference** supporting migrations boosted by new supply services Reduce TCO with an **architecture** framework supporting interface standardization and CCS asset management. Enable collaboration and innovation with an **open** approach powered by EUPL, value-driven and profitability Trace and optimize the performances of the **upgradeable CCS On-board** building blocks as bottleneck for an increased automation of railway traffic.	CER, UIC, EUG as platform to keep consensus between OCORA members and other operators. CER as representative for EU policy issues. Sector event/conference to allow presentation of status, progress and issues Regular meeting with EU industry **Channels** Code of conduct as guidance for collaboration, modern collaborative tools and platforms within OCORA Public repository as channel for publication and feedback collection.	OCORA documentation work should be usable by: - Fleet owners to support their asset management strategy (migration plans, technical standard) - Rail manufacturers to design new generation products - Authorities to rationalize and clarify as well as enhanced regulations applicable to CCS ON-BOARD OCORA collaboration welcomes: - Any fleet Owners (RUs, lessors, ECM) as member - Any stakeholder (RU, IM, manufacturer, NoBo, institutions) that is willing to contribute as fellow/observer

Cost Structure	**Revenue Streams**
Design and maintain the CCS On-board architecture including engineering activities (requirement capture, modeling, mock up, prototyping, etc.) and coordination within OCORA membership and other rail stakeholders Purchasing CCS components (design, build, maintain) and retrofitting rolling stock unit with new CCS configurations	Financing mechanism through: - S2R/S2R2 (OCORA documentation work and OCORA related demonstrations) - co-investment from solution providers - deployment funds (e.g. CEF, national schemes…) Revenue from new services to customer or increased offer unable by automation

Figure 1 - Business model canvas

2.2 Economic assessment methodology to be used for OCORA

The fleet owners will obviously gain from an open reference architecture. Nevertheless, it is also a case where suppliers will benefit. Designing a new CCS On-board concept requires technical, organisational but also economic/business considerations: the industrial relevance will grow if collective steps are taken to build accurate economic models.

A sector business model allows to explore and balance all interest in order to drive speed and sustainability, based on the following scenarios:

A. An optimised and affordable cost structure

- ⇨ Designing an OCORA Minimum Viable Product based on ERTMS, Universal Vital CCS Bus, vehicle interface adapter, and ATO GOA2
- ⇨ Developing the OCORA architecture
- ⇨ Maintaining a high industrial readiness for CCS On-board building blocks
- ⇨ Delivering enhanced CCS functionalities: applications and peripherals not included in the MVP (e.g. ATO GoA4, computing platform…)

B. A value-driven migration planning

- ⇨ Decoupling physical and digital subsystems life cycles for adaptable vehicle performance
- ⇨ More volumes with quicker renewal/modifications for a dynamic supply market
- ⇨ Financing interoperable solutions for rail automation and class B transition

C. Openings: new markets, new values

- ⇨ A consolidated European supply chain for new products and new services supporting stakeholders and shareholders satisfaction
- ⇨ Innovative investment amortization and new technologies with less investment risks
- ⇨ Fast readiness with OCORA collaboration: early operation and continuous exploration

In order to have a comprehensive economic model, OCORA targets to model the relation between users (i.e. fleet owner, RUs) requirements and technical choices. OCORA requirement collection **Error! Reference source not found.** shall serve as a basis for this model. Identifying relations between requirements should help to anticipate the impact of technology choice or on the ability of a tool on the architecture design and performance parameters. Business objectives and requirements being traced to architecture design, a comprehensive model can be developed in order to make sensitivity analysis and support industrial choices (e.g. granularity of OCORA modules, performance range for architecture solution). The figure 2 is a first tentative architecture for OCORA economic modelling. The challenge is now to identify and define the relation between value and cost drivers.

