

# OCORA

Open CCS On-board Reference Architecture

## Virtual ETCS Transponder Service OB

Discussion Paper

This OCORA work is licensed under the dual licensing Terms EUPL 1.2 (Commission Implementing Decision (EU) 2017/863 of 18 May 2017) and the terms and condition of the Attributions- ShareAlike 3.0 Unported license or its national version (in particular CC-BY-SA 3.0 DE).



Document ID: OCORA-TWS01-301

Version: 1.0

Date: 21.06.2024

## Management Summary

Current ETCS systems requires many trackside physical balises for location purposes and giving location based information. These physical balises create many constraints and costs for the trackside and on-board ETCS systems: trackside asset installation, trackside maintenance cost increase (removing and reinstalling the balises for maintenance) and complex BTM system on-board.

The Virtual ETCS Transponder Service aims to reduces the costs and constraints linked to ETCS systems by exploiting new technologies introduced in the new CCS-OB architecture : ASTP, digital map and perception. VETS may also enable a significant increase of ETCS area of use, for instance by allowing trains to run in ETCS on unfitted lines.

The first revision of this VETS discussion paper is to introduce the problem statement and operational needs.

## Revision History

Version	Change Description	Initials	Date of change
1.0	First Version	CM	21-06-2024

**Author** : Charles Mostacchi (SNCF)

**Contributors**: Jérôme Lalouette (SNCF), Laurent Pinori (SNCF), Martin Lindenmaier (SBB), Guilhem Herbelet (SNCF)

# Table of Contents

1	Introduction	6
1.1	Purpose of the document	6
1.2	Applicability of the document	6
1.3	Context of the document	6
1.4	Requirements Engineering Process	7
2	Operational analysis	9
2.1	Problem statement	9
2.2	Operational Epics	10

# References

Reader's note: please be aware that the document ids in square brackets, e.g. [OCORA-BWS01-010], as per the list of referenced documents below, are 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.

[OCORA-BWS01-010] – Release Notes  
[OCORA-BWS01-020] – Glossary  
[OCORA-BWS01-030] – Question and Answers  
[OCORA-BWS01-040] – Feedback Form  
[OCORA-BWS02-020] - Program Slide Deck  
[OCORA-BWS02-030] - Technical Slide Deck  
[OCORA-BWS02-040] - Program Posters  
[OCORA-BWS02-050] - Technical Posters  
[OCORA-BWS03-010] - Introduction to OCORA  
[OCORA-BWS03-020] - Guiding Principles  
[OCORA-BWS04-010] - Problem Statements  
[OCORA-BWS05-010] - Road Map  
[OCORA-TWS01-010] – Design Requirements  
[OCORA-TWS01-011] – System Requirements  
[OCORA-TWS01-020] – System Capabilities  
[OCORA-TWS01-030] – System Architecture  
[OCORA-TWS01-035] – CCS-On-Board Architecture  
[OCORA-TWS01-100] – Localisation On-Board (LOC-OB) – Introduction  
[OCORA-TWS01-101] – Localisation On-Board (LOC-OB) – Requirements  
[OCORA-TWS01-102] – Localisation On-Board (LOC-OB) – Standard Communication Interface Specification  
[OCORA-TWS05-010] – Requirements – Management Guideline  
[OCORA-TWS05-020] – Stakeholder Requirements  
[OCORA-TWS05-021] – Program Requirements  
[OCORA-TWS05-022] – Design Requirements  
[RCA.Doc.46] - Concept : Digital Map (BL0 R2)  
[RCA.Doc.56] - Digital Map - Evaluation Publish Onboard Map Approaches (1.1 - 2021-11-30)  
[EUG 21E109] - Vehicle Locator Concept Architecture, LWG, version 1.0, 2021-07-15

# 1 Introduction

## 1.1 Purpose of the document

This document is the OCORA Virtual ETCS Transponder Service (VETS) discussion paper. This document introduces the problem statement of the current localisation by physical balises. To solve this problem, the VETS concept (terminology and main characteristics of the architecture) and high level requirements will be presented in a future release. All the concepts are still under discussion.

