vf-OS: virtual factory Operating System

WP8: vf Smart Application Piloting and Validation

D8.1d: Validation Scenarios - Vs: 1.4.0

Deliverable Lead and Editor: Raúl Poler, UPV

Contributing Partners: UPV, MASS, VS, IKERLAN, KBZ, CON, APR, TARDY, UNINOVA

Date: 2018-10

Dissemination: Public

Status: Consortium Approved

Short Abstract

This document serves as umbrella document for the evaluation reports of the vf-OS project pilots. It presents a revision of the roadmap and supporting documents for evaluators.

Grant Agreement: 723710

Document Status

Deliverable Lead	Raúl Poler, UPV
Internal Reviewer 1	Carlos Agostinho, KBZ
Internal Reviewer 2	Eduardo Saiz, IKERLAN
Internal Reviewer 3	Stuart Campbell, ICE
Type	Deliverable
Work Package	WP8: vf Smart Application Piloting and Validation
ID	D8.1d: Validation Scenarios
Due Date	2019-10
Delivery Date	2019-11
Status	Consortium Approved

History

See Annex A.

Status

This deliverable is subject to final acceptance by the European Commission.

Further Information

www.vf-OS.eu

Disclaimer

The views represented in this document only reflect the views of the authors and not the views of the European Union. The European Union is not liable for any use that may be made of the information contained in this document.

Furthermore, the information is provided “as is” and no guarantee or warranty is given that the information is fit for any particular purpose. The user of the information uses it at its sole risk and liability.

Project Partners:

Executive Summary

Deliverable “D8.1d Validation Scenarios” and its annexed documents describe the M30 and M36 evaluation and validation activities conducted using the pilot applications (vApps) defined in the scope of the different validation scenarios. This document recap on the evaluation roadmap, the main objectives of the evaluation activities, and the methodology. It also includes the new six vApps developed on the scope of vf-OS.

Each of the three annexes provides an evaluation report of the validation activities per pilot:

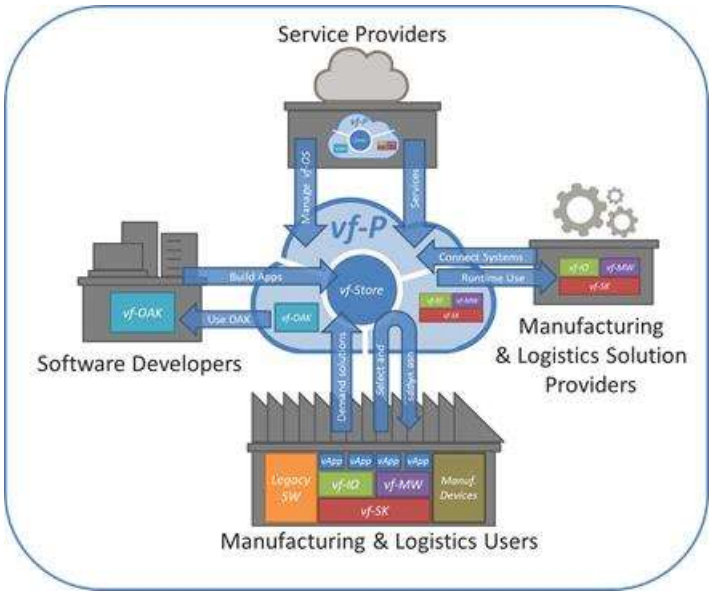
- **Pilot 1: Manufacturing and Logistics / Automation.** Applications focused on providing support to maintenance and spare part stock management in automation production equipment.
- **Pilot 2: Construction / Industrialisation.** Applications to improve time and resource utilisation in construction projects through advanced collaboration between construction managers and material suppliers.
- **Pilot 3: Manufacturing Assembly / Collaboration.** Applications to enable collaborative design and manufacturing of complex products.