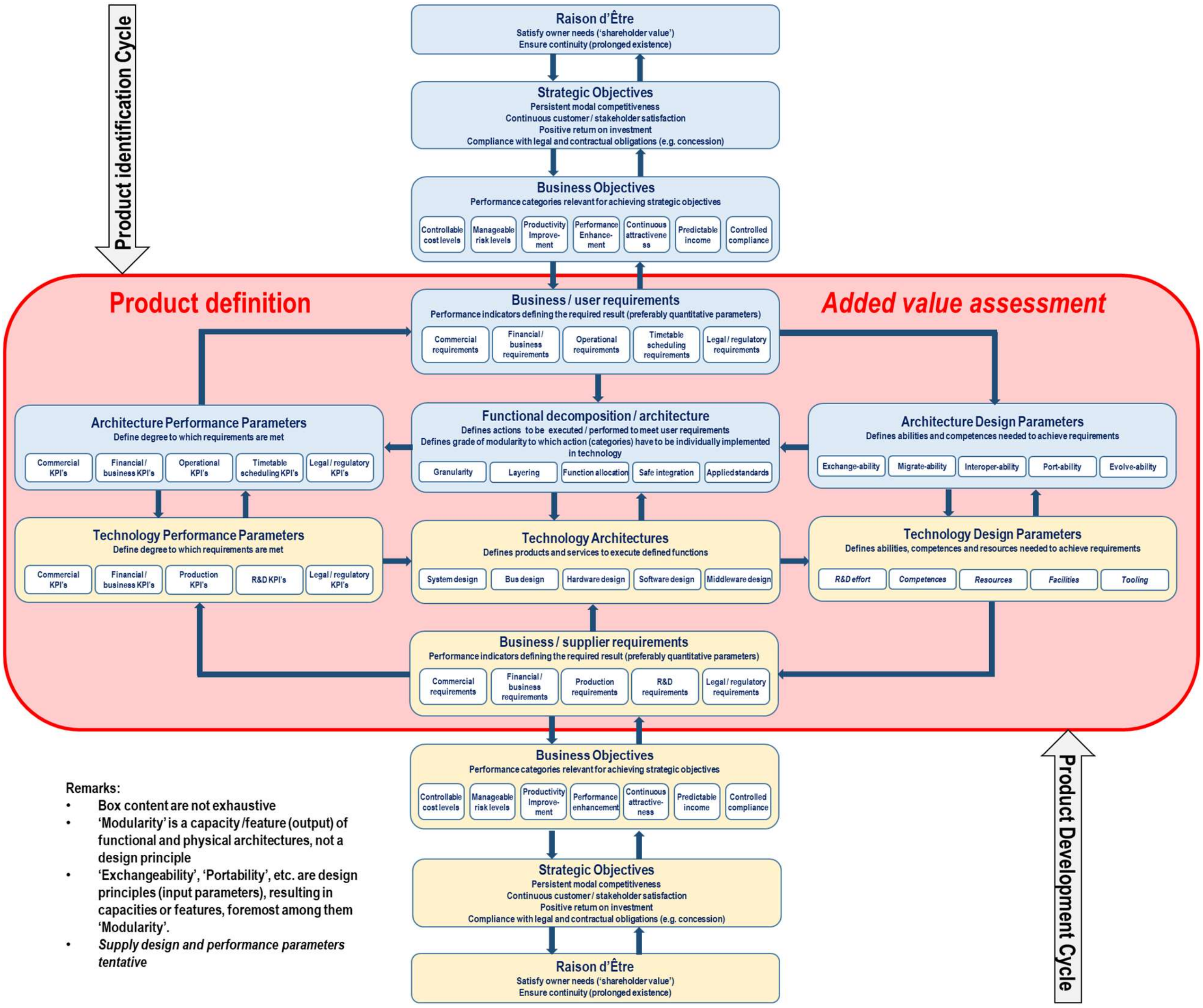


Figure 2 - General value decomposition

3 Economic parameters for OCORA modelling

The following section provides the reader a first identification of economic parameters that will be used for OCORA economic evaluations. It aims to provide hypothesis and reference values in order to build generic but realistic and accurate scenarios to support quantitative assessments and sensitivity analysis.

3.1 Deployment parameters

3.1.1 Fleet Migration Scenario’s

The vehicles of a given fleet have to be distributed among the six categories defining their migration scenarios for CCS On-board defined as follows:

Figure 3 - Vehicle categories according to their level of equipment

Migration Scenario M1 to M5 apply to the existing fleets, according to the level of equipment of the vehicles and their residual value (hence their put-out-of-service date) as the sixth one deals with the future fleet.

We assume that categories M3, M5 and M6 are OCORA compatible, while vehicles from category M4 (fitted with ETCS BL2) can benefit from the OCORA architecture after one upgrade cycle (ex. 10 years), when modified to ETCS L3 + ATO.

The implementation of the game changers would then appear as follows for the OCORA case:

	category	equipment	FRMCS	ETCS	L3	ATO GoA2	ATO Go4
exisitng fleet	M1	no ETCS					
	M2	no ETCS	non ocora				
	M3	no ETCS	ocora	ocora	ocora	ocora	ocora
	M4	ETCS BL2	non ocora	non ocora	ocora	ocora	ocora
	M5	ETCS BL3	ocora	ocora	ocora	ocora	ocora
future fleet	M6		ocora	ocora	ocora	ocora	ocora

Table 1 - Implementation of the Game Changers for the different vehicle categories

3.1.2 Fleets scenarios

As this document does not aim at providing the OCORA impact assessment for any individual case, nor the full sector. But for a first quantitative assessment we use a generic fleet including 1000 vehicles with 30 different types of vehicles, distributed over the different categories M1 to M6 as shown in Table 2.

	Vehicles	Types
Migration Scenario M1 - Train/Loco will be faced out before FRMCS is required (2025-2030)	100	5
Migration Scenario M2 - Train/Loco will only require an GSM-R to FRMCS update and will be faced out before ETCS L3 (2030-2040)	100	3
Migration Scenario M3 - Train/Loco has no ETCS now but required ETCS L3 incl. game changer	300	10
Migration Scenario M4 - Train/Loco has ETCS Bl. 2 now but required ETCS L3 incl. game changer	200	4
Migration Scenario M5 - Train/Loco has ETCS Bl.3 now but required ETCS L3 incl. game changer	100	3
Migration Scenario M6 - Train/Loco will be refittd with ETCS L3 incl. game changer as new build	200	5
Total	**1000**	**30**

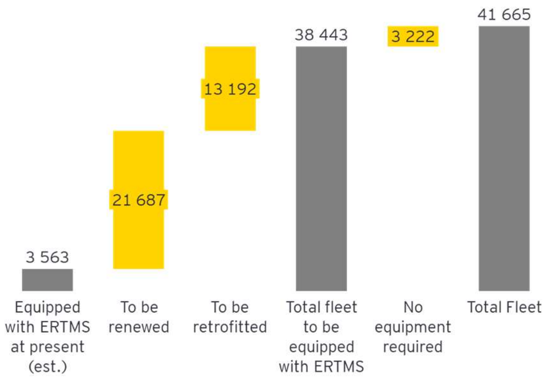
Table 2 - Description of the generic fleet

Beyond this need of categorisation, useful to properly assess the potential impact of the OCORA architecture benefits, it might be relevant to have a realistic view of the market volume at European scale in the next decades.

According to the ERTMS Coordinator Work Plan published in May 2020 [4], *"The number of vehicles already equipped in the EU amounts to some **3.600 vehicles equipped**.*

***The total fleet to be equipped by 2030 is estimated between 27.500 and 38.500 vehicles**. The difference between the low bound and the high bound is due to the capacity of railway undertakings to optimize the fleet required to operate on the CNC in countries where these corridors do not represent significant parts of the network."*

The following graphs show those figures for both low and high bound cases.



