

VALU3S

Verification and Validation of Automated Systems' Safety and Security

Updated/redesigned web-based repository with respect to the feedbacks obtained from D3.3, D3.7, D4.12 and D5.7

Document Type	Report
Document Number	D2.7
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Document Date	2023-04-28
Document Version	1.3 Final
Dissemination Level	Public (PU)
Reference DoA	2022-12-14
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Project Homepage	www.valu3s.eu
JU Grant Agreement	876852



This project has received funding from the ECSEL Joint Undertaking (JU) under grant agreement No 876852. The JU receives support from the European Union's Horizon 2020 research and innovation programme and Austria, Czech Republic, Germany, Ireland, Italy, Portugal, Spain, Sweden, Turkey.



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Project Overview

Manufacturers of automated systems and the manufacturers of the components used in these systems have been allocating an enormous amount of time and effort in the past years developing and conducting research on automated systems. The effort spent has resulted in the availability of prototypes demonstrating new capabilities as well as the introduction of such systems to the market within different domains. Manufacturers of these systems need to make sure that the systems function in the intended way and according to specifications which is not a trivial task as system complexity rises dramatically the more integrated and interconnected these systems become with the addition of automated functionality and features to them.

With rising complexity, unknown emerging properties of the system may come to the surface making it necessary to conduct thorough verification and validation (V&V) of these systems. Through the V&V of automated systems, the manufacturers of these systems are able to ensure safe, secure and reliable systems for society to use since failures in highly automated systems can be catastrophic.

The high complexity of automated systems incurs an overhead on the V&V process making it time-consuming and costly. VALU3S aims to design, implement and evaluate state-of-the-art V&V methods and tools in order to reduce the time and cost needed to verify and validate automated systems with respect to safety, cybersecurity and privacy (SCP) requirements. This will ensure that European manufacturers of automated systems remain competitive and that they remain world leaders. To this end, a multi-domain framework is designed and evaluated with the aim to create a clear structure around the components and elements needed to conduct V&V process through identification and classification of evaluation methods, tools, environments and concepts that are needed to verify and validate automated systems with respect to SCP requirements.

In VALU3S, 13 use cases with specific safety, security and privacy requirements will be studied in detail. Several state-of-the-art V&V methods will be investigated and further enhanced in addition to implementing new methods aiming for reducing the time and cost needed to conduct V&V of automated systems. The V&V methods investigated are then used to design improved process workflows for V&V of automated systems. Several tools will be implemented supporting the improved processes which are evaluated by qualification and quantification of safety, security and privacy as well as other evaluation criteria using demonstrators. VALU3S will also influence the development of safety, security and privacy standards through an active participation in related standardisation groups. VALU3S will provide guidelines to the testing community including engineers and researchers on how the V&V of automated systems could be improved considering the cost, time and effort of conducting the tests.

VALU3S brings together a consortium with partners from 10 different countries, with a mix of *industrial partners* (25 partners) from automotive, agriculture, railway, healthcare, aerospace and industrial automation and robotics domains as well as leading *research institutes* (6 partners) and *universities* (10 partners) to reach the project goal.



Consortium

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Executive Summary

This deliverable describes the activities undertaken in Task 2.2 during the concluding period of the project to meet the requirements of the web-based repository. These requirements were identified in the context of WP2 and were primarily specified in deliverable D2.2 [1]. The result of Task 2.2 is a web-based repository that stores elements of the VALU3S framework. This repository allows for the storage, search and retrieval of information gathered from various V&V methods that have been utilized, developed, and enhanced throughout the project, as well as the V&V tools employed. Additionally, the repository establishes a linkage between the methods and tools with the test cases defined and elaborated for different use cases of the VALU3S project.

During the project, the repository was populated with data collected from various WPs. In late 2022, the repository was relocated to its permanent location and made accessible to the general public. This deliverable presents the final design and implementation of the repository. At the time of writing, the repository has been populated with 13 use cases, 90 methods and 100 tools. Information about the evaluation results of the 15 demonstrators of WP5 will be also updated to the web-based repository. The WP5 results are being mapped during the writing of this document.

