# OCORA

Open CCS On-board Reference Architecture

## Economic Modelling Series

CCS impact on System Life Cycle Costing Scenario Studies



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# Management Summary

The economic justification for the OCORA raison d'être and tooling that support OCORA technical decision-making is presented. Essential precondition for this document is that it represents the fleet owner point of view, but with a keen eye on business interests of the supply industry and on infrastructure manager's needs. The model aims to provide analytic tools that help to satisfy common business objectives.

This document introduces the economic modelling approach enabling a quantitative assessment of the benefits of OCORA. It is the foundation for developing a more extensive reasoning on an open architecture approach and therefore shall embrace various dimension, at various levels of abstraction.

# Revision history

| Version | Change Description | Initial | Date of change |
|---|---|---|---|
| 0.00 | ▪ Initial draft | NPT | 19.05.2022 |
| 0.01 | ▪ Revised draft including all results from LH and PV | NPT | 03.06.2022 |
| 0.02 | ▪ Revised draft including further results | NPT | 09.06.2022 |
| 1.00 | 1st release version | NPT | 10.06.2022 |
| 1.10 | Review for R4 | VI | 12.06.2023 |
| 1.11 | Editorial work in Introduction | LDL | 31.01.2025 |

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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-BWS06-030 – Economic Model – Model Description

[8] Verband der Bahnindustrie in Deutschland e. V., Die Zukunft Der Schiene Soll Rasch Beginnen, Umfassender Konzeptvorschlag: Aus- und Umrüstung von Schienenfahrzeugen mit ETCS-Bordgeräten, www.bahnindustrie.info

[9] ERTMS Coordinator Work Plan, May 2020

# 1 Introduction

## 1.1 Purpose of the document

The purpose of this document is to reflect the current state of discussion on the development of analytic tools for demonstrating the added value of the OCORA drive for modularising the CCS on-board according to the OCORA design principles. It specifically addresses the issue of cost assessment, which is but one aspect of economic modelling. Its major objective is to spark discussion between OCORA and stakeholders, thus enabling validation and verification of the assumptions underlying future economic analysis OCORA is preparing, as well as of the actual calculations.

The calculations and approaches proposed by different OCORA members in this document, using the Economic Model – Model Description [7], make use of numbers that were adopted from formal reports and analysis from the European Commission (EC) or other sources. The sources are indicated in the document where relevant.

Assumptions underlying both methodology and calculations, will be specifically indicated to facilitate discussions.

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 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-inspred CCS building blocks, for tendering complete on-board CCS system, or also for on-board CCS replacements for functional upgrades or for life-cycle reasons.

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

The Economic Model for OCORA should help fleet owners and suppliers to build relevant 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 sets 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.

## 1.2 Applicability of the document

The document is considered informative. Subsequent releases of this document will be developed based on a modular and iterative approach, evolving within the progress of the OCORA collaboration.

## 1.3 Context of the document

This document is published as part of the OCORA Release, together with the documents listed in the Release Notes [1]. Before reading this document, it is recommended reading them. If you are interested in the context and the motivation that drives OCORA we recommend reading 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 The fleets investigated

## 2.1 Introduction

Several fleets have been considered to perform the sensitivity analysis. Different sizes and distributions have been chosen, in order to have a large panel of cases.

## 2.2 The European fleet

European fleet level analysis is based on the Ruete report [9] figures as depicted below in **Figure 1**. The Ruete report has elaborated two scenarios for fleet development in the years 2020 – 2030: a high bound and a low bound scenario. From this report, the total European fleet to be equipped by 2030 is estimated between 27.500 and 38.500 vehicles.

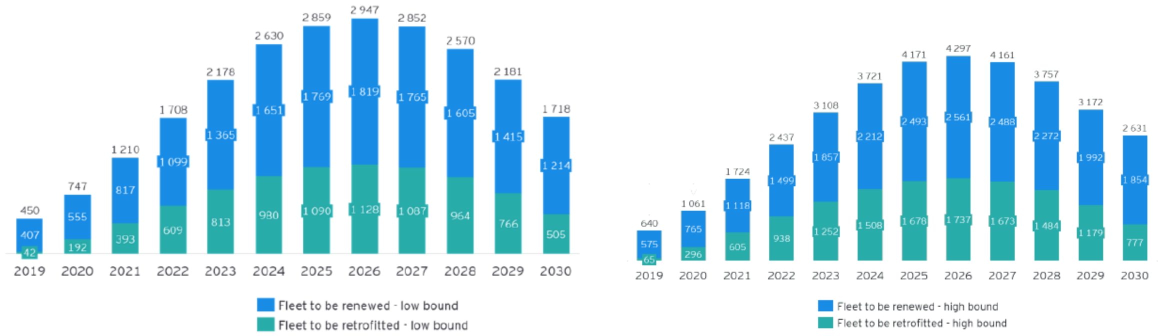


**Figure 1** Ruete low (left) and high (right) bound scenario for rolling stock to be renewed or retrofitted

The figures considered for the acquisition and retrofit of vehicles are in **Table 1**:

| SCENARIO WITH: Fleet to equip/retrofit | OCORA (insert above product na | Type | Product used | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 | 2033 | 2034 | 2035 | 2036 | 2037 | 2038 | 2039 | 2040 | 2041 | 2042 | 2043 | 2044 | 2045 | 2046 | 2047 | 2048 | 2049 | 2050 | 2051 | 2052 | 2053 | 2054 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Fleet 1 | EMU/DMU Class 1 | new build | EVC | 407 | 555 | 817 | 1099 | 1365 | 1651 | 1769 | 1819 | 1765 | 1605 | 1415 | 1214 | | | | | | | | | | | | | | | | | | |
| Fleet 2 | EMU/DMU Class 2 | retrofit | EVC | 42 | 192 | 393 | 609 | 813 | 930 | 1090 | 1128 | 1087 | 964 | 766 | 505 | | | | | | | | | | | | | | | | | | |
| Fleet 1 | EMU/DMU Class 1 | new build | pre-O. | 407 | 555 | 817 | 1099 | 1365 | 1651 | 1769 | 1819 | 1765 | 1605 | 1415 | 1214 | | | | | | | | | | | | | | | | | | |
| Fleet 2 | EMU/DMU Class 2 | retrofit | pre-O. | 42 | 192 | 393 | 609 | 813 | 930 | 1090 | 1128 | 1087 | 964 | 766 | 505 | | | | | | | | | | | | | | | | | | |
| | Total fleet | | | 449 | 747 | 1210 | 1708 | 2178 | 2581 | 2859 | 2947 | 2852 | 2569 | 2181 | 1719 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Table 1** European scale (low bound) deployment scenario

## 2.3 The VDB fleet

This simulation task aimed for a realistic overview of the ETCS-retrofit plan for the German fleet. Basis of this calculation was the VDB study published in [8] which is freely available.

The study made deep investigations in specifying the process of ETCS retrofitting according to the German roll-out plan. The first indicative numbers used in our simulation were the numbers of vehicles divided into the years from 2022 to 2030. The next relevant indicator was the defined equipment cluster. In total, three different equipment clusters were presented, and only one of them was suiting the OCORA requirements: the fully integrated solution with TCMS. That cluster includes the following specifications:

- Digital interface of the ETCS/ATO OBU to the vehicle through TCMS
- Implementation of comfort functions, e.g. vehicle diagnostics, processing of track conditions

- DMI functionally and mechanically integrated in driver's cab
- During integration/conversion, the OEM must be fully involved

The VDB study also divided the number of total vehicles into the three clusters. The next step was to calculate the number of vehicles per year by the ratio of the vehicles of that relevant cluster. After that was done, the third indicator was mentioned: the different vehicle types. In total, six different vehicle types are mentioned in the VDB study: high-speed train ICE, e-locomotive, d-locomotive, EMU, DMU & H2 and track construction and special vehicles. Dividing the number of relevant vehicles per year to the ratio of these vehicle types, the final table was calculated.

| | ICE | Lok E | Lok D | EMU | DMU, H2 | Track construction etc. |
|---|---|---|---|---|---|---|
| **2022** | 0 | 4 | 1 | 3 | 2 | 2 |
| **2023** | 1 | 19 | 5 | 16 | 10 | 10 |
| **2024** | 8 | 154 | 36 | 127 | 81 | 81 |
| **2025** | 13 | 250 | 59 | 206 | 131 | 131 |
| **2026** | 16 | 307 | 72 | 253 | 161 | 161 |
| **2027** | 16 | 317 | 74 | 261 | 166 | 166 |
| **2028** | 16 | 317 | 74 | 261 | 166 | 166 |
| **2029** | 16 | 317 | 74 | 261 | 166 | 166 |
| **2030** | 16 | 317 | 74 | 261 | 166 | 166 |
| **Total:** | 102 | 2000 | 470 | 1650 | 1050 | 1050 |

**Table 2** Number of relevant vehicles per year to the ratio of the vehicle types from the VDB report.

## 2.4 A typical regional fleet

A typical regional fleet of 100 vehicles is also considered, with all the vehicles being equipped the first year.

## 2.5 A distributed fleet

For this fleet, a combination of several types of vehicles has been considered in order to illustrate a typical program of combining ETCS on-board equipment (retrofit and upgrade) on existing vehicles and newly built vehicles. The goal of this distribution is to find and understand any potential differences in the model's outcomes introduced by varying in size (ranging from 50 to 200 vehicles) and type of ETCS project (upgrade – retrofit – newbuilt).

For the retrofit fleets, a remaining lifecycle of 18 years has been considered. After this period the vehicles will be taken out of consideration. For retrofitted and newly built vehicles, an introduction rate of 50 vehicles per years has been considered.