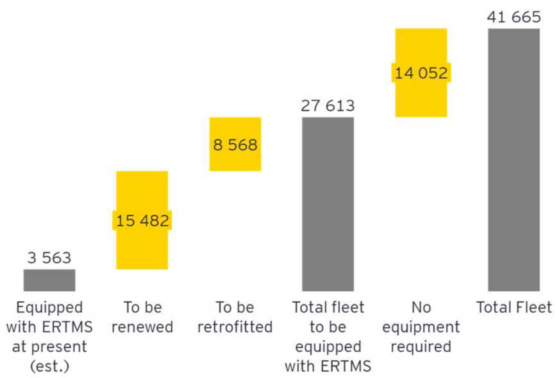


Figure 4 - Total European fleet to be equipped: high bound (left) and low bound (right)

The ERTMS Coordinator Work Plan [4] gives an estimation of the market volume, as shown in next figure, for the low bound:

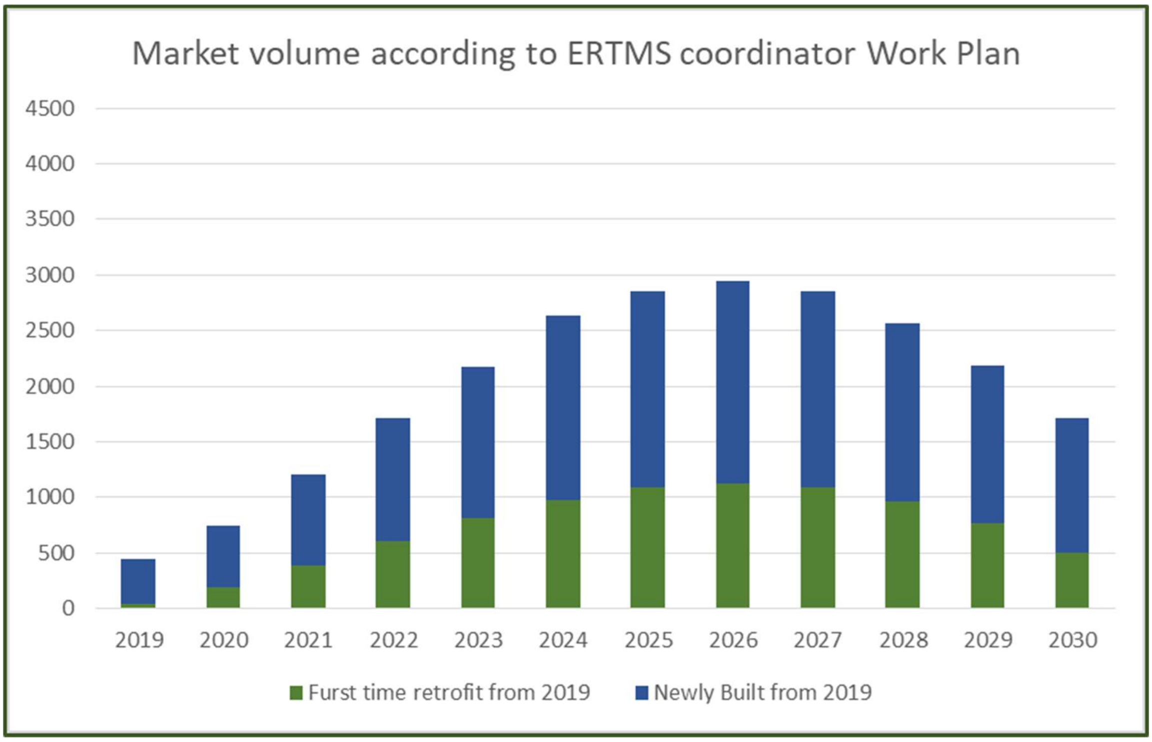


Figure 5 - Market volume according to ERTMS coordinator Work Plan [4] (low bound figures)

Nevertheless, and as already stated in [2] (section "Market Dynamics"),considering the need of the regular CCS On-board replacement, with a frequency varying between 5 and 15 years, the market volume would be larger, as it would include the retrofit of the retrofitted vehicles (ie upgrades), see figure below.

For this exercise, at preliminary stage, we considered a replacement rate of 7 years.

The benefits of the OCORA architecture would then be much higher than estimated here with the considered generic fleet.