Although the initial design and implementation of the web-based repository was done and presented in D2.4 in the first year of the project, the web-based repository has been in progress and updating to support WP3, WP4 and WP5 until the end of the project. Within the scope of WP3 - Design of SCP (Safety, Cybersecurity, and Privacy) V&V (Verification and Validation) methods for automated systems, D3.7 corresponds to an update of VALU3S web-based repository of V&V methods with information collected regarding the methods used and improved during VALU3S project and D3.3 identifies gaps and limitations of the V&V methods. The WP4 deliverable D4.12 - *Updated Web-based Repository, Linking V&V Tools to the Framework*, corresponds to an update of the VALU3S web-based repository with the V&V tools developed, improved, or used as a support for the implementation of the V&V workflows designed during the project. The deliverable D5.7 - *Updated Web-based Repository, Linking V&V evaluation results to the Framework*, is related to an update and mapping of the of the VALU3S web-based repository regarding V&V evaluation results obtained applying the V&V workflows in each of the WP5 demonstrators. Hence, this deliverable is an update of D2.4 with respect to the needs and feedbacks obtained from D3.3 [2], D3.7 [3], D4.12 [4] and D5.7 [5].

The team worked through an early conceptualization phase, advanced from user interface mock-ups to a web-based prototype and subsequently to a functional version of the repository. Some effort was dedicated to ensuring coherence with the requirements and design constraints described in other deliverables (namely, D2.1 [6] and D2.2 [1]). The Plone content management system (CMS) [7] was selected as the basis for the repository and the team tailored it to suit the needs of the project. It was made available to project partners, starting in late 2020, and joint meetings between Tasks 2.2 and 2.3 took place to ensure good coordination toward populating the repository with data. At a later stage, coordination with WP3, WP4 and WP5 was necessary to support their requirements.



Updated/redesigned web-based repository with respect to the feedbacks obtained from D3.3, D3.7, D4.12 and D5.7

The software is ready for usage within the VALU3S project, and all contributing partners have received institutional accounts. Considered a key exploitable result for VALU3S partners, the VALU3S web-based repository was made public on November 30th, 2022 during the 8th General Assembly held in Hamburg, after moving it to its final location (<https://repo.valu3s.eu/>).

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Revision History

Version	Date	Author (Affiliation)	Comment
0.1	2023-03-17	Raul Barbosa (COIMBRA)	Initial version of the document, based upon the previous deliverable from T2.2.
0.2	2023-03-29	All authors	Contributions and updates to D2.7.
0.3	2023-03-30	Raul Barbosa (COIMBRA)	Revision and integration of new content.
0.4	2023-04-25	All authors	Document fully revised on the basis of the comments provided by the reviewers
1.0	2023-04-26	Raul Barbosa (COIMBRA)	Document finalized and last remaining comments addressed and resolved
1.1	2023-04-26	Behrooz Sangchoolie (RISE)	Review of the final draft of the report, while making some formatting changes and adding additional comments to be addressed.
1.2	2023-04-27	Joseba Agirre (MGEP)	Addressing the remaining review comments.
1.3	2023-04-28	Behrooz Sangchoolie (RISE)	Final version of the report to be submitted.

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Acronyms

ATS	Automated Test Suite
CMS	Content Management System
EA	Enterprise Architect
ER	Entity-Relationship
MDA	Model Drivel Architecture
MDG	Model Driven Generation
PIM	Platform Independent Model
PSM	Platform Specific Model
SCP	Safety, Cybersecurity and Privacy
UML	Unified Modelling Language
V&V	Verification and Validation
WP	Work Package
XML	Extensible Markup Language

Chapter 1 Introduction

The goal of Task 2.2 is to create a web-based repository to store the elements of the VALU3S framework. This deliverable (D2.7) takes mainly as input the design decisions specified in D2.2 [1] and describes the work carried out in the context of Task 2.2 towards the final version of the repository. Contributing partners have received institutional credentials to access the repository, which has been made available through a development server, hosted at the University of Coimbra, which provided the means for developing new features and for data population since late 2020. In 2022, the repository was migrated to a new server, hosted by RISE, and can now be found at <https://repo.valu3s.eu> where it became publicly available.

The main idea was for the web-based repository to provide a searchable catalogue of V&V methods applicable to specific domains and application scenarios. This deliverable presents the main views that provide content to the users and describes the data architecture and the content types constructed to support the repository. These derive from the data model presented in D2.2 [1] and aim to store the information related to the framework elements. To this end, the design and structure of the created data types is described throughout the document and examples are provided on how to edit and insert content. Toward the later stages of the project, the content types were refined to support the requirements of WP3, WP4 and WP5, so this deliverable largely focuses on those more recent updates.

Within the scope of WP3 - Design of SCP (Safety, Cybersecurity, and Privacy) V&V (Verification and Validation) methods for automated systems, D3.7 [3] corresponds to an update of VALU3S web-based repository of V&V methods with information collected regarding the methods used and improved during VALU3S project. Support for storing V&V methods was therefore added to the repository.

In WP4, Deliverable D4.12 - *Updated Web-based Repository, Linking V&V Tools to the Framework* [4], is associated to an update of the VALU3S web-based repository with the V&V tools developed, improved, or used as a support for the implementation of the V&V workflows designed during the project, but also with the workflow developed in the context of Task 4.2. Support for V&V tools and their relations to other framework elements was developed into repository.