**Table 3** gives the figures for the resulting fleet of 1500 vehicles.

| 1500 vehicles | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 | 2033 | 2034 | 2035 | 2036 | 2037 | 2038 | 2039 | 2040 | 2041 | 2042 | 2043 | 2044 | 2045 | 2046 | 2047 | 2048 | 2049 | 2050 | 2051 | 2052 | 2053 | 2054 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Fleet to equip/retrofit | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Upgrade_1 | 100 | 100 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Upgrade_2 | 100 | 50 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Upgrade_3 | 100 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Upgrade_4 | | 50 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Retro_1 | 50 | 50 | 50 | 50 | | | | | | | | | | | | | | | -50 | -50 | -50 | -50 | | | | | | | | |
| Retro_2 | 50 | 50 | 50 | | | | | | | | | | | | | | | | -50 | -50 | -50 | | | | | | | | | |
| Retro_3 | | 50 | 50 | | | | | | | | | | | | | | | | | -50 | -50 | | | | | | | | | |
| Retro_4 | | | | 50 | | | | | | | | | | | | | | | | | | -50 | | | | | | | | |
| New_1 | | | 50 | 50 | 50 | 50 | | | | | | | | | | | | | | | | | | | | | | | | |
| New_2 | | | 50 | 50 | 50 | | | | | | | | | | | | | | | | | | | | | | | | | |
| New_3 | | | | 50 | 50 | | | | | | | | | | | | | | | | | | | | | | | | | |
| New_4 | | | | | | 50 | | | | | | | | | | | | | | | | | | | | | | | | |

**Table 3** Number of relevant vehicles per year for the distributed fleet.

# 3 The parameters investigated

## 3.1 Cost variation

For the first three fleets, three scenarios have been investigated, with cost variation:

a. Baseline case: EVC product vs pre-OCORA product

b. WBS case: variation of the class parameter in the Work Breakdown Structure for the class value in specification/industrialization tasks (with pre-OCORA product)

c. PBS Commissioning case: decrease of the cost parameter value for the commissioning costs, with the pre-OCORA architecture

| | Product | WBS<br>Specification & industrialization values for Class | PBS<br>Commissioning cost |
|---|---|---|---|
| **Baseline** | **- EVC**<br>**- Pre-OCORA** | 0.50 | Core CCS = 5<br>MCG (GSM-R, FRMCS) = 5<br>Train Loc. = 10 |
| **WBS case** | Pre-OCORA | **- 0.25**<br>**- 0.50** | Core CCS = 5<br>MCG (GSM-R, FRMCS) = 5<br>Train Loc. = 10 |
| **Commissioning case** | Pre-OCORA | 0.50 | **Core CCS = 2**<br>**MCG (GSM-R, FRMCS) = 2**<br>**Train Loc. = 2** |

**Table 4** Summary of cases investigated for the three fleets: European fleet, VDB fleet and regional fleet, with varying parameter in blue.

The accompanying roadmaps are the following ones, for both EVC and pre-OCORA products.

Products PBS ROADMAP

| CCS Subsystem Component | EVC | pre-OCORA Minimum Solution | OCORA Full Modular Solution | Digital CCS | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 | 2033 | 2034 | 2035 | 2036 | 2037 | 2038 | 2039 | 2040 | 2041 | 2042 | 2043 | 2044 | 2045 | 2046 | 2047 | 2048 | 2049 | 2050 | 2051 | 2052 | 2053 | 2054 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| On-board CCS | x | | | | TSI | | | | | TSI | | | | | | TSI | | | | | TSI | | | | | TSI | | | | | | | TSI | | | | |
| Core CCS | x | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Core CCS - ATP (ETCS Core) | x | | | | | Upgrade (SW) | | | | | Upgrade (SW) | | HW obs | Upgrade (SW) | | | Upgrade (SW) | | | | | Upgrade (SW) | | | | | Upgrade (SW) | | | | | | | Upgrade (SW) | | | |
| CCS addon - NTC-STM | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| CCS addon - ATO | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| CCS addon - other functions/services | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Communication and interfaces | x | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| I/O Ports | x | | | | | | | | | | | | Obso (HW) | | | Obso (HW) | | | | | | | | | | | | | | | | | | | | | |
| Functional Vehicle Adapter (FVA) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| UVCC | x | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Gateway | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| MCG (GSM-R, FRMCS…) | x | | | | | | | | | | | | 5G(HW/SW) | | | | | | | | 6G (HW/SW) | | | | | | | | | | | | 7G (SW) | | | | |
| Sensoring | x | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| ETCS Sensoring (eg Odo, BTM, LTM) | x | | | | | | | | | | | Obso (HW) | | | | | | | | | | | | | | | | | | | | | | | | | |
| Train Loc (GNSS, Inertial…) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Perception sensoring (other sensors) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| DMI | x | | | | | | | | | | | Obso (HW) | | | | | | | | | | | | | | | | | | | | | | | | | |
| Tools | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Testing tools (eg test bench, simulator) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Maintenance tools | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Training tools | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

**Figure 2** PBS roadmap for the EVC product

Lifecycle

Product: PBS ROADMAP

| CCS Core/ Peripheral or external | CCS Subsystem Component | EVC as is solution | pre-O. | OCORA Full Modular Solution | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 | 2033 | 2034 | 2035 | 2036 | 2037 | 2038 | 2039 | 2040 | 2041 | 2042 | 2043 | 2044 | 2045 | 2046 | 2047 | 2048 | 2049 | 2050 | 2051 | 2052 | 2053 | 2054 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | First HW and SW release | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| CCS | On-board CCS | | x | | | | | | | TSI | | | | | | TSI | | | | | TSI | | | | | TSI | | | | | | | TSI | | | | |
| CCS Core | Core CCS | | x | | | | | | | | | | | | | | | | | | | | | | | HW obs | | | | | | | | | | | |
| CCS Core | Core CCS - ATP (ETCS Core) | | x | | | | | | | | Upgrade (SW) | | | | | | Upgrade (SW) | | | | | Upgrade (SW) | | | | | Upgrade (SW) | | | | | | | Upgrade (SW) | | | |
| CCS Core | CCS addon - NTC-STM | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| CCS Core | CCS addon - ATO | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| CCS Core | CCS addon - other functions/services | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| CCS peripherals | Communication and interfaces | | x | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| CCS peripherals | I/O Ports | | x | | | | | | | | | | | | | | | | | | | | | | | Obso (HW) | | | | | | | | | | | |
| CCS peripherals | Functional Vehicle Adapter (FVA) | | x | | | | | | | | | | | | | | | | | | | | | | | Obso (HW) | | | | | | | | | | | |
| CCS peripherals | UVCC | | x | | | | | | | | | | | | | | | | | | | | | | | Obso (HW) | | | | | | | | | | | |
| CCS peripherals | Gateway | | x | | | | | | | | | | | | | | | | | | | | | | | Obso (HW) | | | | | | | | | | | |
| CCS peripherals | MCG (GSM-R, FRMCS…) | | x | | | | | | | | | | FRMCS (HW/SW) | | | | | | | | 6G (SW) | | | | | | | | | | | | 7G (SW) | | | | |
| CCS peripherals | Sensoring | | x | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| CCS peripherals | ETCS Sensoring (eg Odo, BTM, LTM) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| CCS peripherals | Train Loc (GNSS, Inertial…) | | x | | | | | | | | | | | | | | | | | | | | | | | Obso (HW) | | | | | | | | | | | |
| CCS peripherals | Perception sensoring (other sensors) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| CCS peripherals | DMI | | x | | | | | | | | | | | | | | | | | | | | | | | Obso (HW) | | | | | | | | | | | |
| CCS tools | Tools | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| CCS tools | Testing tools (eg test bench, simulator) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| CCS tools | Maintenance tools | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| CCS tools | Training tools | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

**Figure 3** PBS roadmap for the pre-OCORA product (for European, VDB and regional fleets)

## 3.2 Roadmap variation

The update frequency of the CCS system has been investigated for the distributed fleet, with a variation of no updates at all (to use as a reference), 2 years and from 2 to 10 years. **Figure 2** to **Figure 8** show the different PBS roadmaps considered; all being used with the pre-OCORA product.

| Lifecycle | | Products PBS ROADMAP | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CCS Core/ Peripheral or external | CCS Subsystem Component | EVC as is solution | pre-O. | OCORA Full Modular Solution | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 | 2033 | 2034 | 2035 | 2036 | 2037 | 2038 | 2039 | 2040 | 2041 | 2042 | 2043 | 2044 | 2045 | 2046 | 2047 | 2048 | 2049 | 2050 | 2051 | 2052 | 2053 | 2054 |
| | | | | | First HW and SW release | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| CCS | On-board CCS | | x | | | | | | | TSI | | | | | | TSI | | | | | TSI | | | | | TSI | | | | | | | TSI | | | | |
| CCS Core | Core CCS | | x | | | | | | | | | | | | | | | | | | | | | | | HW obs | | | | | | | | | | | |
| CCS Core | Core CCS - ATP (ETCS Core) | | x | | | | | | | | Upgrade (SW) | | Upgrade (SW) | | Upgrade (SW) | | Upgrade (SW) | | Upgrade (SW) | | Upgrade (SW) | | Upgrade (SW) | | Upgrade (SW) | | Upgrade (SW) | | Upgrade (SW) | | Upgrade (SW) | | Upgrade (SW) | | Upgrade (SW) | | Upgrac |
| CCS Core | CCS addon - NTC-STM | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| CCS Core | CCS addon - ATO | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| CCS Core | CCS addon - other functions/services | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| CCS peripherals | Communication and interfaces | | x | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| CCS peripherals | I/O Ports | | x | | | | | | | | | | | | | | | | | | | | | | | Obso (HW) | | | | | | | | | | | |
| CCS peripherals | Functional Vehicle Adapter (FVA) | | x | | | | | | | | | | | | | | | | | | | | | | | Obso (HW) | | | | | | | | | | | |
| CCS peripherals | UVCC | | x | | | | | | | | | | | | | | | | | | | | | | | Obso (HW) | | | | | | | | | | | |
| CCS peripherals | Gateway | | x | | | | | | | | | | | | | | | | | | | | | | | Obso (HW) | | | | | | | | | | | |
| CCS peripherals | MCG (GSM-R, FRMCS...) | | x | | | | | | | | | | FRMCS (HW/SW) | | | | | | | | 6G (SW) | | | | | | | | | | | | 7G (SW) | | | | |
| CCS peripherals | Sensoring | | x | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| CCS peripherals | ETCS Sensoring (eg Odo, BTM, LTM) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| CCS peripherals | Train Loc (GNSS, Inertial...) | | x | | | | | | | | | | | | | | | | | | | | | | | Obso (HW) | | | | | | | | | | | |
| CCS peripherals | Perception sensoring (other sensors) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| CCS peripherals | DMI | | x | | | | | | | | | | | | | | | | | | | | | | | Obso (HW) | | | | | | | | | | | |
| CCS tools | Tools | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| CCS tools | Testing tools (eg test bench, simulator) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| CCS tools | Maintenance tools | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| CCS tools | Training tools | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