The requirements listed in this document will be developed from a VETS building block perspective. According to the OCORA definition, they are part of the OCORA D-Level requirements (refer to [1.4 - Requirements Engineering Process](#)). The building block requirements (OCORA D-Level requirements) are detailing the OCORA system requirements [\[OCORA-TWS01-011\]](#).

The building block requirements captured in this document will be developed to reach a common understanding and communicate a precise OCORA view of the functional and non-functional requirements towards future VETS.

The building block requirements listed in this document will be prepared as an input for:

- EU-Rail and OCORA system architecture and design activities, shaping future TSI specifications, other legal frameworks, and other specifications
- Contracting entities, preparing tenders, and executing testing / certification activities for VETS

This document is addressed to experts in the CCS domain and to any other person, interested in the OCORA requirements for VETS. The reader is invited to provide feedback to the OCORA collaboration and can, therefore, engage in shaping these requirements. Feedback to this document and to any other OCORA documentation can be given by using the feedback form [\[OCORA-BWS01-040\]](#).

If you are an organisation interested in developing VETS according to the OCORA requirements, information provided in this document can be used as input for your development.

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 [\[OCORA-BWS01-040\]](#).

## 1.2 Applicability of the document

The document is currently considered informative but may become mandatory at a later stage for OCORA compliant on-board CCS solutions. 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 an OCORA Release, together with the documents listed in the release notes [\[OCORA-BWS01-010\]](#). Before reading this document, it is recommended to read the Release Notes [\[OCORA-BWS01-010\]](#). If you are interested in the context and the motivation that drives OCORA we recommend to read the Introduction to OCORA [\[OCORA-BWS03-010\]](#), and the Problem Statements [\[OCORA-BWS04-010\]](#). The reader should also be aware of the Glossary [\[OCORA-BWS01-020\]](#) and the Question and Answers [\[OCORA-BWS01-030\]](#).

## 1.4 Requirements Engineering Process

OCORA requirements elicitation follows the Requirements Management Guideline [OCORA-TWS05-010]. The requirements are engineered in a top-down manner:

- As a starting point all **Objectives** are captured. Objectives are the high-level goals to be achieved by developing an Open CCS On-Board Reference Architecture.
- Next, the program **Guidelines** are developed. They define tools, processes, methodologies and design rules to be used within the program and to be considered during the system analysis and the system design/architecture work.
- **References** to identified applicable Standards, Regulations and Specifications are captured.
- Stakeholder centric **Operational Epics** are captured and corresponding **Operational & System Requirements** derived.
- Based on the System Requirements, the MBSE architecture work defines the Building Blocks taking into account all applicable **Guidelines**.
- All applicable requirements are apportioned to the identified building blocks, resulting in **Building Block Requirements**, used for tendering OCORA compliant Building Blocks.