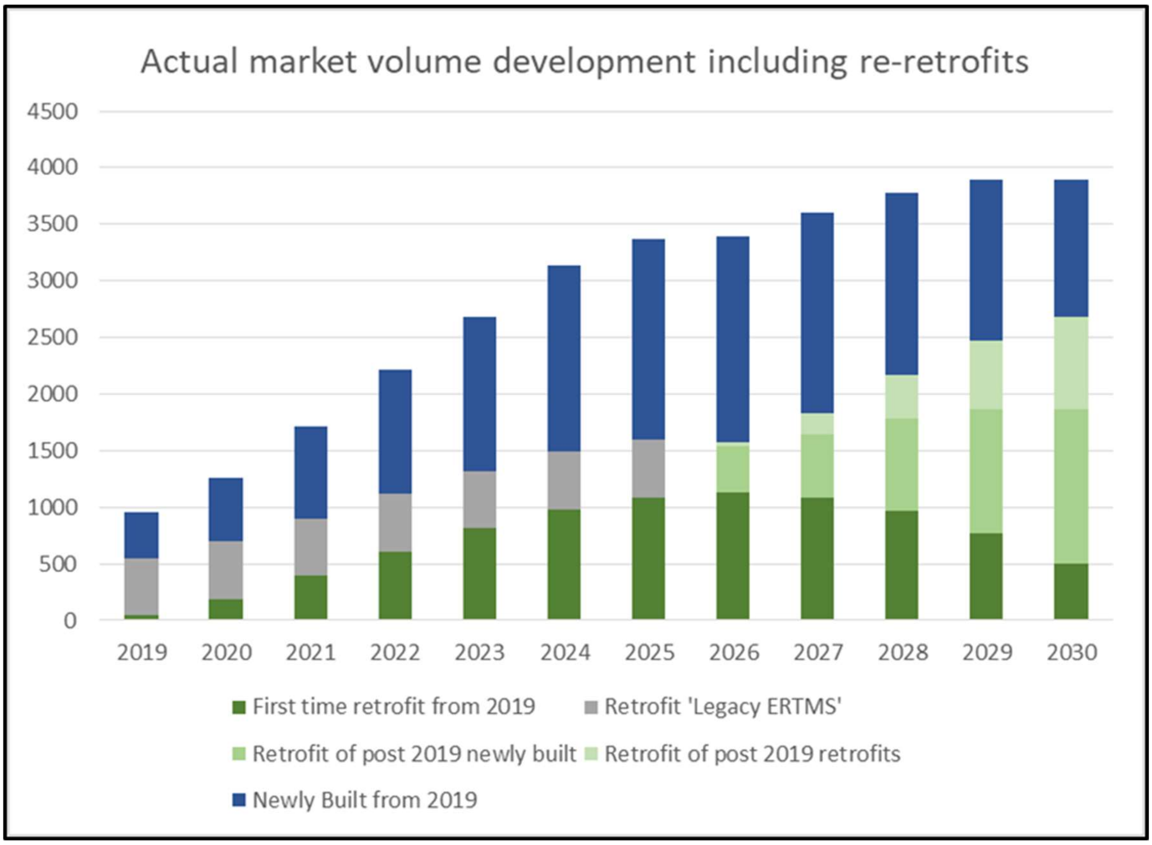


Figure 6 - Actual market volume development including re-retrofits (low bound figures) – the replacement frequency is taken for this estimate at 7 years

Year AD	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	
Year Sequence	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Assumptions
Already equipped before 2019	509	509	509	509	509	509	509	0	0	0	0	0	0	0	0	0	0	0	0	Fleet = 3563 retrofitted in 2018 evenly spread
Retrofit 'Legacy ERTMS'								509	509	509	509	509	509	509	0	0	0	0	0	(509 / year), replacement rate once per 7
Decommissioned 'Legacy ERTMS'															509	509	509	509	509	years, Average residual lifetime = 15 years
Newly built incl ERTMS								407	555	817	1099	1365	1651	1769	1819	1765	1605	1415	1214	
Retrofit of newly built															407	555	817	1099	1365	Replacement rate every 7 year
Retrofit existing fleet								42	192	393	609	813	980	1090	1128	1087	964	766	505	
Retrofit of retrofit															42	192	393	609	813	Replacement rate every 7 year
Total newly built	0	0	0	0	0	0	0	407	555	817	1099	1365	1651	1769	1819	1765	1605	1415	1214	
Total retrofitted	509	509	509	509	509	509	509	551	701	902	1118	1322	1489	1599	1577	1834	2174	2474	2683	
Grand Total	509	509	509	509	509	509	509	958	1256	1719	2217	2687	3140	3368	3396	3599	3779	3889	3897	

Table 3 - Figures for the actual market volume development including re-retrofits (The replacement frequency is taken here at 7 years))

When considering those upgrade options, the cost of operation including re-retrofits is largely increased, as shown in the next figure.

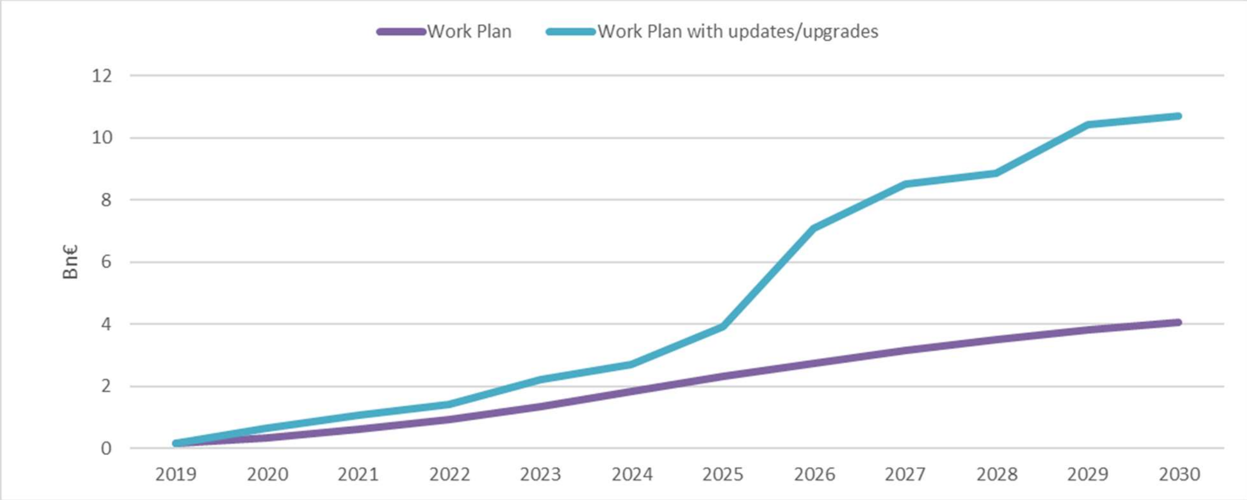


Figure 7 - TCO comparison work plan evolutions with/without updates/upgrades (low bound figures)

The figures presented in figures 6, 7 and table 3 will now have to be challenged and refined. Refined assumptions are needed for a robust economic modeling. New periodicity has to be considered for baseline upgrade and updates, functional increment as well as security patching.