**Figure 4** PBS roadmap for the distributed fleet – 2 years frequency for upgrade

| Lifecycle | | Products PBS ROADMAP | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CCS Core/ Peripheral or external | CCS Subsystem Component | EVC as is solution | pre-O. | OCORA Full Modular Solution | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 | 2033 | 2034 | 2035 | 2036 | 2037 | 2038 | 2039 | 2040 | 2041 | 2042 | 2043 | 2044 | 2045 | 2046 | 2047 | 2048 | 2049 | 2050 | 2051 | 2052 | 2053 | 2054 |
| | | | | | First HW and SW release | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| CCS | On-board CCS | | x | | | | | | | TSI | | | | | | TSI | | | | | TSI | | | | | TSI | | | | | | | TSI | | | | |
| CCS Core | Core CCS | | x | | | | | | | | | | | | | | | | | | | | | | | HW obs | | | | | | | | | | | |
| CCS Core | Core CCS - ATP (ETCS Core) | | x | | | | | | | | Upgrade (SW) | | | | Upgrade (SW) | | | | Upgrade (SW) | | | | Upgrade (SW) | | | | Upgrade (SW) | | | | Upgrade (SW) | | | | Upgrade (SW) | | |
| CCS Core | CCS addon - NTC-STM | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| CCS Core | CCS addon - ATO | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| CCS Core | CCS addon - other functions/services | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| CCS peripherals | Communication and interfaces | | x | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| CCS peripherals | I/O Ports | | x | | | | | | | | | | | | | | | | | | | | | | | Obso (HW) | | | | | | | | | | | |
| CCS peripherals | Functional Vehicle Adapter (FVA) | | x | | | | | | | | | | | | | | | | | | | | | | | Obso (HW) | | | | | | | | | | | |
| CCS peripherals | UVCC | | x | | | | | | | | | | | | | | | | | | | | | | | Obso (HW) | | | | | | | | | | | |
| CCS peripherals | Gateway | | x | | | | | | | | | | | | | | | | | | | | | | | Obso (HW) | | | | | | | | | | | |
| CCS peripherals | MCG (GSM-R, FRMCS...) | | x | | | | | | | | | | FRMCS (HW/SW) | | | | | | | | 6G (SW) | | | | | | | | | | | | 7G (SW) | | | | |
| CCS peripherals | Sensoring | | x | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| CCS peripherals | ETCS Sensoring (eg Odo, BTM, LTM) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| CCS peripherals | Train Loc (GNSS, Inertial...) | | x | | | | | | | | | | | | | | | | | | | | | | | Obso (HW) | | | | | | | | | | | |
| CCS peripherals | Perception sensoring (other sensors) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| CCS peripherals | DMI | | x | | | | | | | | | | | | | | | | | | | | | | | Obso (HW) | | | | | | | | | | | |
| CCS tools | Tools | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| CCS tools | Testing tools (eg test bench, simulator) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| CCS tools | Maintenance tools | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| CCS tools | Training tools | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

**Figure 5** PBS roadmap for the distributed fleet – 4 years frequency for upgrade

| Lifecycle | | Products PBS ROADMAP | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CCS Core/ Peripheral or external | CCS Subsystem Component | EVC as is solution | pre-O. | OCORA Full Modular Solution | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 | 2033 | 2034 | 2035 | 2036 | 2037 | 2038 | 2039 | 2040 | 2041 | 2042 | 2043 | 2044 | 2045 | 2046 | 2047 | 2048 | 2049 | 2050 | 2051 | 2052 | 2053 | 2054 |
| | | | | | First HW and SW release | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| CCS | On-board CCS | | x | | | | | | | TSI | | | | | | TSI | | | | | TSI | | | | | TSI | | | | | | | TSI | | | | |
| CCS Core | Core CCS | | x | | | | | | | | | | | | | | | | | | | | | | | HW obs | | | | | | | | | | | |
| CCS Core | Core CCS - ATP (ETCS Core) | | x | | | | | | | | Upgrade (SW) | | | | | | Upgrade (SW) | | | | | | Upgrade (SW) | | | | | | Upgrade (SW) | | | | | | Upgrade (SW) | | |
| CCS Core | CCS addon - NTC-STM | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| CCS Core | CCS addon - ATO | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| CCS Core | CCS addon - other functions/services | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| CCS peripherals | Communication and interfaces | | x | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| CCS peripherals | I/O Ports | | x | | | | | | | | | | | | | | | | | | | | | | | Obso (HW) | | | | | | | | | | | |
| CCS peripherals | Functional Vehicle Adapter (FVA) | | x | | | | | | | | | | | | | | | | | | | | | | | Obso (HW) | | | | | | | | | | | |
| CCS peripherals | UVCC | | x | | | | | | | | | | | | | | | | | | | | | | | Obso (HW) | | | | | | | | | | | |
| CCS peripherals | Gateway | | x | | | | | | | | | | | | | | | | | | | | | | | Obso (HW) | | | | | | | | | | | |
| CCS peripherals | MCG (GSM-R, FRMCS...) | | x | | | | | | | | | | FRMCS (HW/SW) | | | | | | | | 6G (SW) | | | | | | | | | | | | 7G (SW) | | | | |
| CCS peripherals | Sensoring | | x | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| CCS peripherals | ETCS Sensoring (eg Odo, BTM, LTM) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| CCS peripherals | Train Loc (GNSS, Inertial...) | | x | | | | | | | | | | | | | | | | | | | | | | | Obso (HW) | | | | | | | | | | | |
| CCS peripherals | Perception sensoring (other sensors) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| CCS peripherals | DMI | | x | | | | | | | | | | | | | | | | | | | | | | | Obso (HW) | | | | | | | | | | | |
| CCS tools | Tools | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| CCS tools | Testing tools (eg test bench, simulator) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| CCS tools | Maintenance tools | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| CCS tools | Training tools | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

**Figure 6** PBS roadmap for the distributed fleet – 6 years frequency for upgrade

**Lifecycle** — **Products PBS ROADMAP**

| CCS Core/ Peripheral or external | CCS Subsystem Component | EVC as is solution | pre-O. | OCORA Full Modular Solution | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 | 2033 | 2034 | 2035 | 2036 | 2037 | 2038 | 2039 | 2040 | 2041 | 2042 | 2043 | 2044 | 2045 | 2046 | 2047 | 2048 | 2049 | 2050 | 2051 | 2052 | 2053 | 2054 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | First HW and SW release | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| CCS | On-board CCS | | x | | | | | | | TSI | | | | | | TSI | | | | | TSI | | | | | TSI | | | | | | | TSI | | | | |
| CCS Core | Core CCS | | x | | | | | | | | | | | | | | | | | | | | | | | HW obs | | | | | | | | | | | |
| CCS Core | Core CCS - ATP (ETCS Core) | | x | | | | | | | | Upgrade (SW) | | | | | | | | Upgrade (SW) | | | | | | | | Upgrade (SW) | | | | | | | | Upgrade (SW) | | |
| CCS Core | CCS addon - NTC-STM | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| CCS Core | CCS addon - ATO | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| CCS Core | CCS addon - other functions/services | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| CCS peripherals | Communication and interfaces | | x | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| CCS peripherals | I/O Ports | | x | | | | | | | | | | | | | | | | | | | | | | | Obso (HW) | | | | | | | | | | | |
| CCS peripherals | Functional Vehicle Adapter (FVA) | | x | | | | | | | | | | | | | | | | | | | | | | | Obso (HW) | | | | | | | | | | | |
| CCS peripherals | UVCC | | x | | | | | | | | | | | | | | | | | | | | | | | Obso (HW) | | | | | | | | | | | |
| CCS peripherals | Gateway | | x | | | | | | | | | | | | | | | | | | | | | | | Obso (HW) | | | | | | | | | | | |
| CCS peripherals | MCG (GSM-R, FRMCS...) | | x | | | | | | | | | | FRMCS (HW/SW) | | | | | | | | 6G (SW) | | | | | | | | | | | | 7G (SW) | | | | |
| CCS peripherals | Sensoring | | x | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| CCS peripherals | ETCS Sensoring (eg Odo, BTM, LTM) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| CCS peripherals | Train Loc (GNSS, Inertial...) | | x | | | | | | | | | | | | | | | | | | | | | | | Obso (HW) | | | | | | | | | | | |
| CCS peripherals | Perception sensoring (other sensors) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| CCS peripherals | DMI | | x | | | | | | | | | | | | | | | | | | | | | | | Obso (HW) | | | | | | | | | | | |
| CCS tools | Tools | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| CCS tools | Testing tools (eg test bench, simulator) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| CCS tools | Maintenance tools | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| CCS tools | Training tools | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