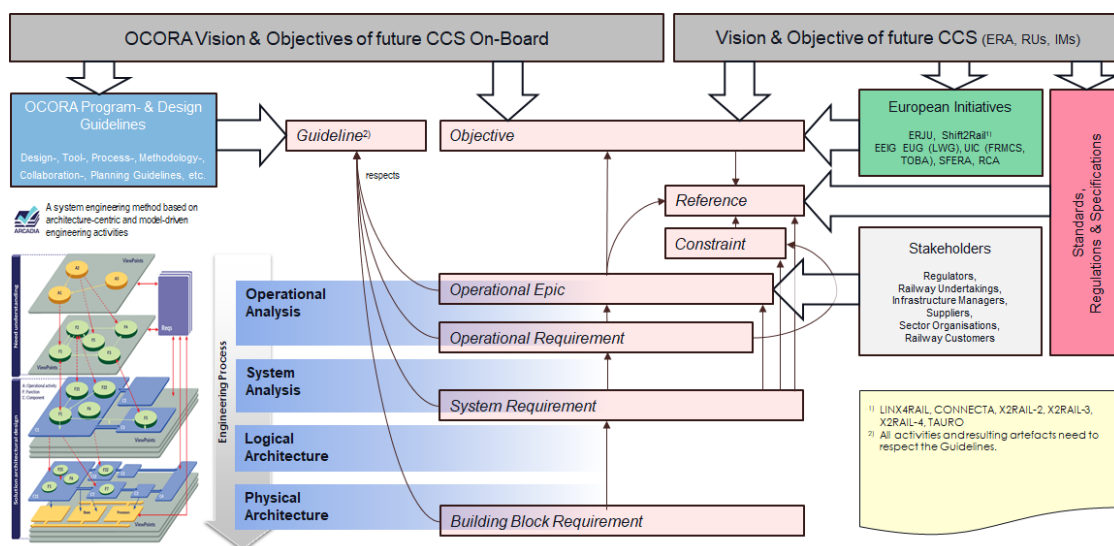


Figure 1 OCORA Requirements Engineering Process

Artefact	Description
Objective	Objectives define strategic approaches of what to do on a very high level and are formulated for the CCS Ob-Board.
Guideline	Guidelines describe OCORA program defined tools, processes, methodologies and design rules to be used within the program and to be considered during the system analysis and the system design/architecture work.
Reference	References point to external Standards, Regulations and Specifications that are relevant to the CCS On-Board.
Constraint	Constraints are specific artefacts of referenced Standards, Regulations and Specifications that may be linked to Operational Epics, Operational Requirements and/or System Requirements.
Operational Epics	Operational Epics describe a tangible vision or stakeholder need with a scope fitting the CCS On-Board. Epics do not follow the formal rules for requirements. However, they are formulated using a defined sentence template.

Artefact	Description
<b>Operational Requirement</b>	Requirements regarding operational processes and/or organisations derived from Objectives, Operational Epics and/or Constraints.
<b>System Requirement</b>	Requirements in regards to the CCS On-Board system are developed in the MBSE System Analysis, based on the Objectives, Operational Epics, Operational Epics, References and/or Constraints.
<b>Building Block Requirement</b>	Requirements in regards to the OCORA building blocks are developed in the MBSE System Architecture (logical / physical), taking into account the MBSE System Analysis.

*Table 1 Requirements Management Artefacts*



## 2 Operational analysis

### 2.1 Problem statement

Current ETCS systems requires many trackside physical balises for location purposes and giving location based information. These physical balises create many constraints and costs for the ETCS systems both on-board and trackside :

- Trackside asset installation, with area with few available free space.
- Trackside maintenance cost increase (removing and reinstalling the balises for maintenance)
- Complex BTM system on-board, introducing integration constraints and impacting system availability
- Complex system update, requiring to manually update the balises one by one
- Trackside deployment preconditioning ETCS operations

As an example, in some ETCS level 2 lines in France the distance between balise group varies from 50 to 1800m.

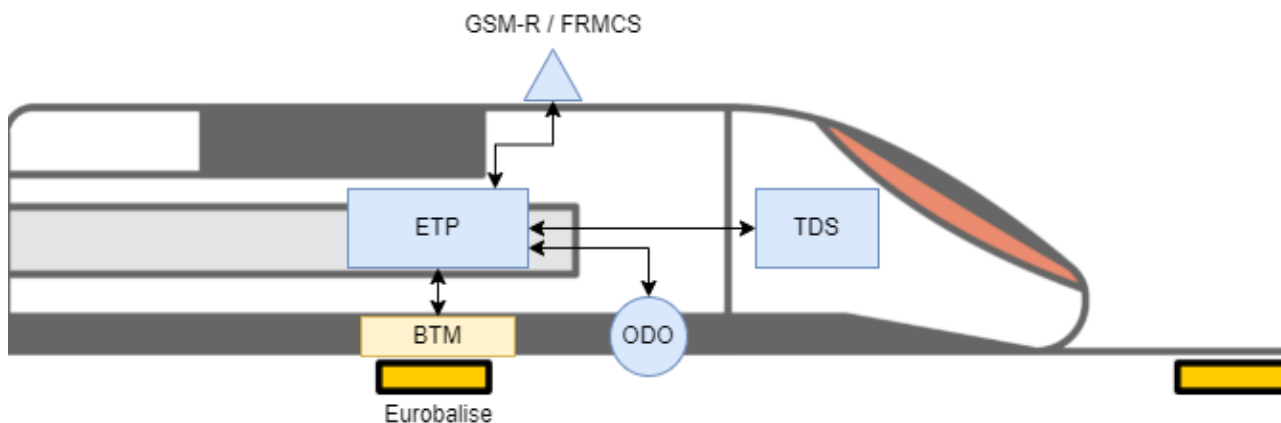


Figure 2 : current situation

The Virtual ETCS Transponder Service aims to reduces these costs and constraints by exploiting new technologies introduced in the new CCS-OB architecture : ASTP, digital map and perception.