Table of Contents

0 Introduction 1
1 Evaluation Roadmap Recap 5
2 Validation Scenarios 7
2.1 vApp -Final Coverage of vf-OS Components 7
2.2 GQM Methodology 8
2.3 Expanding the Validation with new vApps 9
3 Conclusions 11

0 Introduction

0.1 vf-OS Project Overview



vf-OS – virtual factory Open Operating System – is a project funded by the H2020 Framework Programme of the European Commission under Grant Agreement 723710 and conducted in the period October 2016 until October 2019. It engages 13 partners (Users, Technology Providers, Consultants and Research Institutes) from 7 countries with a total budget of circa 7.5M€. Further information can be found at www.vf-OS.eu.

The World is facing the fourth industrial revolution based on ICT, specifically architectures and services, as key innovation drivers for manufacturing companies. Traditional factories will increasingly be transformed into smart digital manufacturing environments but currently, the full potential for ICT in manufacturing is far from being fully exploited. Factories are complex systems of systems and there is a need to develop a platform on which future manufacturing applications can be built. Examples of platforms exist in some industrial sectors but there is a lack of cross-cutting platforms based on open standards for creating an ecosystem for cooperative innovation. Innovative open platforms to attract talent from solution developers and to provide accessible manufacturing smart applications to European SMEs are examples of the kind of solutions being sought.

The goal of vf-OS is to develop an Open Operating System for Virtual Factories composed of a kernel, application programming interface, and middleware specifically designed for the factory of the future. An Open Applications Development Kit (OAK) will be provided to software developers for deploying Manufacturing Smart Applications for industrial users, using the vf-OS Manufacturing Applications Store all operated through a Virtual Factory Platform.

The Virtual Factory Platform is an economical multi-sided market platform with the aim of creating value by enabling interactions between four customer groups:

- **Software Developers (independent or within individual manufacturers)** which will build Manufacturing Apps either through innovation or from manufacturing user demand
- **Manufacturing and Logistic Users** which will explore the marketplace for already created solutions, ready to be run on the vf-OS
- **Manufacturing and Logistics Solutions Providers** which will provide ICT interfaces and manufacturing connections
- **Service Providers (vf-OS innovators and third parties)** will make available services (hosting, storage, connected cloud services, etc.) including those based on developed solutions

The Virtual Factory Platform will provide a range of services to the connected factory of the future to integrate better manufacturing and logistics processes. Manufacturing Applications Store will be open to software developers who, using the free Open Applications Development Kit provided, will be able to quickly develop and deploy smart applications to enable and optimise communication and collaboration among supply networks of all manufacturing sectors in all the manufacturing stages and logistic processes.

vf-OS aims to become the reference system software for managing factory related computer hardware and software resources and providing common services for factory computational programs. This operating system will be the component of the system software in a real factory system where all factory application programs will run.

0.2 Deliverable Purpose and Scope

Deliverable D8.1d is a report detailing the validation activities using the vApps requested in the vf-OS pilot domains, as agreed between the vf-OS Software Developers and Manufacturing Logistic Users involved on each project pilot. This deliverable describes:

- The objectives of the evaluation activities on every evaluation phase
- The dependencies between developed components and vApps functionalities and an aggregated plan of vApp releases regarding vf-OS component availability that is detailed in the annexes
- The pilot applications evaluated in every phase
- The roles of each partner in the pilot and evaluation guidelines for all pilots.

This document itself acts as an umbrella document for the reports providing the results of the evaluation of pilot applications at different stages of the project, following the guidelines defined in this document. The evaluation reports are presented in the three annexes C, D and E of this document, corresponding to each pilot.

0.3 Target Audience

This public deliverable describes the vApps functionalities used to validate the vf-OS project and therefore, it is primarily aimed at project partners. However, since the vApps can be used to solve common problems to different sectors, the document can be useful for the wider scientific and industrial community. This includes any other organisation that may be interested in the potential functionality of the vf-OS technology, as well as other publicly funded projects which may be interested in collaboration activities.