**Figure 7** PBS roadmap for the distributed fleet – 8 years frequency for upgrade

**Lifecycle** — **Products PBS ROADMAP**

| CCS Core/ Peripheral or external | CCS Subsystem Component | EVC as is solution | pre-O. | OCORA Full Modular Solution | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 | 2033 | 2034 | 2035 | 2036 | 2037 | 2038 | 2039 | 2040 | 2041 | 2042 | 2043 | 2044 | 2045 | 2046 | 2047 | 2048 | 2049 | 2050 | 2051 | 2052 | 2053 | 2054 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | First HW and SW release | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| CCS | On-board CCS | | x | | | | | | | TSI | | | | | | TSI | | | | | TSI | | | | | TSI | | | | | | | TSI | | | | |
| CCS Core | Core CCS | | x | | | | | | | | | | | | | | | | | | | | | | | HW obs | | | | | | | | | | | |
| CCS Core | Core CCS - ATP (ETCS Core) | | x | | | | | | | | | | Upgrade (SW) | | | | | | | | | | Upgrade (SW) | | | | | | | | | | Upgrade (SW) | | | | |
| CCS Core | CCS addon - NTC-STM | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| CCS Core | CCS addon - ATO | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| CCS Core | CCS addon - other functions/services | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| CCS peripherals | Communication and interfaces | | x | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| CCS peripherals | I/O Ports | | x | | | | | | | | | | | | | | | | | | | | | | | Obso (HW) | | | | | | | | | | | |
| CCS peripherals | Functional Vehicle Adapter (FVA) | | x | | | | | | | | | | | | | | | | | | | | | | | Obso (HW) | | | | | | | | | | | |
| CCS peripherals | UVCC | | x | | | | | | | | | | | | | | | | | | | | | | | Obso (HW) | | | | | | | | | | | |
| CCS peripherals | Gateway | | x | | | | | | | | | | | | | | | | | | | | | | | Obso (HW) | | | | | | | | | | | |
| CCS peripherals | MCG (GSM-R, FRMCS...) | | x | | | | | | | | | | FRMCS (HW/SW) | | | | | | | | 6G (SW) | | | | | | | | | | | | 7G (SW) | | | | |
| CCS peripherals | Sensoring | | x | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| CCS peripherals | ETCS Sensoring (eg Odo, BTM, LTM) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| CCS peripherals | Train Loc (GNSS, Inertial...) | | x | | | | | | | | | | | | | | | | | | | | | | | Obso (HW) | | | | | | | | | | | |
| CCS peripherals | Perception sensoring (other sensors) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| CCS peripherals | DMI | | x | | | | | | | | | | | | | | | | | | | | | | | Obso (HW) | | | | | | | | | | | |
| CCS tools | Tools | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| CCS tools | Testing tools (eg test bench, simulator) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| CCS tools | Maintenance tools | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| CCS tools | Training tools | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

**Figure 8** PBS roadmap for the distributed fleet – 10 years frequency for upgrade

# 4 Results of the sensitivity analysis

## 4.1 Cost variation: Baseline case

The baseline case (EVC product vs pre-OCORA product) has been applied on the four fleets previously described.

The following table gives the overall impact of the introduction of the pre-OCORA architecture on the global cost for 30 years.

| | **European fleet** | **VDB fleet** | **Distributed fleet** | **Regional fleet** |
|---|---|---|---|---|
| **EVC cost** | 1 258 940 | 350 423 | 90 245 | 5 524 |
| **Pre-OCORA cost** | 1 192 465 | 237 517 | 61 023 | 4 712 |
| ***reduction*** | *-5%* | *-32%* | *-32%* | *-15%* |

**Table 5** Results for cost variation on three fleets: European fleet, VDB fleet and regional fleet

The resulting reduction clearly depends on the planning of the equipment of the vehicles.

In the case of the European fleet, the reduction with the pre-OCORA product is minored, due to remaining high costs for the obsolescence phase in 2043, balancing the costs for obsolescence of the EVC product in 2033: the number of vehicles in the fleet is higher in 2043 than in 2033, hence the discrepancy.

For a given fleet, the potential foreseen obsolescence for some on-board equipment has to be taken carefully into account for the assessment of the costs linked to the CCS on-board, both for retrofitted and new vehicles.

For VDB and distributed fleets, the reduction appears similar, as all vehicles will be equipped by 2030.

For the regional fleet, the effect of having one unique type of vehicle affects the impact of the reduced cost of the pre-OCORA product; less class means here less decrease.

The following sections give the distributions of the costs over years for all considered fleets.