In the future, the ASTP system will reduce the number of physical balise required for location purposes. VETS proposes to further reduce those balise by removing the physical balises required to transmit location based information.

Reducing the number of balises will :

- Lower ETCS deployment cost
- Lower trackside maintenance cost
- Easier and faster system update

Removing completely the needs for physical balise would further enable :

- Faster deployment of ETCS, and extending the ETCS area of use
- Reducing the ETCS-OB integration constraints by removing the BTM

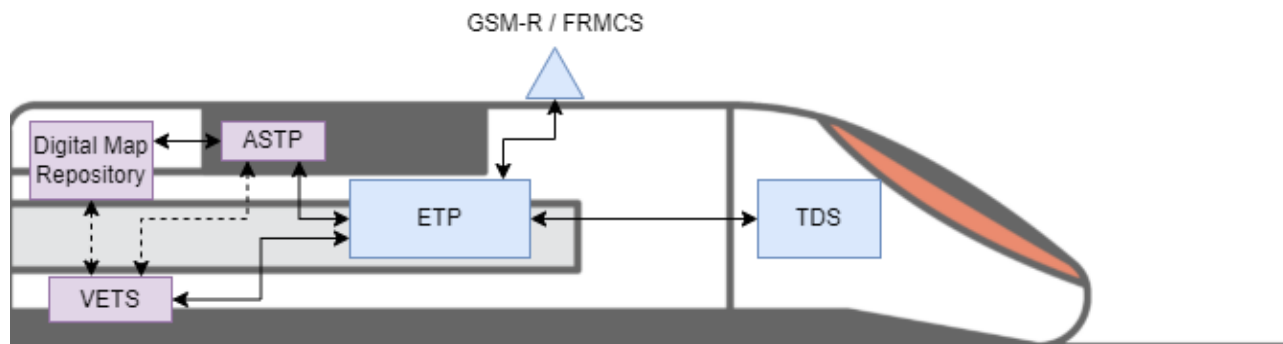


Figure 3 : VETS projected situation

## 2.2 Operational Epics






In the following section, identified key operational epics related to VETS are listed. These epics tackle down the pitfalls expressed above. All epics descriptions follow the same pattern :

- initially it is stated, who benefits from the epics (e.g. infrastructure manager, railway undertaking and/or supplier);
- then the epics itself is formulated;
- and finally the rationale of the epic is provided.

Also, the derivation of the Operational Epics from the Common Business Objectives from ERJU are shown. This link will ensure a continuity with System Pillar activities.




### OCORA-10402 - Operational EPICS: Operate ETCS Level 2/3 without the need of physical balises

As an Infrastructure manager, I want the possibility to operate an ETCS Level 2 area without using physical balises or with a significantly reduced number of physical balises.

Rationale	<ul style="list-style-type: none"> <li>- reduced the number of trackside asset.</li> <li>- save time and money of the installation of physical balises.</li> <li>- save time and money of the maintenance of physical balises.</li> <li>- save time and money on the infrastructure maintenance : no need to remove and reinstall the balises</li> <li>- avoid complex installation of physical balises where there are no more free space.</li> <li>- reduce interference issues between balise and metallic mass on or near the track</li> </ul>
Remark	<p>This Operational EPIC applies for new deployment or update existing Level 2 by removing physical balises.</p> <p>This Operational EPICS would require a SIL 4 safety level for the VETS system :</p> <ul style="list-style-type: none"> <li>- The virtual balise will be used as a reference in the train location report to the trackside.</li> <li>- The VETS could be used to send national values or level transition order for example</li> </ul>
Linked Work Items	<p>has parent:  OCORA-8893 - <a href="#">Operational Epics</a> ,</p> <p>refines:  OCORA-8812 - <a href="#">less trackside assets</a> ,</p> <p>refines:  OCORA-8820 - <a href="#">overall CAPEX/OPEX optimisation(1)</a> ,</p> <p>refines:  OCORA-8822 - <a href="#">availability: less assets</a> ,</p> <p>refines:  OCORA-10492 - <a href="#">robustness against weather</a></p>



### OCORA-10420 - Operational EPICS : Operate trains without BTM

As a railway undertaking, I want to operate train in ETCS without Balise Transmission Module.