0.4 Deliverable Context

This document is one of the main documents supporting the development of the applications that will be used to validate the vf-OS project. Its relationship to other documents is as follows:

- **Vision Consensus (D1.1):** A report to strengthen the common understanding of the project vision and the overall aims and objectives of the project. Available now
- **User Scenarios Characterisation (D1.2):** A report providing the characterisation of the main industrial scenarios and the initial pilot scenarios description. Available now

- **Requirements Specifications (D1.5):** The requirements specifications for the vf-OS Platform and the pilot vApps. Available now
- **Validation Scenarios (D8.1a):** Provides the methodology that establishes a reference for the interactions between different vf-OS customer groups developing and using new vApps. Available now
- **Validation Scenarios (D8.1b):** Defines the functionalities of the different pilot applications (vApps) in the project pilots. Available now
- **Validation Scenarios (D8.1c):** Defines the functionalities of the different pilot applications (vApps) in the project pilots. Available now
- **Pilot 1: Manufacturing & Logistic – Automation (D8.2abc):** A series of demonstrators of the applications developed for pilot domain 1, reported in Annex C of this deliverable
- **Pilot 2: Construction – Industrialisation (D8.3abc):** A series of demonstrators of the applications developed for pilot domain 2, reported in Annex D of this deliverable
- **Pilot 3: Manufacturing Assembly – Collaboration (D8.4abc):** A series of demonstrators of the applications developed for pilot domain 3, reported in Annex E of this deliverable

0.5 Document Structure

This deliverable is broken down into the following sections:

- **Section 1:** **Evaluation Roadmap** Recap**:** A revision of the evaluation objectives and roadmap
- **Section 2:** **Validation Scenarios:** A revision of the evaluation objectives and main points used with those in mind
- **Section 3:** **Conclusions:** The conclusions of this document

- **Annexes**:
  - **Annex A**: Document History
  - **Annex B**: References
  - **Annex C:** Pilot 1 Evaluation Report (Separate Document)
  - **Annex D:** Pilot 2 Evaluation Report (Separate Document)
  - **Annex E:** Pilot 3 Evaluation Report (Separate Document)

0.6 Document Status

This document is listed in the Description of Action as “public”.

0.7 Document Dependencies

This document has three preceding documents, D8.1a, in which the methodology used to define and validate generic user scenarios in vf-OS project is described, D8.1b, that describes how vf-OS partners have applied this methodology in the definition of the pilots vApps, and D8.1c describes the development process of the vApps and present the validation process applied to verify if the vApps.

0.8 Glossary and Abbreviations

A definition of common terms related to vf-OS, as well as a list of abbreviations, is available in the supplementary and separate document “vf-OS Glossary and Abbreviations”.

Further information can be found at http://www.vf-OS.eu/glossary.

0.9 External Annexes and Supporting Documents

This document has the following external annexes:

- **Annex C:** Pilot 1 Evaluation Report
- **Annex D:** Pilot 2 Evaluation Report
- **Annex E:** Pilot 3 Evaluation Report

0.10 Reading Notes

None

1 Evaluation Roadmap Recap

This section presents a recap on the evaluation roadmap introduced in D8.1c and followed until the end of the project. D8.1c explained the then misaligned of releases between vf-OS components and vApps, meaning that many vf-OS Platform Components were not mature enough to make a fair evaluation of the project objectives at M24 and M30 validation phases. With that in mind, a methodology was laid, based on three phases (see Figure 1).