Deliverable D5.7 - *Updated Web-based Repository, Linking V&V evaluation results to the Framework* [5], is associated with an update and mapping of the of the VALU3S web-based repository regarding V&V evaluation results obtained applying the V&V workflows in each of the WP5 demonstrators. The needs and feedback collected from WP5, as well as WP4 and WP3, were therefore collected and this deliverable reports on the resulting updates.

The remainder of the report describes the views and features of the repository in Chapter 2, details the data architecture decisions and content types in Chapter 3, describes the validation effort in Chapter 4 and presents concluding remarks in Chapter 5.

Chapter 2 Views and Functionalities

The web-based repository was constructed according to the set of user stories described in D2.2 [1], which specifies how the VALU3S framework and repository shall benefit users. This chapter presents and describes the views and features that are available, as well as a summary of the rationale for decisions and technological options. There are two main roles for authenticated users that access the repository: administrator and editor. The *administrator* role is mainly associated with the partners of Task 2.2, who are responsible for tailoring and configuring the repository to meet the needs of the project; the *editor* role is appropriate for project partners only involved in publishing content (*e.g.*, adding methods, tools and use cases). The public can access the published content in the web-based repository without requiring an account.

The team adopted the Plone CMS [7] as the basis for the repository, customized the content types according to the data architecture developed in D2.2 [1], created the necessary roles, constructed the views that provide information to users (including advanced search features), changed the underlying template to meet the visual identity of the project, among other tasks. A key aspect relates to the content types, which maps the previously designed data architecture to the database of the Plone CMS. The so-called Dexterity subsystem was adopted as the means to provide the necessary content types, to enable and disable various behaviours of the system and to coordinate the work of the diverse project partners.

The two different types of users (non-authenticated and authenticated) gave rise to two distinct areas of the repository: front-end, which is available to all users, and back-end, which is available only to registered users. The following sections provide an overview of these areas. The front-end is presented first, including the search features, followed by the back-end for data publishing.

2.1 Front-end

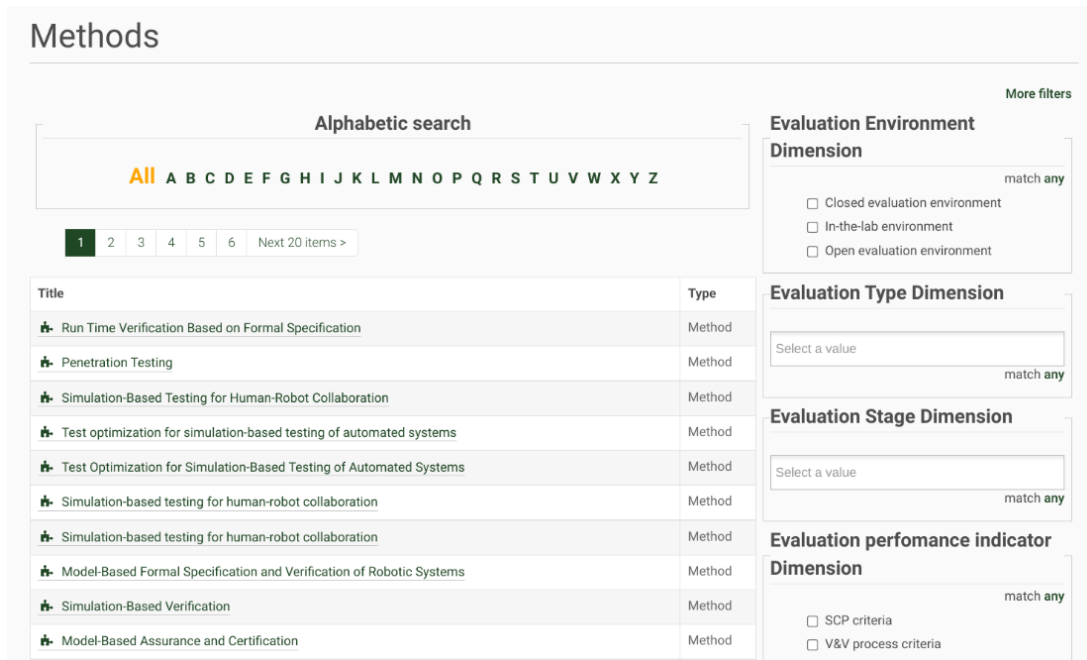
The dimensions and layers developed in the context of WP2 and refined in D2.2 [1] provided the natural entry point to the application. As shown in Figure 2.1, upon entry the view contains links to the high-level entities (Use Cases, Methods, Tools, Standards, Organizations and Glossary) of the data architecture. A simple search bar is shown in the frontpage and is complemented by advanced search features presented further below. All views follow a common template, which contains a top bar that includes the VALU3S logo and a textbox for search, a thin bottom bar with informative content, and a left sidebar with options for administrators and editors.