Rationale	<ul style="list-style-type: none"> <li>- The BTM is a key system which impact the availability of the system</li> <li>- The BTM is a complex component to integrate (CEM constraints, physical space under the carriage)</li> </ul>
Remark	<p>This Operational EPICS would require a SIL 4 safety level for the VETS system :</p> <ul style="list-style-type: none"> <li>- The virtual balise will be used as a reference in the train location report to the trackside.</li> <li>- The VETS could be used to send national values or level transition order for example</li> </ul>
Linked Work Items	<p>has parent:  <a href="#">OCORA-8893 - Operational Epics</a> ,</p> <p>refines:  <a href="#">OCORA-8820 - overall CAPEX/OPEX optimisation(1)</a> ,</p> <p>refines:  <a href="#">OCORA-8822 - availability: less assets</a></p>






#### OCORA-10421 - Operational EPICS : Reducing constraints on the BTM when running a train in ETCS

As a railway undertaking, I want to lower the constraint on BTM when running a train in level ETCS.

Rationale	- Subset 91 : ETCS_OB06, ETCS_OB08, ETCS_OB09, BTM-H1/4/7/8/9 and LTM-H4
Remark	<p>This Operational EPICS would require a SIL 4 safety level for the VETS system :</p> <ul style="list-style-type: none"> <li>- The virtual balise will be used as a reference in the train location report to the trackside.</li> <li>- The VETS could be used to send national values or level transition order for example</li> </ul>
Linked Work Items	<p>has parent:  <a href="#">OCORA-8893 - Operational Epics</a> ,</p> <p>refines:  <a href="#">OCORA-8820 - overall CAPEX/OPEX optimisation(1)</a></p>





#### OCORA-10403 - Operational EPICS: restrict shunting movement without the need of physical balises

As an IM, I want the possibility to restrict shunting movement (to control the boundary of the allowed shunting area) without using physical balises or a significantly reduced number of physical balises.

Rationale	<ul style="list-style-type: none"> <li>- reduced the number of trackside asset.</li> <li>- save time and money of the installation of physical balises.</li> <li>- save time and money of the maintenance of physical balises.</li> <li>- avoid complex installation of physical balises, especially in shunting yard, where there are no more free space.</li> </ul>
Remark	<p>Thanks to the improvement of the Localisation-OB that can provide absolute safe train positioning, CCS-OB can determine its position in a Digital Map. Thanks to that, CCS-OB can detect when the train is crossing the limite of a shunting area. If an ETCS packet is associated to this limite, it can be received by a virtual balise included in the Digital Map.</p> <p>This Operational EPICS would require a SIL 4 safety level for the VETS system to restrict access to the main line for trains performing shunting movement</p>
Linked Work Items	<p>has parent:  <a href="#">OCORA-8893 - Operational Epics</a> ,</p> <p>refines:  <a href="#">OCORA-8812 - less trackside assets</a> ,</p> <p>refines:  <a href="#">OCORA-8820 - overall CAPEX/OPEX optimisation(1)</a> ,</p> <p>refines:  <a href="#">OCORA-8822 - availability: less assets</a> ,</p> <p>refines:  <a href="#">OCORA-10492 - robustness against weather</a></p>




#### OCORA-10404 - Operational EPICS: Allow ETCS trains on an infrastructure equipped with line side signals only (no ETCS trackside equipment)

As an IM, I want to allow the train to be supervised by ETCS without installing ETCS trackside equipment (e.g. by reading the light signal on the track using machine perception).