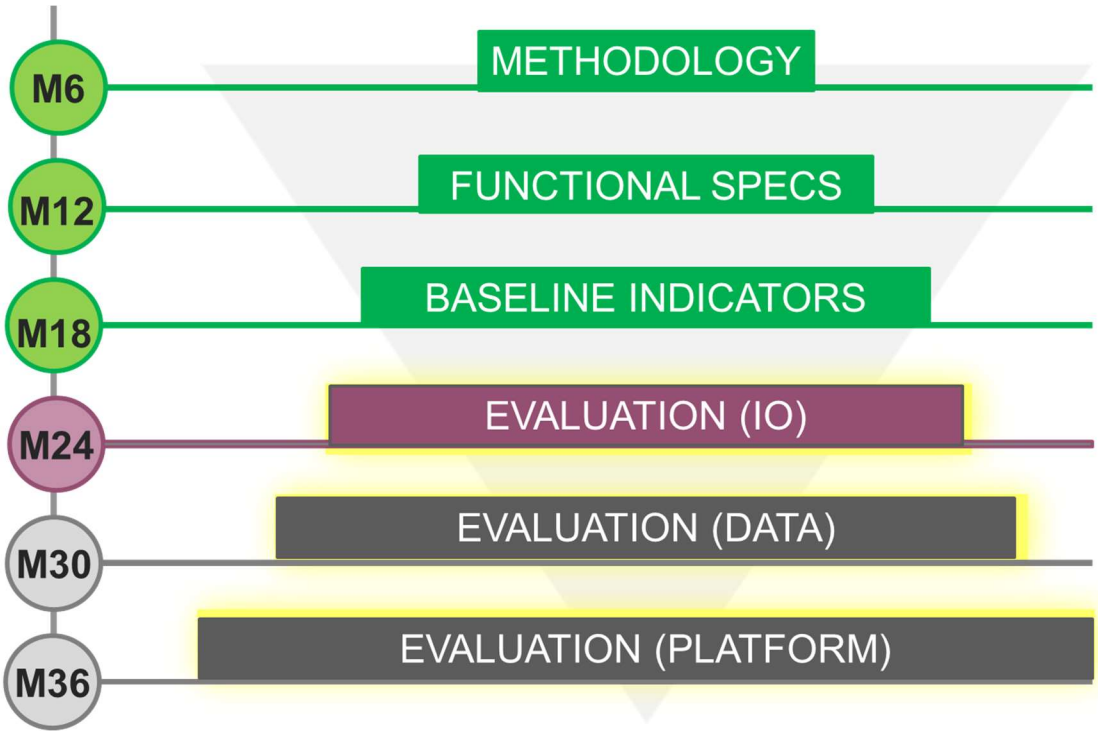


Figure 1: Evaluation roadmap

- **Phase 1. Evaluation of IO Components and Enablers Framework:** Interaction with manufacturing assets. The first evaluation period is focused on evaluating the capability of the vApps to interact with the manufacturing environment, via components that interact with manufacturing equipment (ie Device Drivers), legacy Software and file formats (ie API Connectors), and specific enablers (vf-OS Enablers) from open source platforms like FI-WARE.
- **Phase 2. Evaluation of Data Management and Processing Components:** Data management and processing. The second evaluation period addresses the evaluation of vApps with an emphasis on their data processing and storage functionalities. The second iteration of Process Designer, Data Mapping, Process Execution, Storage, Transformation and Analytics vf-OS components assure a maturity level where these functionalities can be tested.
- **Phase 3. Evaluation of the vf-OS Platform:** vf-OS Platform Evaluation. The final evaluation considers all aspects of the platform, but the emphasis will be put in horizontal components, such as the vf-Store, the vf-Platform, the vf-OAK, and vf-Studio. All of them are wrapping and integrating other vf-OS components and are the main components that vApps developers and users will make use of.

The proposed iterative roadmap proved to be right as developers focused on some use cases to build early versions (Minimum Viable Products) of the selected vApps from the first phase, and build on iteratively until embedding and debugging the final versions of the vApps at M36. As stated, that made some applications run through more testing, but technical knowledge of the vf-OS SDK made developers more effective at the final stages, making them build last components with fewer errors in a consistent way. The final result is shown in the annexes of this deliverable, showing proper levels of success.

2 Validation Scenarios

From a technical point of view, the validation of scenarios of the vApps was oriented with the following objectives:

- Objective 1: the main one, to validate the appropriateness of the development, meaning the coverage of business needs, during the consequent business impact on business KPIs.
- Objective 2: proving the usefulness of the vf-OS components as effective development tools that can accelerate the productivity of industrial developers.
- Objective 3: checking of coverage of usage of the vf-OS components in real industrial scenarios.

Two key drivers were posted to achieve that:

- Evaluating technically the vApps by users and developers (objective 1 and 2) through the usage of a GQM methodology.
- Assuring the coverage of usage of vf-OS components into vApps (objective 2 and 3).

2.1 vApp - Final Coverage of vf-OS Components

D8.1c depicted the assessment of coverage of vApps and vf-OS components assuring the validation in real industrial developments of the components (see Figure 2).