Figure 2.1 Front-end homepage view

Characterizing V&V methods and being able to visualize the resulting descriptions are features that are specified in the user stories. Figure 2.2 presents the view that displays the list of V&V methods. Users can match search terms against the fields of the data model, such as the evaluation environment or stage, and the results are displayed in a tabular format that contains columns with essential information only (e.g., title, type and date). Pagination is used to ensure that the user is not overloaded with a large number of results shown at once. For the methods collected in D3.1 [8], the additional information provided (e.g., purpose and description) can be obtained by selecting the intended method from the list.

The filters displayed on the right-hand side of Figure 2.2 provide the means to restrict the search keywords according to the terms associated with each framework dimension. This covers the aspects of several user stories, according to which it should be simple for users accessing the repository to navigate the information through restrictions on the dimensions.



Methods

Alphabetic search

All A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

1 2 3 4 5 6 Next 20 items >

Title	Type
Run Time Verification Based on Formal Specification	Method
Penetration Testing	Method
Simulation-Based Testing for Human-Robot Collaboration	Method
Test optimization for simulation-based testing of automated systems	Method
Test Optimization for Simulation-Based Testing of Automated Systems	Method
Simulation-based testing for human-robot collaboration	Method
Simulation-based testing for human-robot collaboration	Method
Model-Based Formal Specification and Verification of Robotic Systems	Method
Simulation-Based Verification	Method
Model-Based Assurance and Certification	Method

More filters

Evaluation Environment Dimension match any

- Closed evaluation environment
- In-the-lab environment
- Open evaluation environment

Evaluation Type Dimension

Select a value match any

Evaluation Stage Dimension

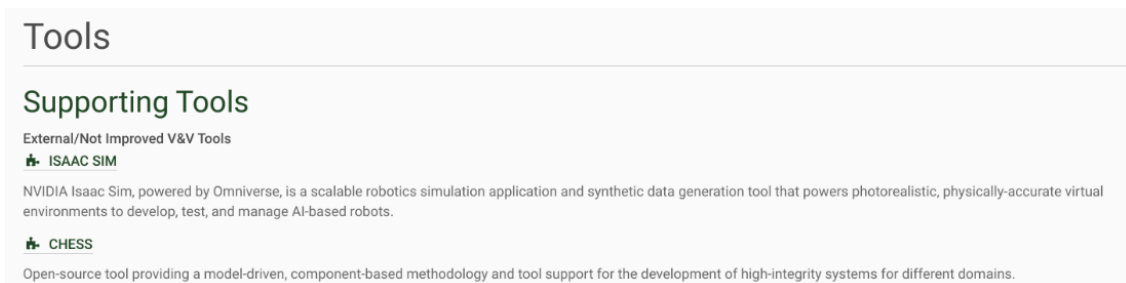
Select a value match any

Evaluation performance indicator Dimension match any

- SCP criteria
- V&V process criteria

Figure 2.2 Front-end displaying V&V methods providing search options

Figure 2.3 contains the view where the information on V&V tools is displayed to the user. The tools are divided into “Supporting Tools” and “Improved/Developed Tools”. Supporting tools are shown in a listing, while a simple table format is adopted for listing the Improved/Developed tools. In addition to listing the tools, there are indications via other elements that point to each individual tool, providing the means to search for appropriate tools for specific scenarios.



Tools

Supporting Tools

External/Not Improved V&V Tools

- ISAAC SIM**
NVIDIA Isaac Sim, powered by Omniverse, is a scalable robotics simulation application and synthetic data generation tool that powers photorealistic, physically-accurate virtual environments to develop, test, and manage AI-based robots.
- CHESS**
Open-source tool providing a model-driven, component-based methodology and tool support for the development of high-integrity systems for different domains.

Figure 2.3 Front-end for listing the V&V tools

Every item presented in any given listing (such as a method, tool, use case, standard, organization, etc.) can be selected to view the respective details. We present an example of such details in Figure 2.4 for one of the VALU3S use cases. Similar views are presented for the V&V methods, tools, etc., so we do not present further images as this one is representative for the general pattern presented to users.