### 4.1.1 European fleet

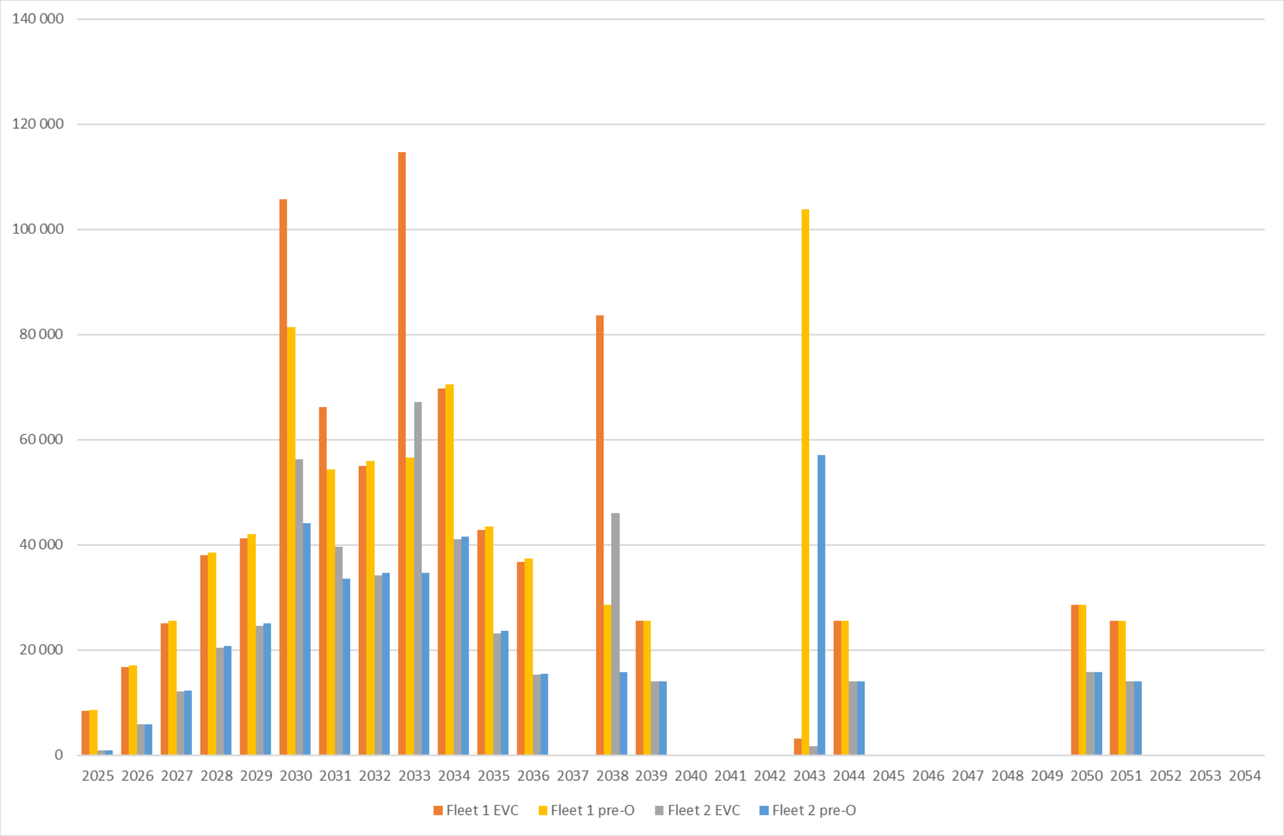


**Figure 9** European fleet: Baseline: distribution per fleet (EVC/pre-OCORA)

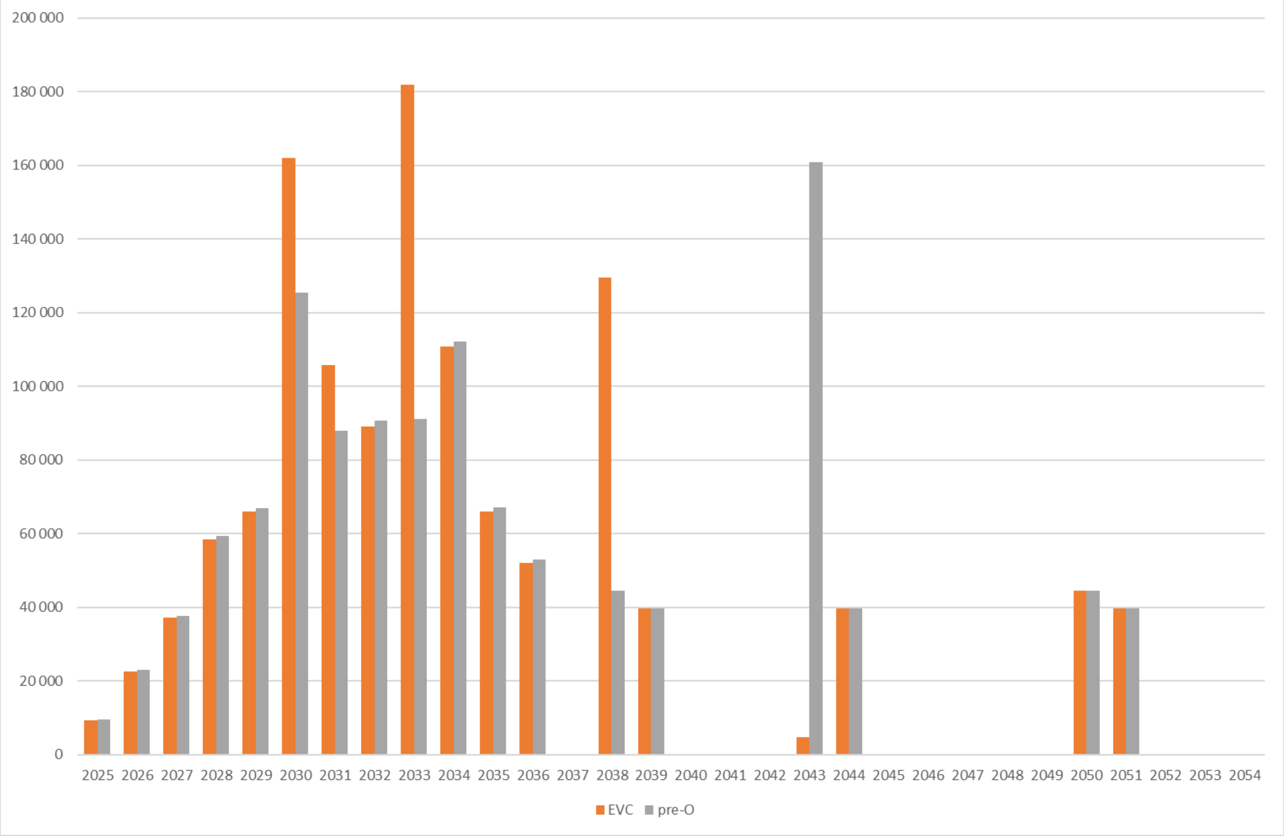


**Figure 10** European fleet: Baseline: distribution per product (all fleets)

### 4.1.2 VDB fleet

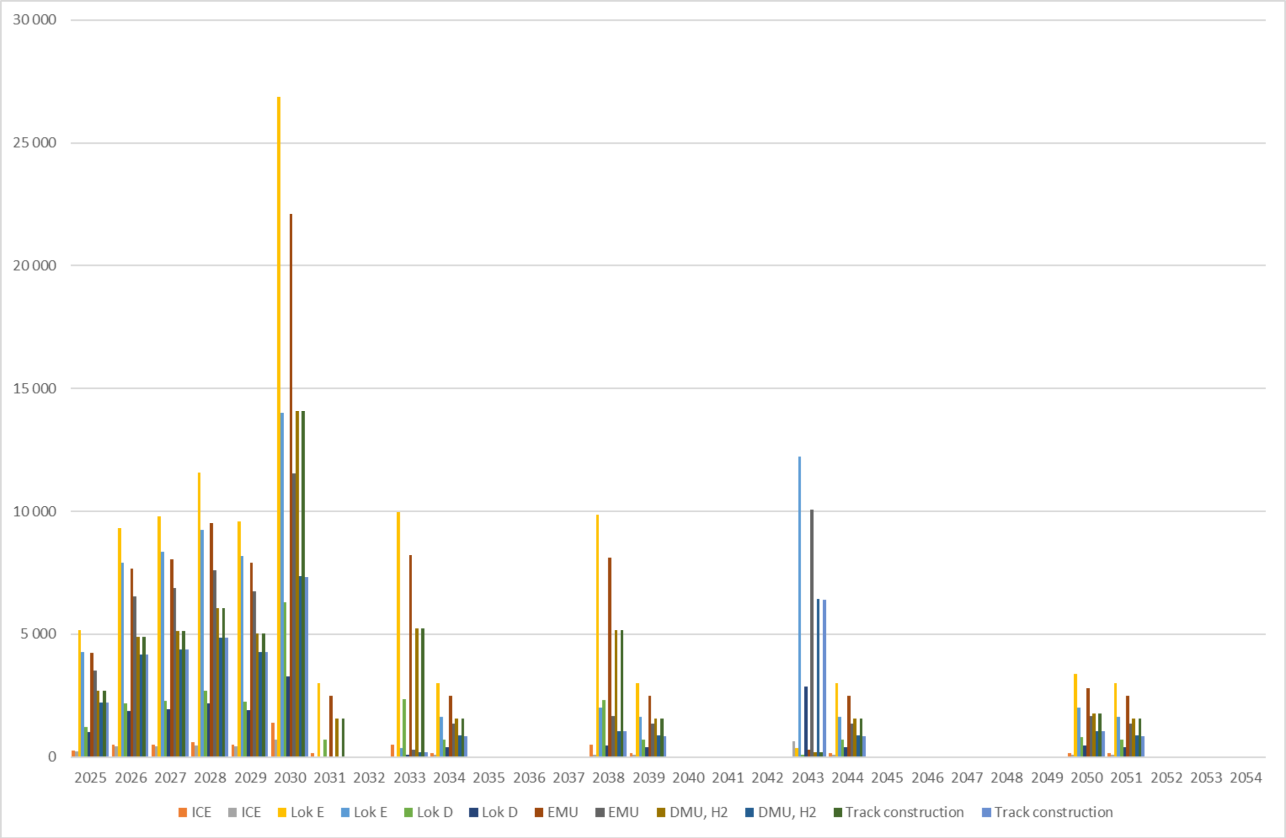


**Figure 11** VDB fleet: Baseline: distribution per fleet (EVC/pre-OCORA)

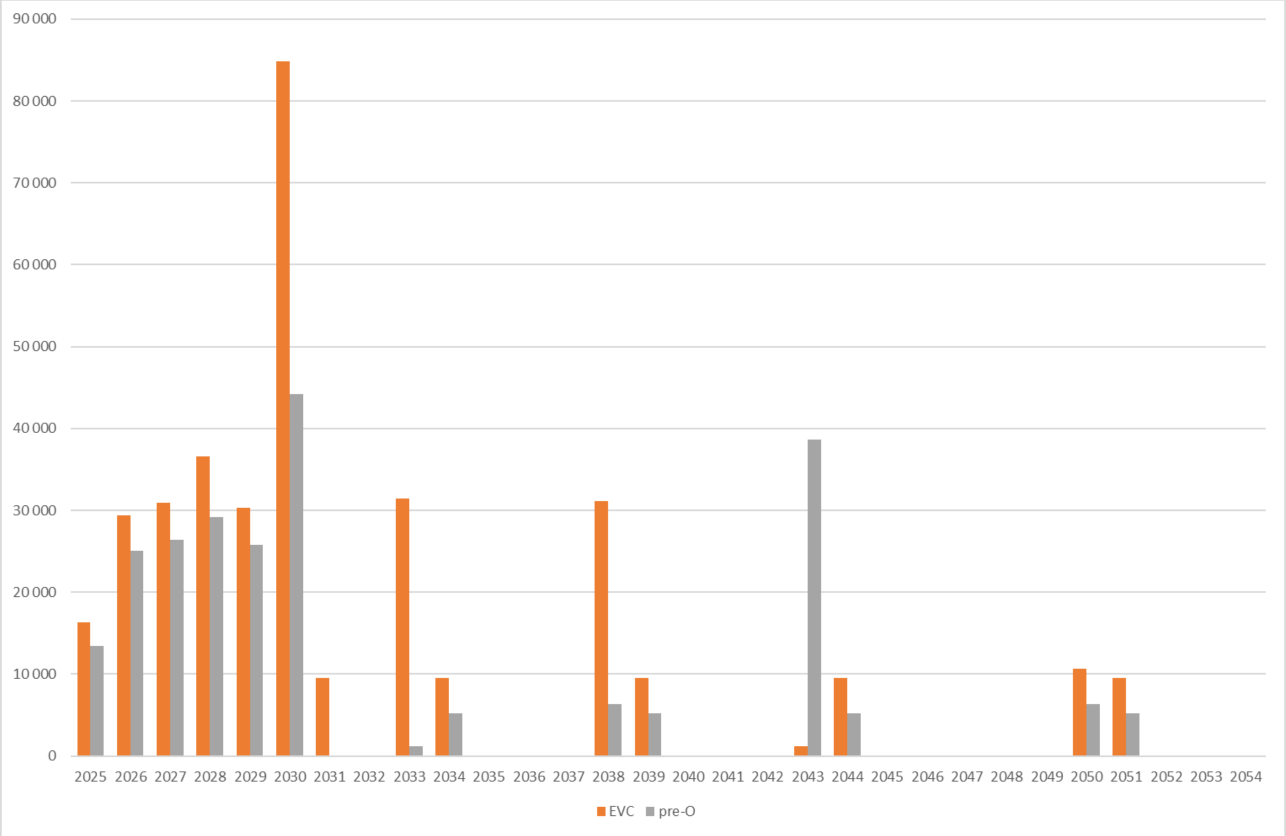


**Figure 12** VDB fleet: Baseline: distribution per product (all fleets)

### 4.1.3 Distributed fleet

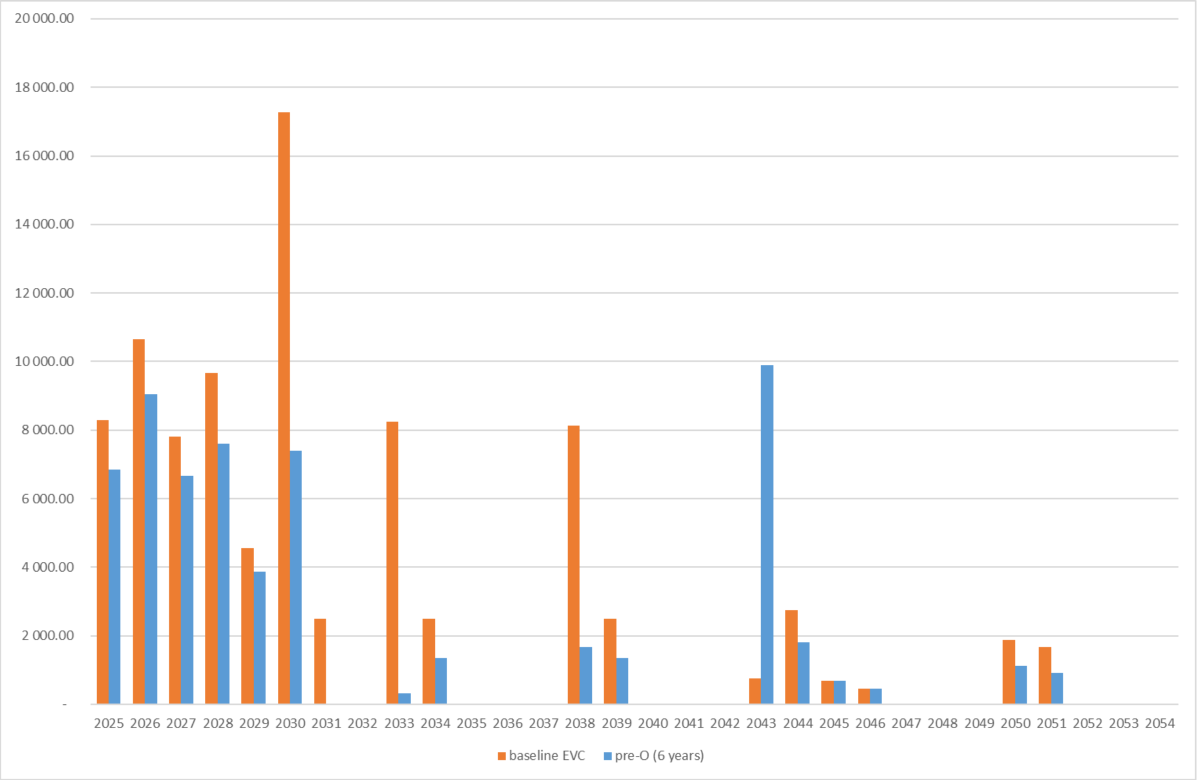


**Figure 13** Distributed fleet: Baseline case: distribution per product (all fleets)

### 4.1.4 Regional fleet

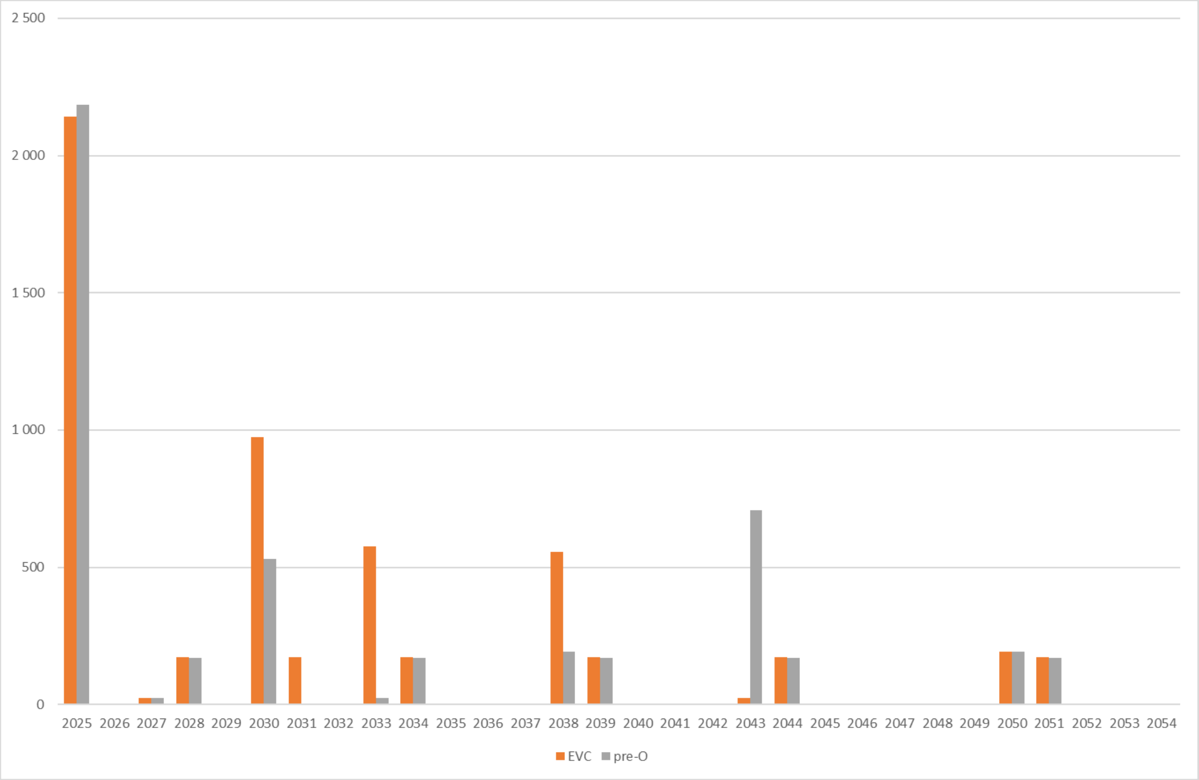


**Figure 14** Regional fleet: Baseline: distribution per product

## 4.2 Cost variation: WBS case (class parameter variation)

The cost variation, from 0.25 to 0.75, for the class parameter has been applied on the European and the VDB fleet. When developing a new generic product, there is still adaptation work for each considered class. Therefore, additional costs are to be taken into account at WBS level. The impact of reducing those costs has to be assessed, hence this cost variation.

A third value for the class parameter (a value of 5) is also considered to maximise the potential impact on the overall costs. This case has been computed only for the VDB fleet.