3.1.3 The industrial challenge

According to the ERTMS Coordinator Work Plan [4]: *"A large part of the vehicles is expected to be equipped thanks to the renewal of the fleet (**between 15.500 and 21.500**); the rest will have to be retrofitted (**between 8.500 and 13.000**). Between 2019 and 2030, this represents **700 to 1.100 vehicles / year to be retrofitted**, and **1.300 to 1.800 vehicles / year to be renewed**. Furthermore, this assessment does not include the needed upgrades of vehicles from baseline 2 to baseline 3, which will also affect the industrial capacity of suppliers."*

In addition, we have considered the necessary updates and upgrades which will have to take place once.

3.2 Economic assumptions

The figures considered are mainly based on the document "The ERTMS business case on the 9 core network corridors – Second release", provided by the European Commission in June 2019 [6].

Relevant figures also appear in the Decision published by the European Commission in 2019 to notify the unit contributions for supporting ERTMS deployment under the Connecting Europe Facility (CEF). For the on-board part, those unit contributions were assessed for different categories of retrofitting, upgrade and fitment. They were derived from both the costs identified for the aforesaid ERTMS Business case study, and 93 CEF applications for on-board equipment.

From these reports are in particular extracted the capex cost for ETCS (M4 and M5), the re-investment period with an upgrade frequency of 5 years. The 10-years re-investment frequency of the capex has been taken here at 15 years.

3.2.1 Investment Timelines

The investment timeline will have to be adjusted according to both the availability and the introduction of the different game changers, mainly FRMCS, L3, ATO.

Beside fixed assumptions for investment horizon, it is important that the economic modelling allows to anticipate changes in technology life cycle. Following figure illustrate the general trend. It should be taken into account for a detailed economic model.

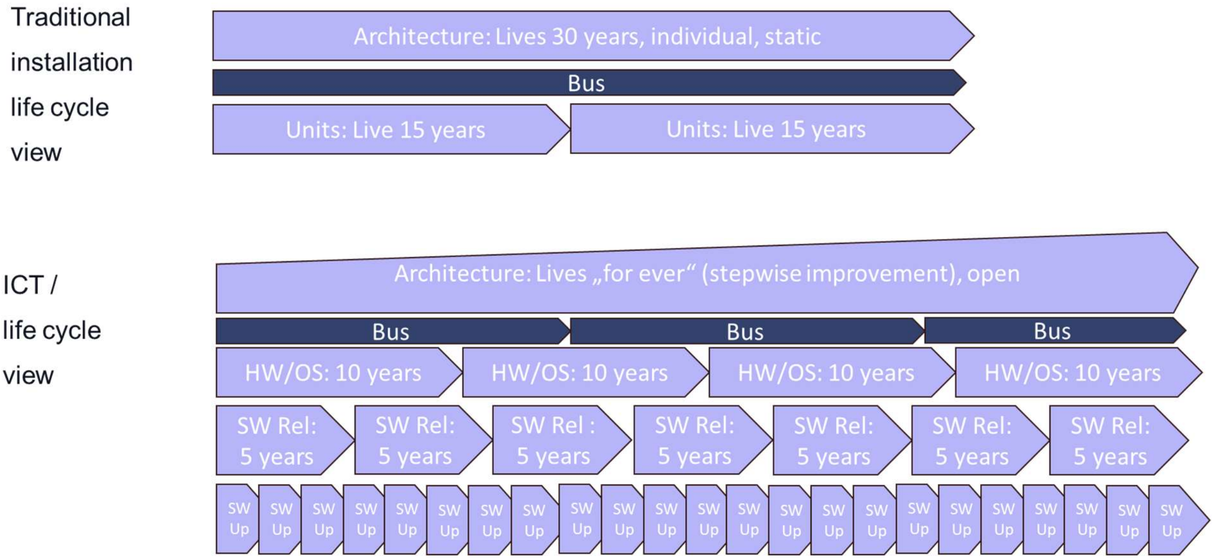


Figure 8 - View of the frequency of the updates/upgrades throughout the life cycle of a vehicle

3.2.2 Base figures for CAPEX

The OCORA business case model is on the CAPEX perspective based on a re-investment period of 15 years for the following items:

- FRMCS Update (per vehicle)
- ETCS Hardware (per vehicle)
- ATO GoA2 Hardware (per vehicle)
- Localization Hardware (per vehicle)
- Fitment Costs (per vehicle)
- Engineering Costs (per Fleet)
- Application Costs (per Fleet)

When using OCORA solution, CAPEX will also be impacted by following elements:

- A reduction of the need for re-authorization and a reduction of the cost and time of authorization procedure
- A limited number of transitional steps to reach the targeted architecture with the needed functionalities (L3, ATO, FRMCS)
- Product adaptability by design

The OCORA solution will therefore have a significant impact when retrofitting vehicles, when considering the generic retrofit cost distribution in the figure below. There would be a strong impact on both the supplier part and the authorization costs. The human costs take into account mostly the engineering costs and fitment works.