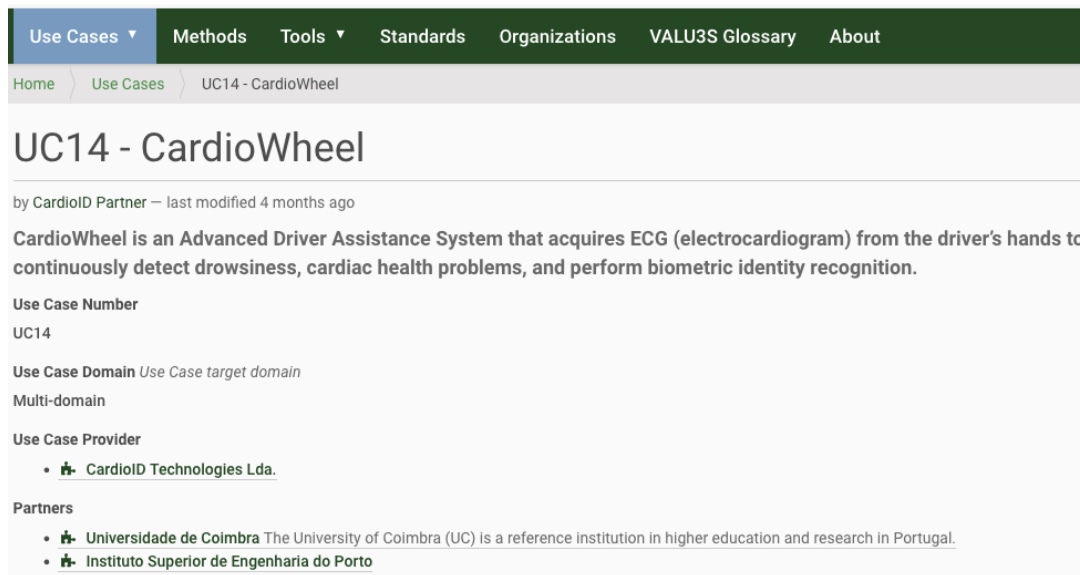


Figure 2.4 Front-end view providing the details of a use case

2.2 Back-end

Authenticated users have access to a wider range of functionalities than non-authenticated users, which usually entail being able to create and edit content in the platform. We refer to these features as the back-end and present an overview in this section.

One aspect that is specified across several of the repository's user stories is the ability to characterize elements of the framework. Figure 2.5 depicts the view presented to editors in order to characterize a V&V method. The characterization space requires categorizing V&V methods according to the dimensions of the VALU3S framework, which are extensively described in other project deliverables. To this end, the view presented in Figure 2.5 allows one to select multiple items of each dimension that become associated to the new V&V method.

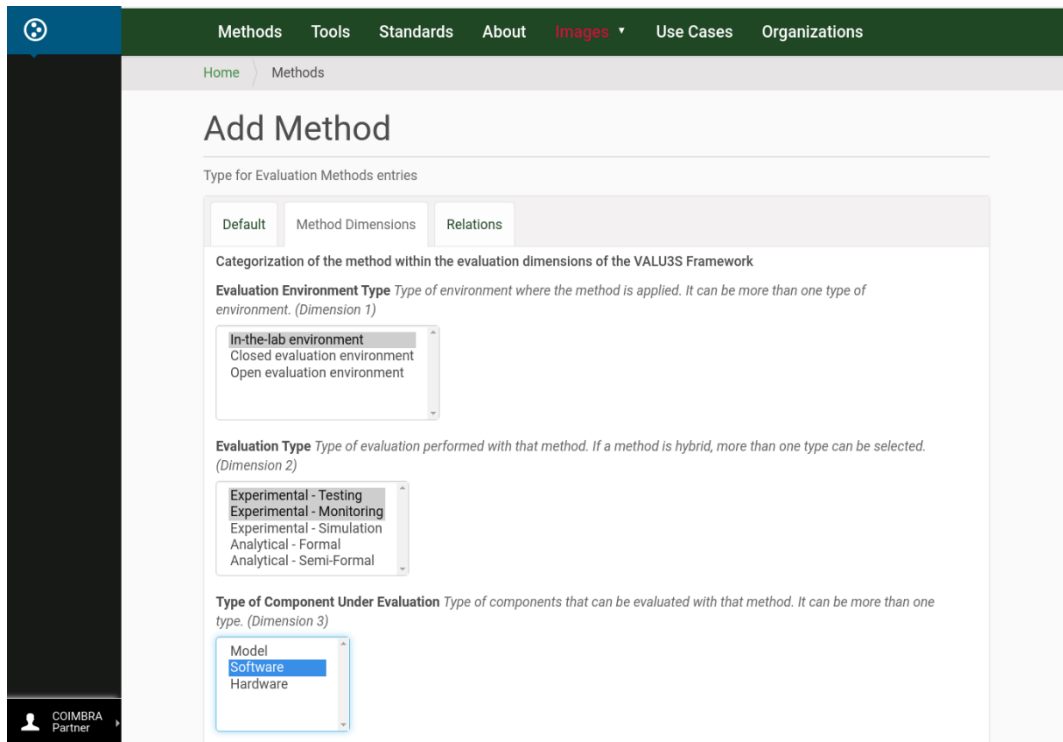


Figure 2.5 Back-end for adding a new V&V method (dimensions tab)