The following table gives the overall impact of the introduction of the pre-OCORA architecture on the global cost for 30 years for the two fleets.

| | European fleet | | VDB fleet | |
|---|---|---|---|---|
| **EVC cost** | 1 258 940 | | 350 423 | |
| **Pre-OCORA (WBS 025) cost** | 1 192 441 | *- 5.2800%* | 237 453 | *- 32.225%* |
| **Pre-OCORA (WBS 050) cost** | 1 192 465 | *- 5.2802%* | 237 517 | *- 32.220%* |
| **Pre-OCORA (WBS 075) cost** | 1 192 490 | *- 5.2804%* | 237 580 | *- 32.215%* |
| **Pre-OCORA (WBS 500) cost** | | | 238 657 | *- 31.908%* |

**Table 6** Results for cost variation (WBS case) on two fleets: European fleet and VDB fleet

Looking at the numbers, there is a very slight impact of the cost variation as introduced at the WBS level.

As expected, the difference is proportional to the number of classes of trains, hence the stronger discrepancies between the three cases for the VDB fleet, where 6 types are considered.

Even when considering an important cost for the classes (ten times more, with parameter at 5 instead of 0.5), the overall costs remain almost the same, with a similar reduction. Thus, this parameter appears not as the main cost driver.

The following sections give the distributions of the costs over years for the two fleets.