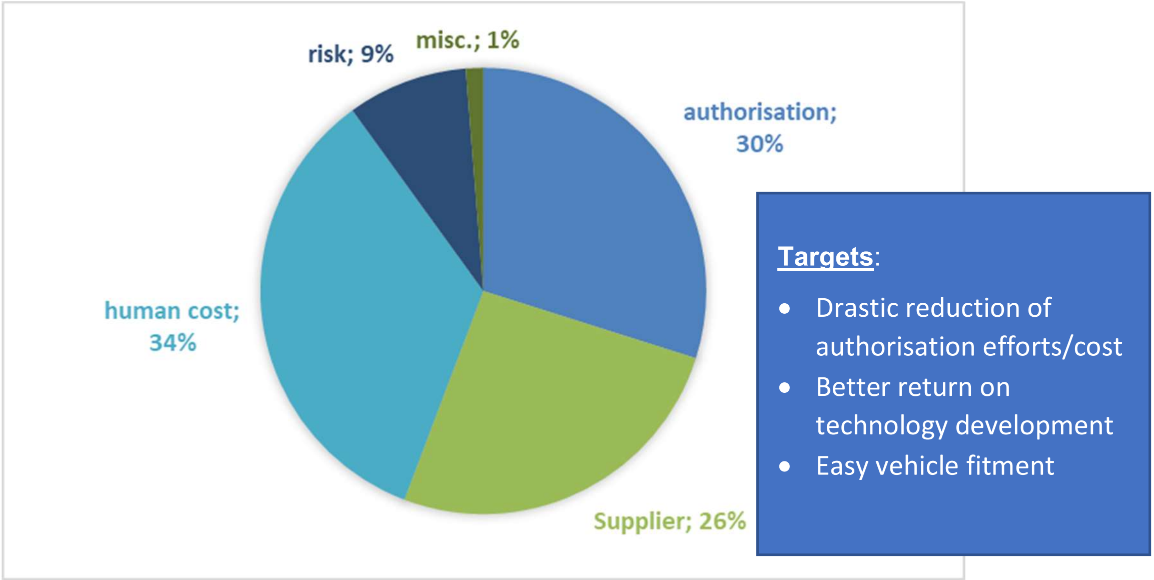


Figure 9 - Actual generic retrofitting cost distribution

In any case, the re-investment linked to the retrofit operation has to carefully considered for middle-aged vehicles as it might affect their competitiveness, compared to new build vehicles.

3.2.3 Base figures for OPEX

The OCORA business case model is on the OPEX perspective based on the following items:

- FRMCS Updates per unit with a re-investment period of 2 years.
- FRMCS Baseline Upgrades per year with a re-investment period of 5 years.
- ETCS Updates per unit with a re-investment period of 2 years.
- ETCS Baseline Upgrades per year with a re-investment period of 5 years.
- ATO Updates per unit with a re-investment period of 2 years.
- ATO Baseline Upgrades per year with a re-investment period of 5 years.
- Localization Updates per unit with a re-investment period of 1 year.
- Localization Upgrades per year with a re-investment period of 5 years.

The security patching is not taken into account within the OCORA framework.

3.2.4 Towards new economic assumptions

The modularization of CCS On-board must maintain a balance between modular interchangeability and suitable bundling. Modularisation is only accepted by market participants, if a positive business case exists. Otherwise, there will be no market for the respective solution components or services.

A harmonised list of CCS modules is desirable for the CCS market, safety and maturity. The actual dismantling of the modules will have to evolve as the OCORA architecture is developed, taking into account existing and expected future life cycles. In addition, the necessary services for integration and operation must be embedded to complete the picture. The new, required approach must include the relevant cost components for CAPEX and OPEX of CCS On-board in the TCO view also addressing the possibility for new revenues.

Already identified modules for CCS On-board are:

- Software Applications (Vehicle Supervisor, Vehicle Locator, ATO Vehicle, ..)
- Computing Platform
- COTS hardware, pre-certified for safety relevant functions up to SIL-4

- Peripherals, such as DMI, JRU, Locator, BTM, Radio
- Connectivity Devices
- Vehicle Adapters

Already identified services to integrate CCS On-board are:

- Integration engineering > integrate a generic OCORA module or set of modules into the specific fleet
- TCMS adjustments > adjustments in order to provide the OCORA compliant train interfaces for control, command and supervision
- Installation (mechanical, electrical)
- Commissioning
- Acceptance testing
- Infrastructure for refurbishment
- Approval generic CCS On-board
- Approval specific refurbishment > for integration into the specific fleet
- Test / reference systems (OCORA compliant or not)

Already identified services to operate CCS On-board are:

- Configuration management, monitoring and diagnose
- Curative maintenance, error correction and repair
- Preventive maintenance
- Spare parts management
- Obsolescence supervising and management
- Training and education
- Baselining, maintaining reference specification and reference implementation
- Module testing

3.3 Technical parameter: Scenarios for levels of modularity

Business models are dependent of the level of modularity reached for the architecture. Those different levels are fully presented in the “Introduction” document [2] (Section “OCORA architecture development stages”), and are only shortly reminded here:

Four levels of modularity can be considered, in addition of the current situation.

- Level of Modularity 0 (current situation): The integrated proprietary CCS system is (again) fully integrated in the proprietary vehicle environment, driving costs and risks and complicating obsolescence issue
- Level of Modularity 1 (short term OCORA objective: Preparing imminent retrofit projects): The interface between proprietary constituents of the CCS system is isolated, enabling exchange of those constituents without affecting either the vehicle or other CCS constituents, simplifying obsolescence and migration issues
    - → Decoupling vehicle and CCS evolution
- Level of Modularity 2 (Modularisation of the CCS sub-system): the CCS domain is decomposed in single building blocks, connected by open interfaces and an open bus system allowing exchangeability between the building blocks without affecting either the vehicle or other CCS constituents
    - → Decoupling CCS building blocks
- Level of Modularity 3 (OCORA CCS platform): the core CCS functions is organised on a generic platform that enables adding, removing or changing software without affecting the hardware and

computing platform on which they are installed or the state of approval of non-affected parts of the system

→ Interoperability and interchangeability, application portability

- Level of Modularity 4 (Convergence of vehicle networks): the CCS integration is facilitated by standardised interface and convergent TCMS and CCS bus technology

  → open system with full plug and play capabilities for applications, hardware and peripherals

Those levels of modularity should be considered as scenarios in OCORA economic evaluation. They need to be used to propose optimised industrialisation paths.