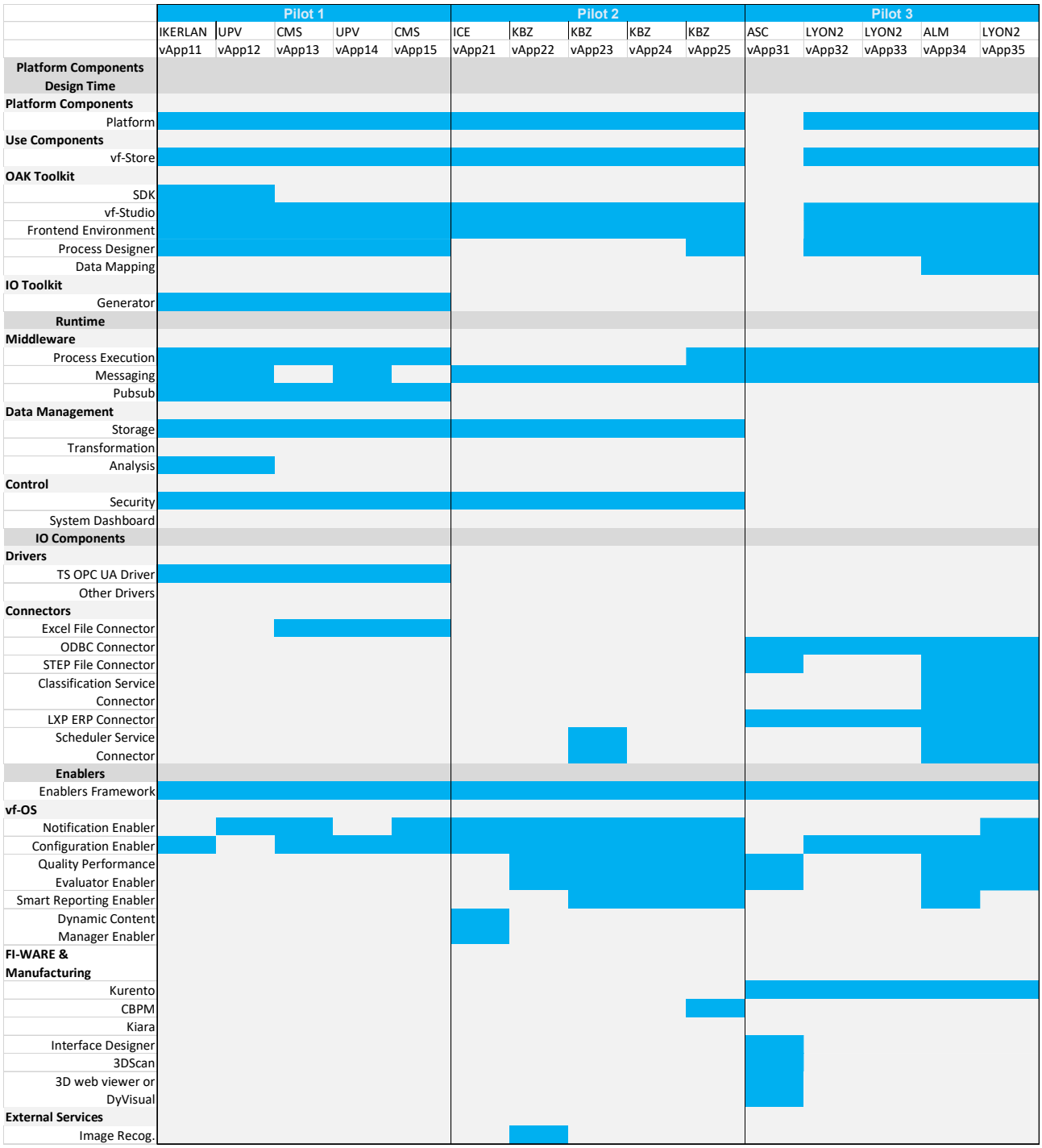


Figure 2: Pilots coverage

2.2 GQM Methodology

The GQM methodology involved three roles when validating the vApps.

- **Manufacturing and Logistic Users:** The customers and consumers of vApps
- **Software Developers:** vApps developers with the necessary capabilities to implement Manufacturing and Logistic Users' needs

- **Evaluators:** The neutral party responsible for evaluation based on data gathered from Manufacturing and Logistic Users and Software Developers.