## 4.2.1 European fleet

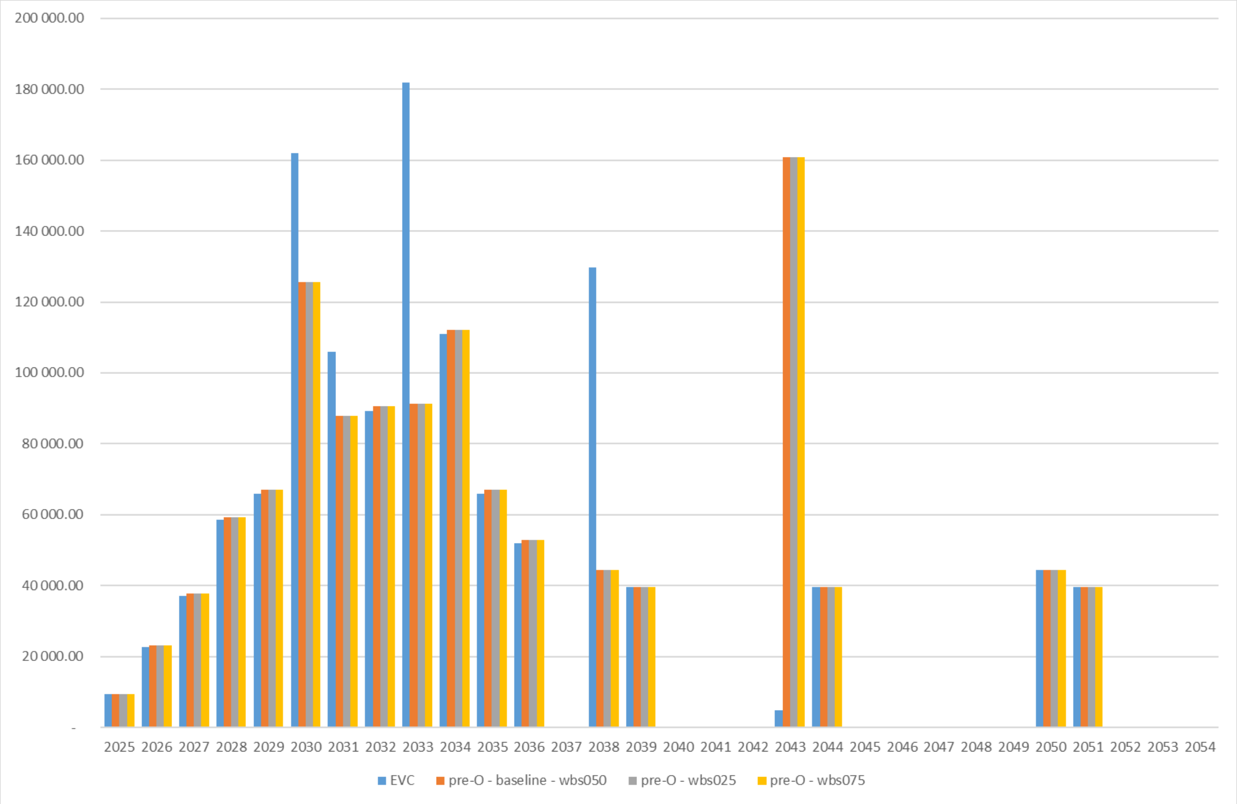


**Figure 15** European fleet: influence of the class weight

## 4.2.2 VDB fleet

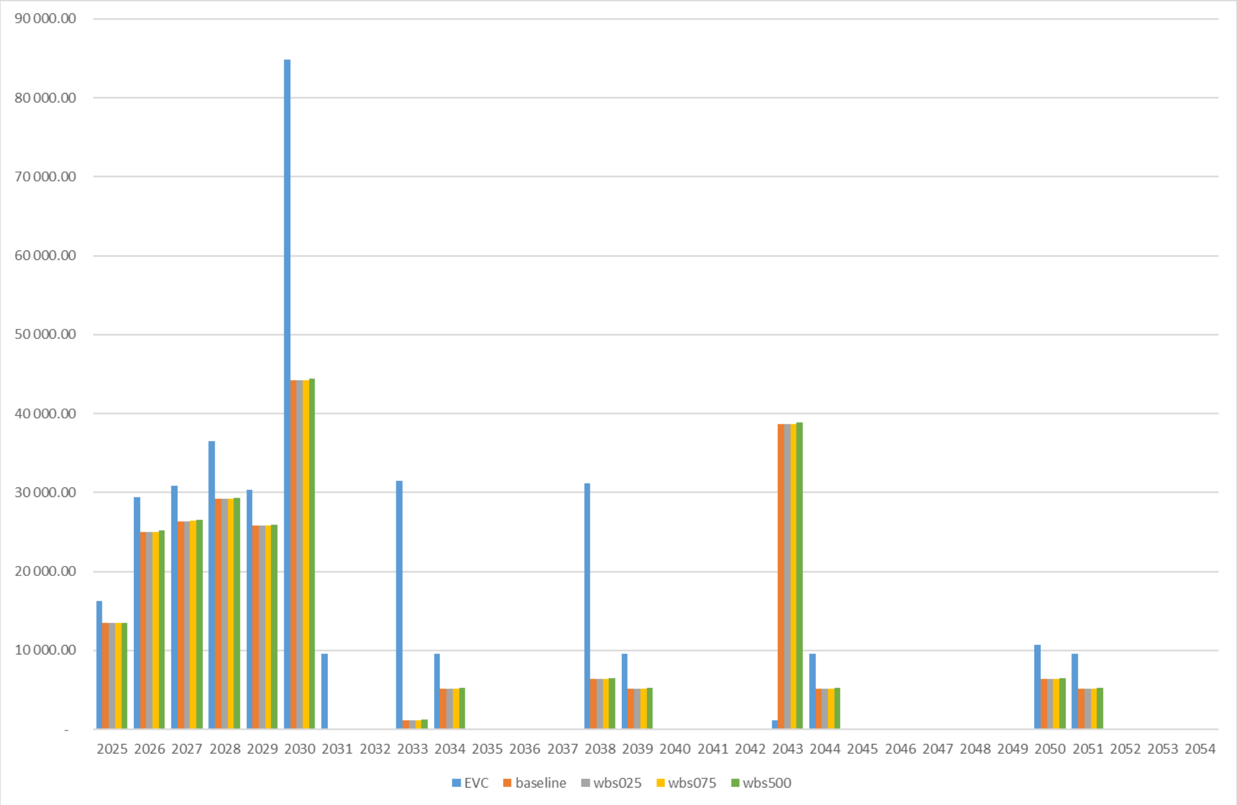


**Figure 16** VDB fleet: influence of the class weight

# 4.3 Cost variation: Commissioning case

The commissioning cost variation has been applied on the three fleets: European fleet, VDB fleet and Regional fleet.

**Table 7** gives the overall impact of the introduction of the pre-OCORA architecture on the global cost for 30 years for those three fleets.

| | European fleet | | VDB fleet | | Regional fleet | |
|---|---|---|---|---|---|---|
| **EVC cost** | 1 258 940 | | 350 423 | | 5 524 | |
| **Pre-OCORA baseline cost** | 1 192 465 | *- 5 %* | 237 517 | *- 32 %* | 4 712 | *- 15%* |
| **Pre-OCORA “com2” cost** | 656 059 | *- 48 %* | 162 096 | *- 54 %* | 2 380 | *- 57 %* |

**Table 7** Results for cost variation (commissioning case) on three fleets: European, VDB and Regional fleet.

The decrease of the commissioning costs when introducing the pre-OCORA architecture strongly impact the overall costs. This decrease affects the three fleets the same way, regardless of the number of vehicles and types, and the planning of their introduction.

The following sections give the distributions of the costs over the years for the three fleets.