The information required to characterize a V&V method is separated into multiple tabs, as shown in Figure 2.5 and Figure 2.6. This was done to limit the complexity of each form and to make a clear distinction between actions such as categorizing methods according to dimensions (Figure 2.5) and describing methods textually (Figure 2.6). This is a general option in place for most views.

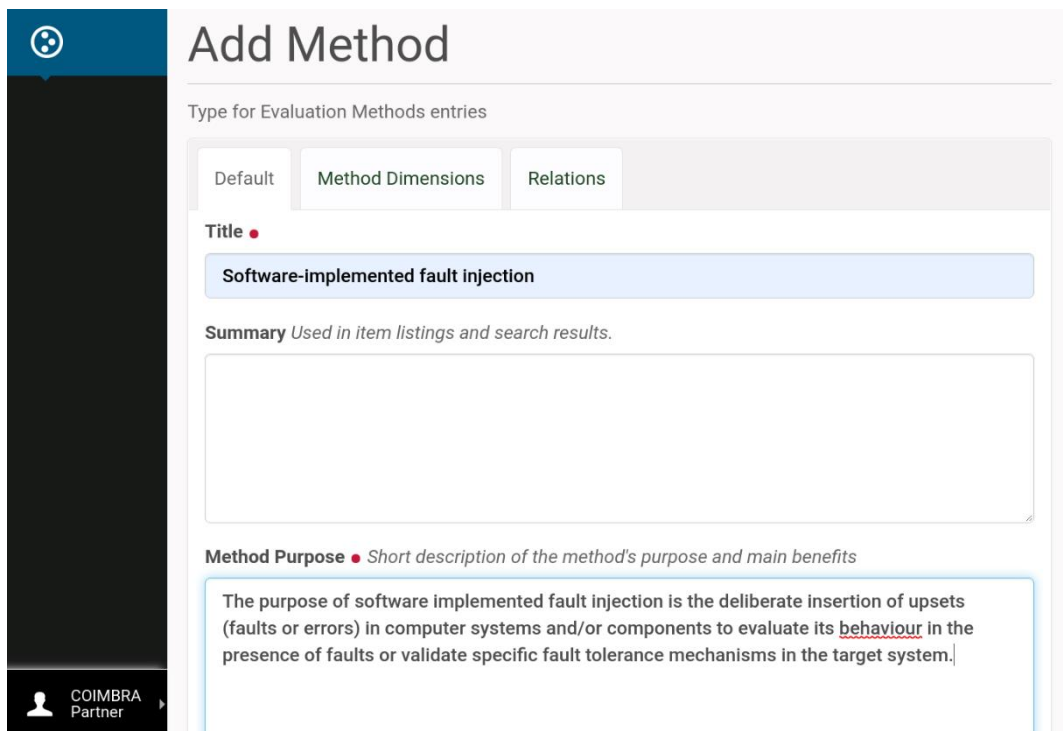


Figure 2.6 Back-end view for describing a new V&V method

One of the aspects that concerns tool developers and vendors is the characterization of tools. This relates to user stories regarding the presentation of tools and their increased visibility to potential users by means of the repository. Figure 2.7 displays the addition of a new tool to the repository. The same tabbed approach visible in previous figures allows one to describe the tool, characterize it with respect to the dimensions and relate it to other elements of the framework.

It is noteworthy to highlight that some of the use cases specified in D2.2 [1] go beyond what can be directly achieved through a repository. User stories 8 through 10, for instance, refer to (i) the need for tool vendors to extend risk analysis and management tools to automated systems to improve tools and increase portfolios, (ii) to build scalable and modular tools to offer services and products to more industries and (iii) to make the tool available to more users to get feedback and make improvements based upon industrial needs. The repository, as a catalogue of V&V elements, plays an important role with regard to these use cases but, nevertheless, can only indirectly support those.