Concisely, as more details are explained at D8.1c, the validation had two phases: the evaluation questionnaires preparation and the evaluation execution. The first main phase comprises the definition of two questionnaires, specifically related to generic/overall and specific pilot information. Annexes introduce for each phase the questionnaires defined. In order to provide a more complete understanding and feedback of the object being evaluated, both questionnaires comprise a combination of qualitative and quantitative questions.

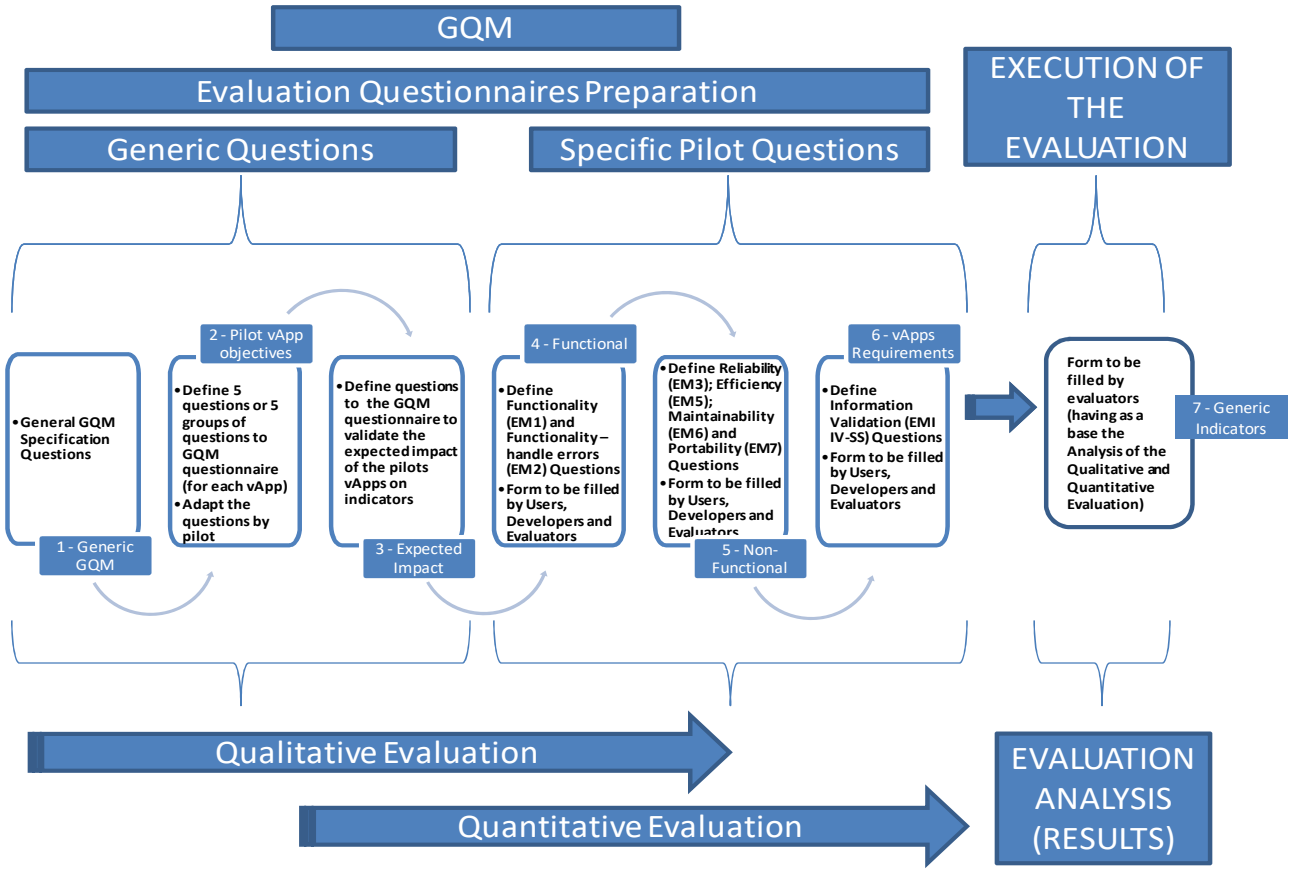


Figure 3: GQM-based Evaluation Methodology

2.3 Expanding the Validation with new vApps

As promised by the DoA, with the purpose of expanding the validation of vApps, vf-OS components and validating the vf-OS business model, additional vf-OS Apps were developed at M36 released that were not initially considered. Any pilot was asked to validate the adaptability capabilities of vf-OS and until the moment developed vApps.