4 Preliminary Assessment of Benefits (qualitative approach)

4.1 Introduction

The introduction of digital technologies in rail can be achieved through modularisation, with the aim to deliver a more flexible and robust system.

OCORA is based on a functional modular architecture using standardised interfaces, moving beyond the current system with proprietary interfaces. The software and hardware installed are operated and maintained following principles and standards as used in the IT domain: regular, scheduled updates with pre-tested configurations ensure errors and shortcomings are eliminated, maintaining all the products and system throughout EU in line with the interoperability specifications, with manageable upgrade mechanisms.

A more modular and adaptable system will reduce the costs and complexity of adding future functionalities. Being a software-based system, ERTMS should be prepared for the future evolutions foreseen in the 2022 CCS TSI revision in a non-disruptive way.

The following figure shows the OCORA objectives, the OCORA TSI-CCS Change Request Topics and the resulting Benefits. The terms used for the OCORA objectives are based on ISO 25010 product quality characteristics.

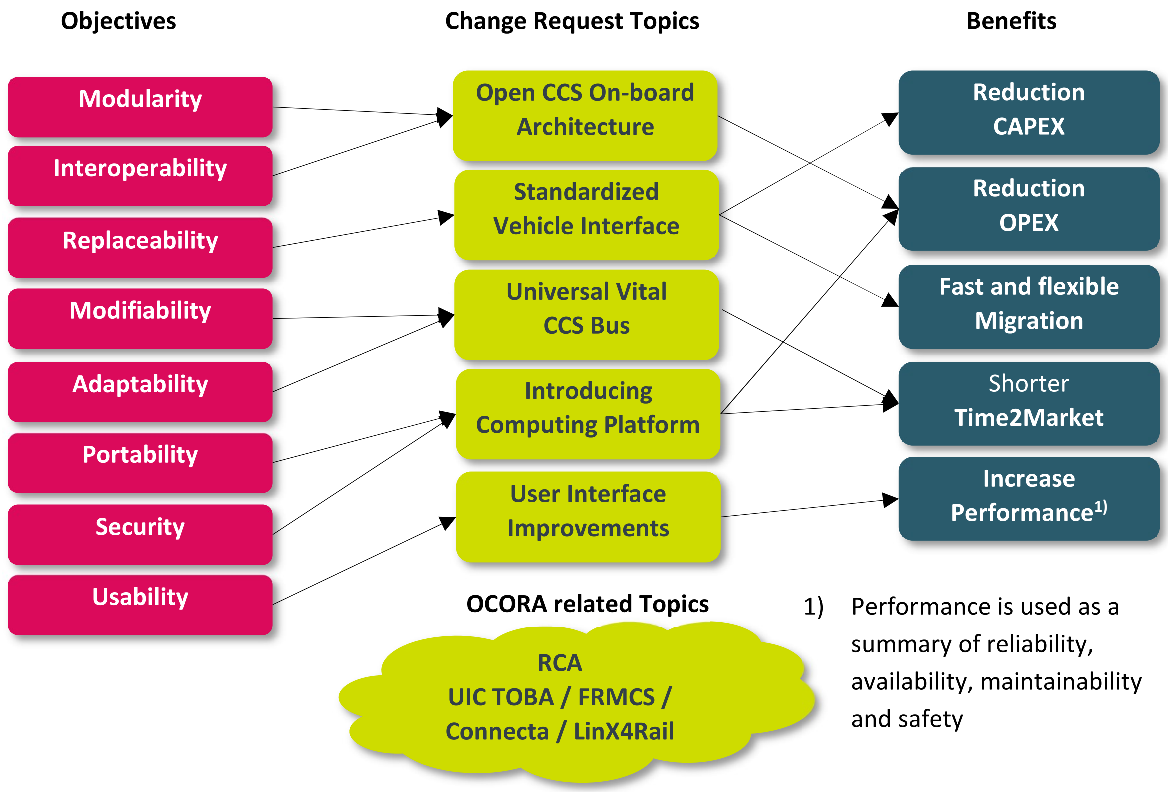


Figure 10 - OCORA objectives and benefits

The OCORA benefit assessment in this document is based on the comparison of a CCS on-board solution (ETCS up to L3, ATO, FRMCS) versus a CCS on-board solution with the related TSI-CCS 2022 change requests (Open CCS on-board Architecture, Standardized Vehicle Interface, Universal Vital CCS Bus, introducing computing platform, User Interface Improvements) and the OCORA related topics (Localization, FRMCS, RCA) in place. The following benefits have been identified.

4.2 OCORA expected benefits

4.2.1 Reduction of CAPEX

Amount of capital expenditure reduced for a CCS on-board solution including the TSI-CCS 2022 change requests. This includes also the non-recurring engineering costs for integration engineering and certification.

OCORA architecture can make the railway sector more competitive with an open supply market. Using proven and harmonised specification will help reducing the development, industrialisation and authorization costs.

A clear separation of safety-related and non-safety-related layers is required and therefore this should enable modular safety cases enabling evolution. This clear separation aims to substantially reduce the need for authorisation procedures when modifications are realised in the non-safety related parts of the system, therefore to reduce CAPEX.

4.2.2 Fast and flexible Migration

Amount of time reduced to introduce a new CCS on-board solution into a vehicle.

Amount of flexibility won to introduce new or adapted CCS functionalities.

This benefit has an indirect value. Two perspectives can be provided by now.

Once all vehicles are migrated to ETCS L3 along with a fail-safe localisation, trackside assets such as axle counters or track circuits can be removed thereafter and will no longer create OPEX. This means a faster migration provides a shorter return on invest.

Due to the separation of computing platform and applicative software the hardware fitment can be made once, while the availability of function can be increased in a flexible and iterative way over time. This is especially beneficial with a view on new application such as ATO where experience is pending. In addition this reduces downtime of the vehicle for fitment in case not all functions are available at one point in time.