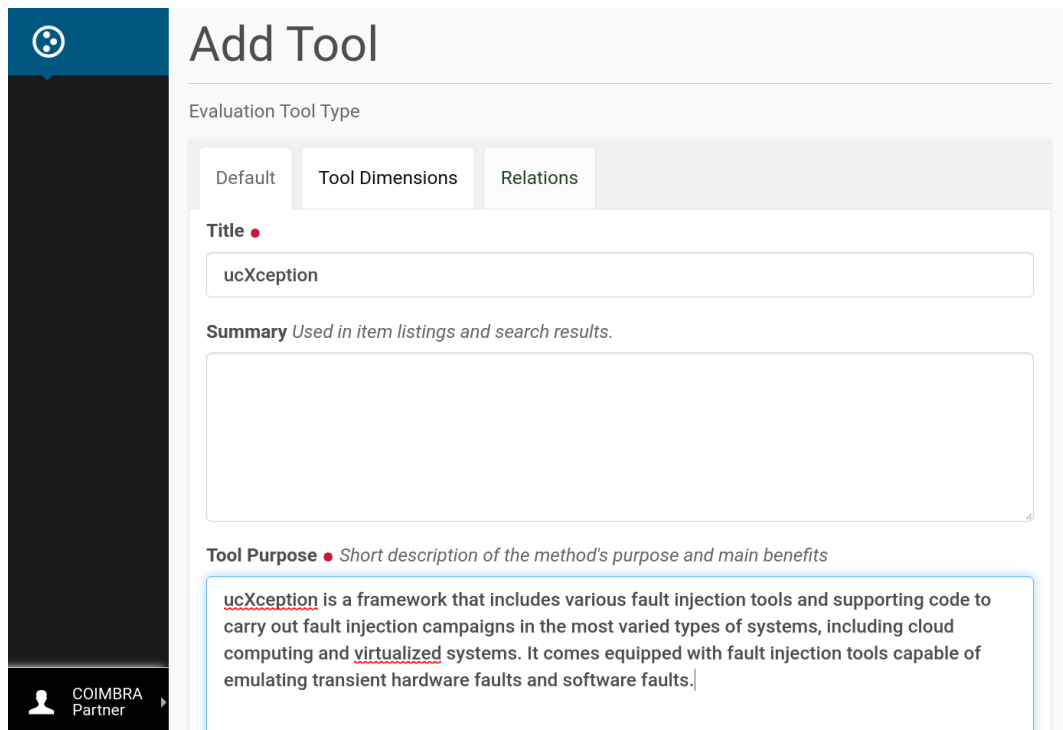


Figure 2.7 Back-end view for characterizing a new V&V tool

Other than adding V&V methods and tools, the web-based repository also offers the possibility to add information about the use cases, their workflows, the partner organizations and standards. Since the views for these operations are similar to the views presented for the methods and tools, for brevity reasons we will not repeat them in this document.

Although initially the content of the repository was kept private, it has since then been made open to the public. Nevertheless, if one partner wishes to insert new content in the future, the partner can keep it initially in the *new* state, which is only available for viewing by the original creator. Then, once the content is ready, it can be published to the public.

2.3 The Content Management System

The team considered several implementation options before choosing the Plone CMS [7] as the basis to develop the web-based repository. There are several advantages and drawbacks associated to this approach. The main advantages are the reliable feature-base on which to build upon, the security and availability of a time-tested approach, the large user- and knowledge-base associated to the Plone CMS and being a solid alternative to ground-up development of a new system. The main drawbacks are the need to tailor a generic basis to the specificities of the VALU3S framework and the obfuscated data model due to the fact that the Plone CMS stores the data in its specific internal representation.

At the early stages of design, the partners participating in Task 2.2 suggested several possible technologies for implementation, mostly deriving from their own expertise. A few resulted in the continued discussion, were considered likely to suit the needs of the task and the project and led to the first throw-away prototype (which is outside the scope of the present deliverable). Node.js [9] and Angular.js [10] were some of the candidate technologies for the front-end. There is a framework called MEAN [11], which stands for MongoDB, Express.js, AngularJS and Node.js (may include Object Relational Mapping), which is a solution stack providing the means to build dynamic web applications. In this stack, all components are written in JavaScript, hence client-side and server-side code is written in the same language. MongoDB could be potentially replaced by MySQL to provide a relational database. In addition to the MEAN stack, the VALU3S consortium also has experience with Django [12] development. Ultimately, the advantages in favour of adopting the Plone CMS and tailoring it to our needs outweighed the disadvantages.