Each vf-OS pilots were asked to test and along with developers two new vApps. The resulting vApps are (more details can be read on corresponding pilots' annexes):

- **Pilot 1:**
  - vfPeelTestFeedback: aims at providing feedback on the results of the on-site welding process to the shop floor

    - vfRecipesManagement: allows managing the information related to the composition (recipe) of sensors and its values used to underline a Machine behaviour.

- **Pilot 2:**
    - vfStationeryStocks: aims to prevent a shortage of consumable items that are relevant for CONSULGAL's and any work site's day-to-day operation
    - vfMaintenanceScheduler: aims to carry out IT equipment preventive maintenance and, eventually, be extended to CONSULGAL's car fleet maintenance needs.

- **Pilot 3:**
    - vfMaintenanceCalendar: aims to carry out preventive maintenance, providing calendars for maintenance operations and notifications informing when maintenance operations are due
    - vfCollaborationTracker: aims to evaluate the business impact of processed projects on both industrial partners.

The functionality, results and validation are explained in annexes of this document, and deliverables 8.2, 8.3 and 8.4, but a statement on the success of the value that the marketplace and the SDK provide to final users and developers can be stated.

3 Conclusions

Deliverable “D8.1d Validation Scenarios” and its annexed documents report on the validation activities successfully conducted along M24 to M37 of the vf-OS project.

The document presents the conclusions of intensive development and validation done by vf-OS vApp developers and pilot manufacturing final users. The validation process though planned in detail has been a real challenge, considering the involvement of many partners while using a composed and evolving vf-OS Platform, with different persons responsible of components.

In summary, the results are satisfactory and all the vApps have been successfully developed as a positive business impact has been achieved (see D82c, D83c, and D84c).

The validation done was extended with the development of six new vApps, two per pilot. New vApps proved that vf-OS developers joining the vf-OS ecosystem can benefit from existing vApps available in the marketplace to adapts and generate new vApps through the vf-OS Studio when open-source terms are present.

The evaluation conducted was mainly in two periods (M30 and M36) and has been documented per pilot basis in the following annexes:

- **Annex C: Pilot 1 Manufacturing and Logistics / Automation.** Applications focused on providing support to maintenance and spare part stock management in automation production equipment.
- **Annex D: Pilot 2 Construction / Industrialisation.** Applications to improve time and resource utilisation in construction projects through advanced collaboration between construction managers and material providers.
- **Annex F: Pilot 3 Manufacturing Assembly / Collaboration.** Applications to enable collaborative design and manufacturing of complex products.

Annex A: History

Document History	
Versions	V1.0.0: • Initial version V1.1.0: • 1st reviewer contribution V1.1.1: • Fixing V1.2.0: • 2nd reviewer contribution V1.3.0: • Coordinator ready document V1.3.1: • Coordinator contribution V1.4.0: EU document ready
Contributions	UPV: • Victor Anaya UNINOVA: • Joao Sarraipa KBZ: • Carlos Agostinho (1st internal review) IKERLAN: • Eduardo Saiz (2nd internal review) ICE: • Óscar García (coordinator review)

Annex B: References

Basili, V., Caldiera, G., & Rombach, D. (1994). In: “The goal question metric approach” Export Find Similar, edited by: Marciniak, J., published by Encyclopedia of Software Engineering (1994).

Annex C, D, E: Evaluation Reports

The Evaluation Reports are handed as separate files. The series of annexed documents are named:

- D8.1d: Annex C: Pilot 1 Evaluation Report
- D8.1d: Annex D: Pilot 2 Evaluation Report
- D8.1d: Annex E: Pilot 3 Evaluation Report

These annexed documents can be found in the same folder as this document and with the appropriate version. This separation is made to help the reader managing the Use Case descriptions since they are more clearly presented grouped per project pilot.

www.vf-OS.eu