4.2.3 Shorter Time2Market

Amount of time reduced to introduce new or adapted CCS functionalities into a vehicle. This is especially required for short term adaptions related to error correction or security patching.

In a preliminary assessment this benefit is required to enable regular and time critical updating, required for cybersecurity patching and error correction.

A direct or indirect cost benefit could not be modelled, yet.

4.2.4 Increase Performance

Other elements will create benefits when implementing open, standardised OCORA solutions:

- Reliability increase of the CCS on-board solution
- Availability increase of the CCS on-board solution
- Maintainability increase of the CCS on-board solution (The malfunctioning reporting can improve the maintainability of the system and reduce the number of incidents in operation
- Maintain current level of safety of the CCS on-board solution

In a preliminary assessment this benefit is required to enable stable and efficient system operation. Further investigation needs to be performed to assess the current level of performance and define related targets. Therefore, this preliminary assessment is not providing results related to direct or indirect cost benefit due to the decrease of vehicle downtime.

5 Preliminary Assessment of Business Case (quantitative approach)

5.1 Introduction

In the current investigation OCORA compares the following:

- Base Case: Implementation of ETCS up to L3, including FRMCS and ATO, based on the current proprietary CCS on-board architecture
- OCORA Case: Implementation of ETCS up to L3, including FRMCS and ATO, based on the OCORA architecture with open standardized interfaces

For both cases the following simplification were used:

- Fleets are migrated from a different existing installation
- It is assumed the L3 fitment takes place between until 2035
- It is assumed the FRMCS upgrade can start from 2030

5.2 Assumptions

Assumptions regarding the game changers:

- We use dynamic values that could be modified as we don't know when and in which order the games changers will be specified and available
- We assume the procurement costs and the integration costs of each game changer will be reduced in an OCORA architecture comparing to the equivalent costs in the current CCS architecture

Assumptions regarding the migrations categories compatibilities with the OCORA Architecture

- Fleets are separated into different categories. Some more work is needed to verify whether or not all the categories are OCORA compatible (except category M1).
- If not we have to precise which category is OCORA compatible and which one is not.

We do not want to jeopardize the investments already made by the owners of fleet so the OCORA architecture should only concern the fleet which do have a non-modular ETCS.

5.3 Preliminary Comparison Base Case vs OCORA Case

The following figure shows a comparison of the evolution of the cumulated Total cost Ownership for both, Base Case and OCORA Case.

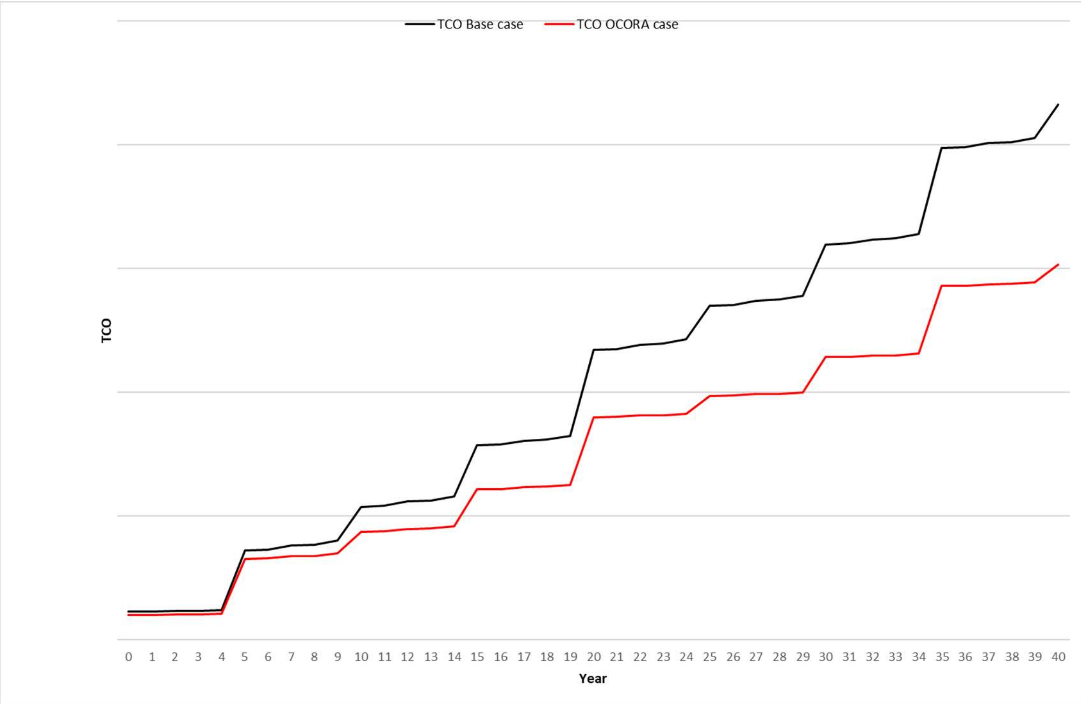


Figure 11 - TCO evolution comparison for both Base Case vs OCORA Case

5.4 Interpretation

The obtained gains for the OCORA case are strongly and undoubtedly dependent on the reduction of the OPEX figures considered for the OCORA case.

Note that no specific development costs have been considered relatively to the introduction of the OCORA related products, assuming that the development expenses could be distributed on the products costs and associated works.

The generic fleet of 1000 vehicles has been considered for this assessment, with a uniform application of retrofit/upgrade/update works, i.e. with the same frequency. Those different works will probably be distributed more evenly over the years, to take into account the industrial capacity.

Another main parameter is the distribution of the fleet which has been considered here for the distribution of the vehicles among the six defined categories.

Performing a sensitivity analysis would help to assess the influence of the choices which have been made for this assessment.