## 4.3.1 European fleet

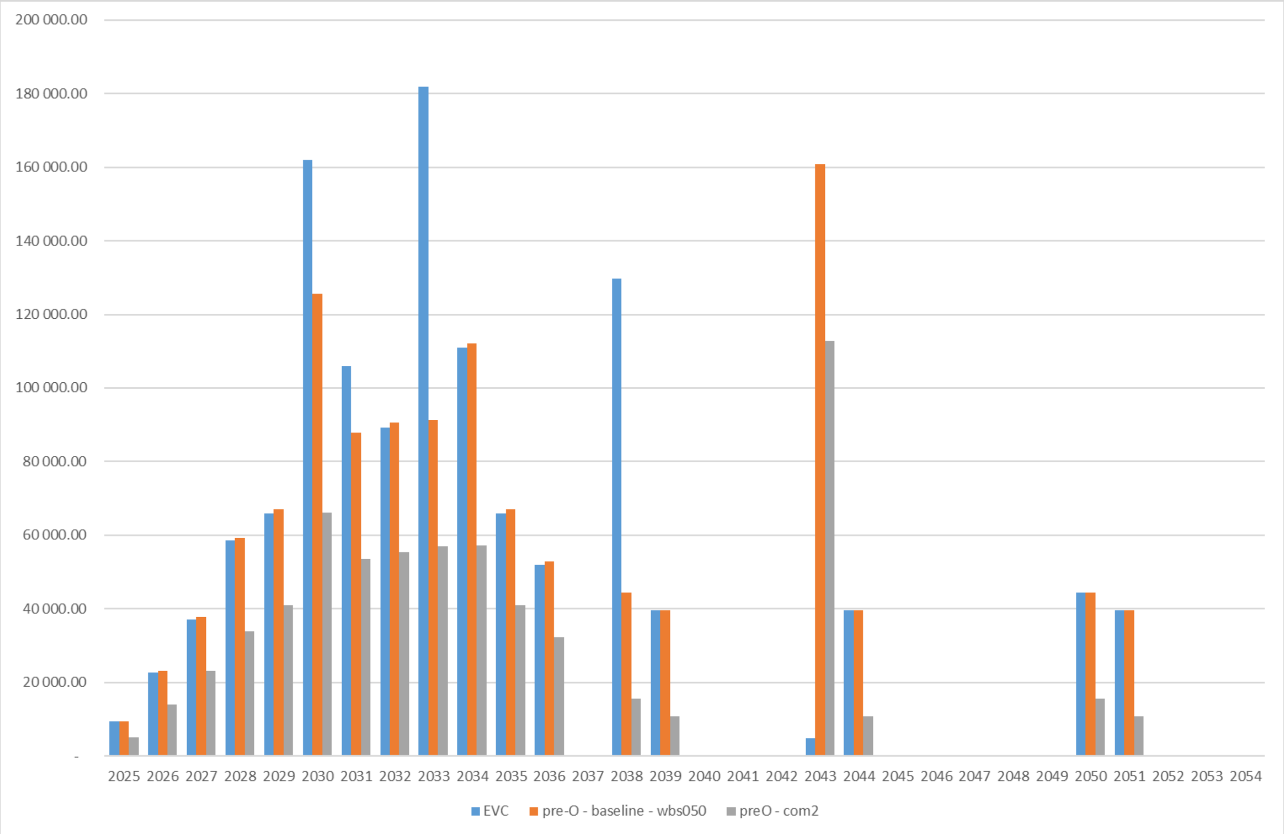


**Figure 17** European fleet: influence of the commissioning cost

### 4.3.2 VDB fleet

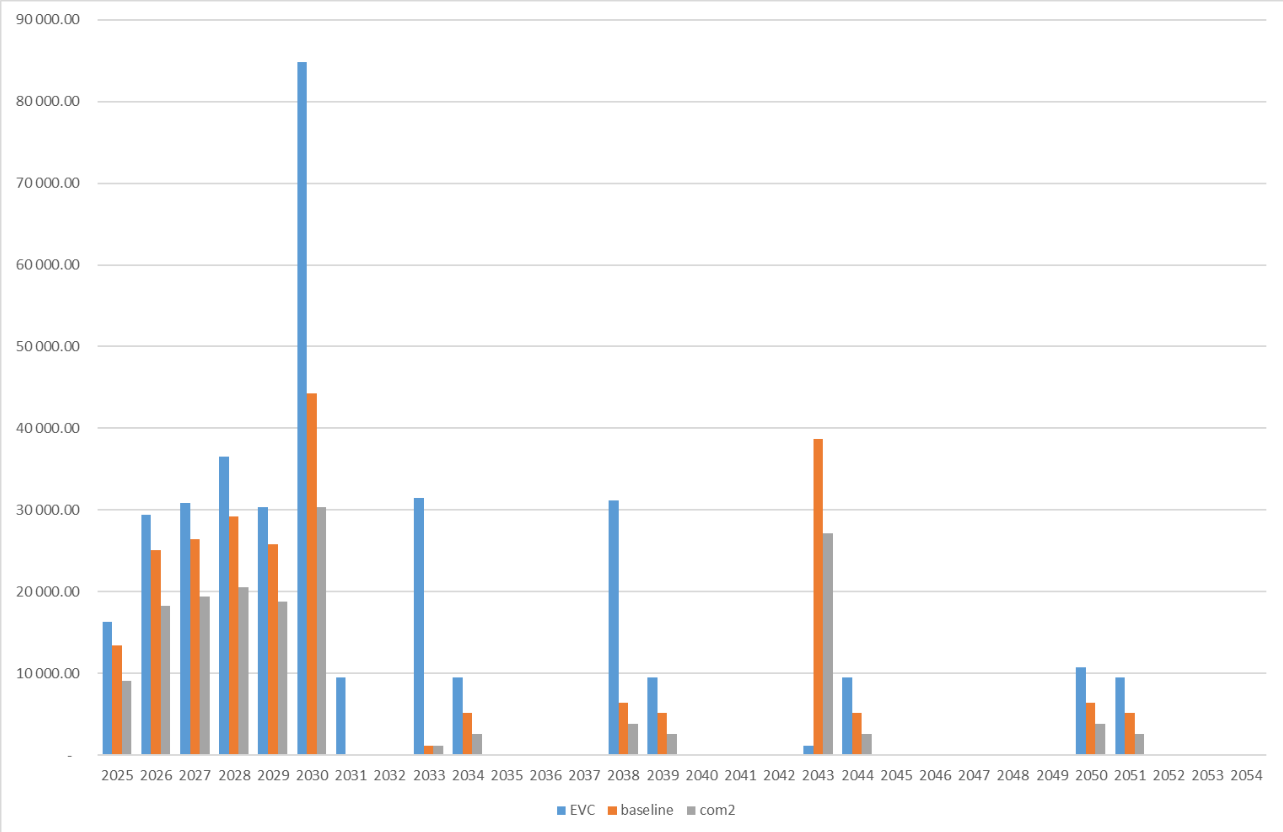


**Figure 18** VDB fleet: influence of the commissioning cost

### 4.3.3 Regional fleet

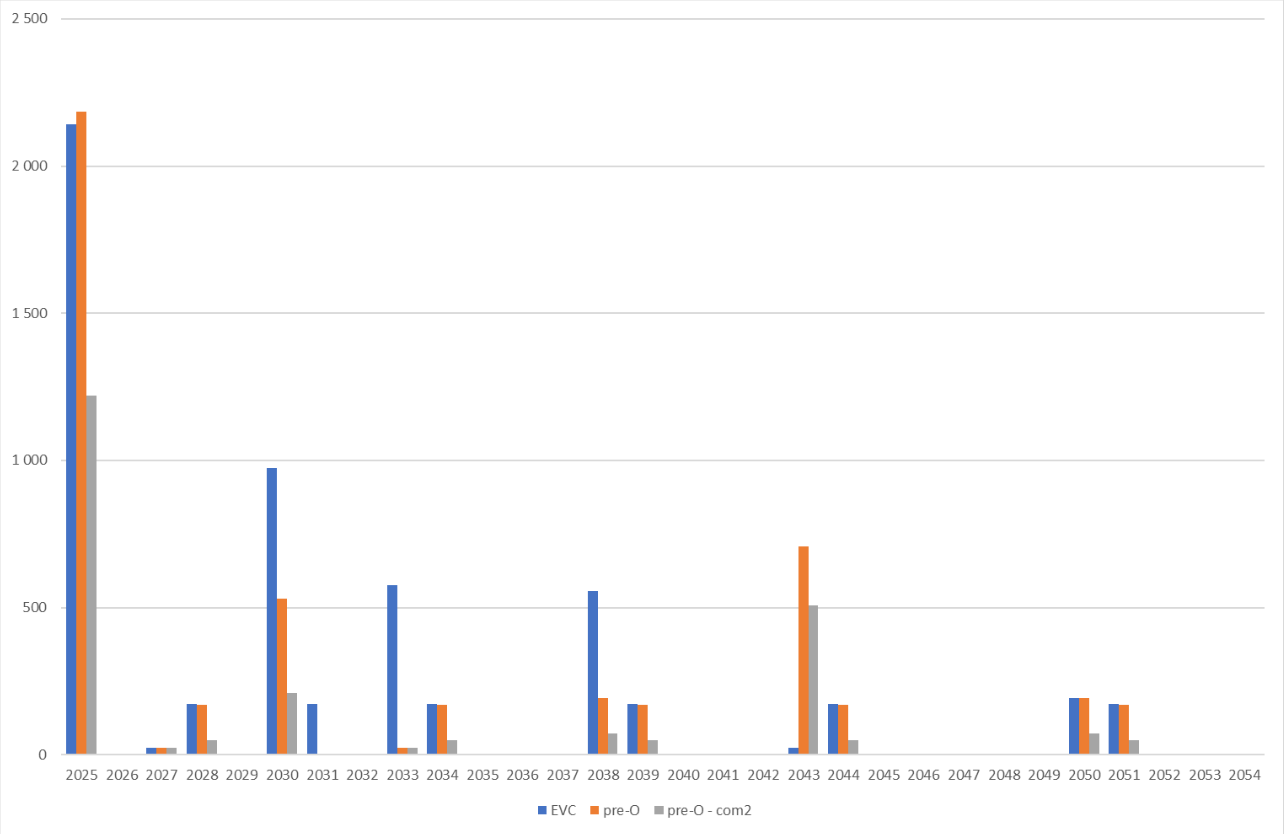


**Figure 19** Regional fleet: influence of the commissioning cost

## 4.4 Upgrade frequency variation (on distributed fleet)

The results obtained for the variation of the frequency of the upgrade of the CCS sub-system are shown in the following table. The goal is to identify the impact of changing the upgrade frequency within the pre-OCORA solution. The baseline has been set at the baseline upgrade frequency (approximately 6 years). The changes have been made according to **Table 8**.

| | Distributed fleet | |
|---|---|---|
| **Pre-OCORA 6 years cost (baseline)** | 61 023 | |
| **Pre-OCORA 2 years cost** | 70 557 | *+16% %* |
| **Pre-OCORA 4 years cost** | 63 294 | *+4 %* |
| | | |
| **Pre-OCORA 8 years cost** | 59 662 | *- 2 %* |
| **Pre-OCORA 10 years cost** | 58 743 | *- 4 %* |
| **Pre-OCORA no upgrade** | 55 122 | *-10%* |
| **EVC cost** | 90245 | |

**Table 8** Results for upgrade frequency variation on the distributed fleet

As expected, the increase of the upgrade frequency leads to an increase of the overall costs on the 30 years. Also, the relation between the increase of frequency is corresponding to the increase of cost. As such the model provides the expected results. Given the current cost assumptions, the difference between no upgrades and the baseline is a cost difference of 10 %.

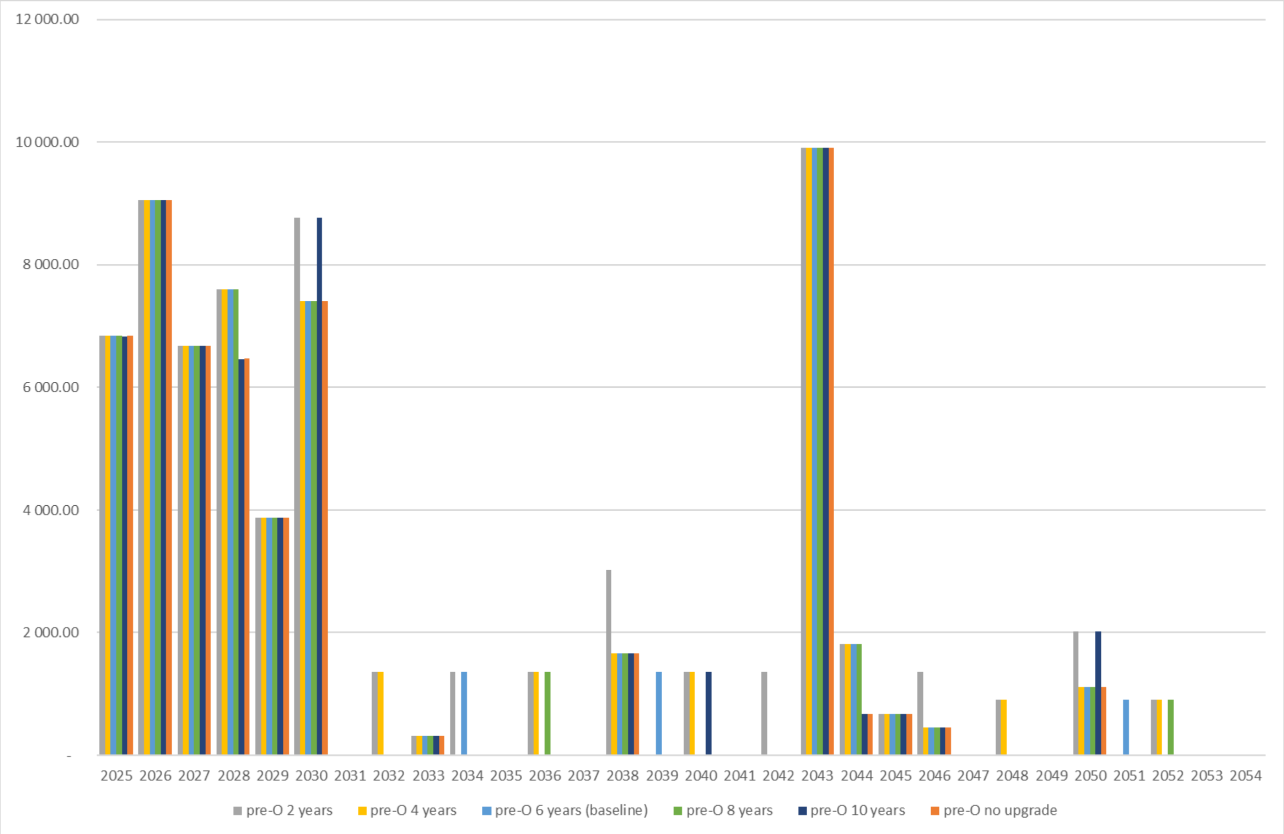


**Figure 20** Distributed fleet: influence of the upgrade frequency variation

# 5 Conclusion

Different scenarios (fleets, roadmaps…) have been run with the economic model and presented in this report.

The effects of variations on both WBS class parameter and commissioning costs have been quantified:

- there is a very slight impact of the cost variation as introduced at the WBS level;
- the decrease of the commissioning costs when introducing the pre-OCORA architecture strongly impact the overall costs;
- the increase of the upgrade frequency leads to a decrease of the overall costs on the 30 years.

The next development steps for the Economic Model consist in:

- finalising the model and its associated tool, including the assessment of the costs (in euros), by:
  - refining the modelling assumption down to technology choices aligned with OCORA architecture principles;
  - enhancing the model with parameter costs: all the costs, including the maintenance costs (preventive, curative, repair).
- identifying several scenarios (fleets, roadmaps…).

The deployment scenarios to help understand cash flows for different stakeholders involved.
There should be a consistency check of the roadmap, preferably automated within the model itself, to prevent any unnecessary activities especially regarding the HW and SW upgrades.

This will require developing deployment and industrialisation scenarios as well as considerations on the capability of the sector to deliver the needed quantities within the different scenarios and for given deployment roadmaps.