Rationale	<ul style="list-style-type: none"> <li>- avoid the deployment cost of physical ETCS trackside equipment.</li> <li>- ease the trackside migration to "physical" ETCS via a costless intermediat step.</li> <li>- increase the number of train equipped with ETCS by increaseng the number of kilometers of line equipped with ETCS</li> <li>- avoid the intermediat step of deployment of physical balises (with the assumption that the future of ETCS will be without physical balises)</li> </ul>
Remark	In this operational EPICS, a safety analysis is required to allocate the safety requirements of the VETS system to achieve the global system safety level .
Linked Work Items	has parent:  OCORA-8893 - <a href="#">Operational Epics</a> , refines:  OCORA-8812 - <a href="#">less trackside assets</a> , refines:  OCORA-8820 - <a href="#">overall CAPEX/OPEX optimisation(1)</a> , refines:  OCORA-8822 - <a href="#">availability: less assets</a>




### OCORA-10422 - Operational EPICS : Operate train in ETCS on a infrastructure not equipped with ETCS trackside assets

As a RU, I want to operate a train in ETCS on an infrastructure not equipped with ETCS trackside assets (e.g. physical balises).

Rationale	<ul style="list-style-type: none"> <li>- accelerate ETCS on-board deployment</li> <li>- save cost by removing the need for on-board STM system</li> <li>- Extend the area of use of ETCS train</li> <li>- Increase overall safety on unfitted lines</li> </ul>
Remark	In this operational EPICS, a safety analysis is required to allocate the safety requirements of the VETS system to achieve the global system safety level .
Linked Work Items	has parent:  OCORA-8893 - <a href="#">Operational Epics</a> , refines:  OCORA-8812 - <a href="#">less trackside assets</a> , refines:  OCORA-8822 - <a href="#">availability: less assets</a>

### OCORA-10423 - Operational EPICS: Operate a train with ATO over ETCS on a infrastructure not equipped with ETCS trackside assets




As a RU, I want to operate a train with ATO over ETCS on a infrastructure not equipped with ETCS trackside assets (e.g. physical balises)

Rationale	<ul style="list-style-type: none"> <li>- avoid the need for ATO over classe B system</li> <li>- accelerate standard ATO over ETCS deployment</li> </ul>
Remark	- The grade of automation will have an impact on the VETS safety requirement.
Linked Work Items	has parent:  OCORA-8893 - <a href="#">Operational Epics</a> , refines:  OCORA-8812 - <a href="#">less trackside assets</a> , refines:  OCORA-8822 - <a href="#">availability: less assets</a>

### OCORA-10471 - Operational EPICS : Operate trains in ETCS level 1 with virtual euroloop



As an IM, I want to deploy virtual euroloop instead of physical euroloop.

Rationale	<ul style="list-style-type: none"> <li>- avoid EMC perturbation</li> <li>- reducing trackside assets</li> <li>- simplify track maintenance operation</li> </ul>
Remark	Physical euroloop are not allowed to be deployed anymore (7.4.1 TSI 2023).

Linked Work Items	has parent:  <a href="#">OCORA-8893 - Operational Epics</a> , refines:  <a href="#">OCORA-8812 - less trackside assets</a> , refines:  <a href="#">OCORA-8822 - availability: less assets</a>
-------------------	--




### OCORA-10472 - Operational EPICS : Temporary speed restriction

As an IM, I want to deploy temporary speed restriction virtual balise on every trackside, except in level NTC areas

Rationale	- avoid work team to equip trackside with temporary balises and add Cover and/or VBC
Remark	<p>The existing solutions using physical balises gives an assurance to trackside work team that the TSR is in the right place.</p> <p>In case of the deployment of such solution, feedback should be given to the work team on the effective deployment of the virtual TSR balises.</p> <p>The deployment and digital map management will need to be further analysed.</p>
Linked Work Items	has parent:  <a href="#">OCORA-8893 - Operational Epics</a> , refines:  <a href="#">OCORA-8812 - less trackside assets</a>

### OCORA-10495 - Operational EPICS : Database update

As an IM, I want any train running on a line section with VETS to have the most recent balise information at any given time.

Rationale	- Avoid line operation disruption by updating all train running on the line - The balises information shall reflect at all time the real situation - Facilitate changes of the train area of use
Remark	- This update could be done remotely or locally
Linked Work Items	has parent:  <a href="#">OCORA-8893 - Operational Epics</a> , refines:  <a href="#">OCORA-8815 - changeability</a> , refines:  <a href="#">OCORA-8817 - Changeability and upgradeability(2)</a>