Chapter 3 Data Architecture and Content Types

This section describes the web content types created in the VALU3S web-based repository to store the information related to the VALU3S framework defined in D2.2 [1]. The repository stores a catalogue of V&V methods and tools, as well as information about the application of those methods in a Use Case. The web-based repository has been updated and populated with the information gathered from WP1 regarding the use case and test case definitions. The repository, also, stores outputs from WP3, WP4 and WP5 such as V&V methods, V&V tools and demonstrator results respectively. Those elements or artefacts are stored in the repository with mappings and characterized by VALU3S multidimensional framework elements. Note that artefact refers to any element that is stored in the repository and that characterizes the application of V&V activities. This is the list of artefacts that can be stored in the repository:

- **V&V Method:** Method that could be used in a V&V activity.
- **Tool:** Evaluation tool that is used as support of a method.
- **Use Case:** This element is used to describe the Use Case.
- **Organization:** This element is used to define the companies or partners contributing to a Use Case. Each Use Case has an associated owner and possibly multiple contributors.
- **Evaluation Scenario of a Use Case:** A Use Case is evaluated using evaluation scenarios.
- **Requirement** (related to dimension 7, which is the type of requirement under evaluation): The concrete requirements evaluated in the evaluation activity.
- **Test Case or Verification & Validation Activity:** This element specifies the evaluation activities performed in a Use Case and is linked to a method. The test case is performed using a method defined in the framework.
- **Standard:** The standard that is followed in the Use Case.
- **Workflow:** The workflow of applied tools.
- **Demonstrator result:** Results of the application of V&V workflows in a use case.

The web-based repository has been implemented using the Plone CMS. In Plone the web content types are described using Dexterity types [13]. The VALU3S web-based repository uses the V&V multi-dimensional layered framework data model, described in D2.2 [1] as the core for the definition and implementation of Web Content types. In this section the Plone based Dexterity Web content types that has been created to store VALU3S work packages information are described.

3.1 V&V Method Content Types

In VALU3S, the aim of WP3 -Design of SCP V&V methods for automated systems has been to create a set of reference methods for automated system V&V. The set of methods includes V&V methods in the strict sense, as well as methods providing the basis for V&V activities, like security and safety analysis. The set of reference methods contains (1) commonly used methods, as well as (2) methods that have



Updated/redesigned web-based repository with respect to the feedbacks obtained from D3.3, D3.7, D4.12 and D5.7

been improved and (3) new methods that have been created by combining methods, chains of methods, and co-usage of different methods.

V&V methods are at the core of the VALU3S framework. The fields, framework dimensions and relations defined in deliverable D2.2 [1] have been mapped into a content type in Plone. These three groups of information are reflected in the repository by using field groups within the Plone content type. Figure 3.1 shows part of the framework dimension entry dialog for an added method. In Figure 3.2, you can see the resulting representation in an example method.

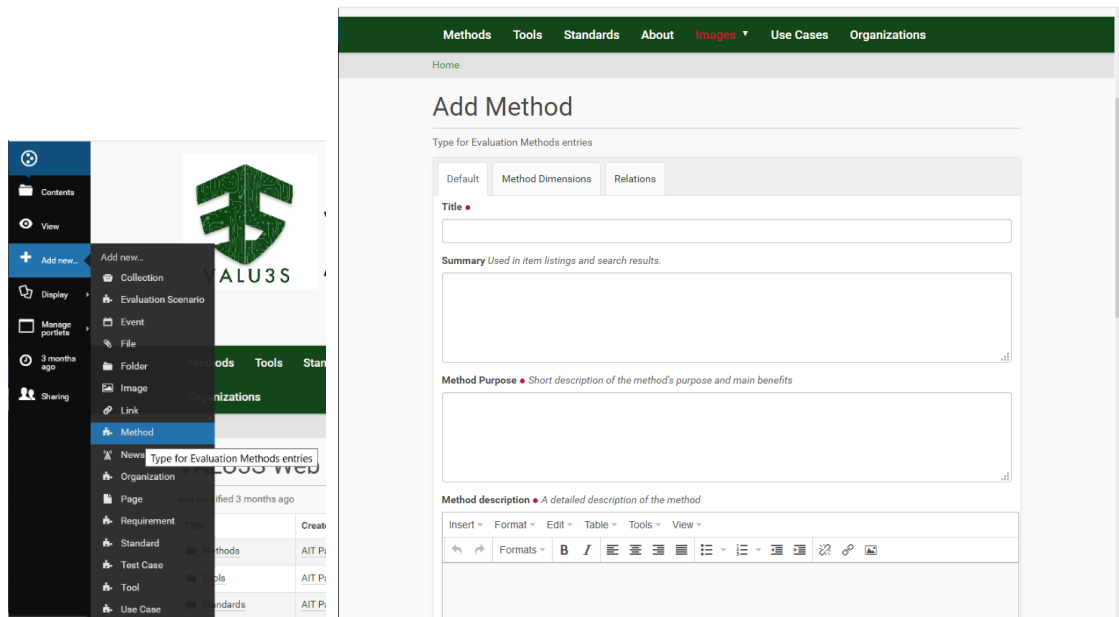


Figure 3.1 Add new Method – menu (left) and entry dialog (right)

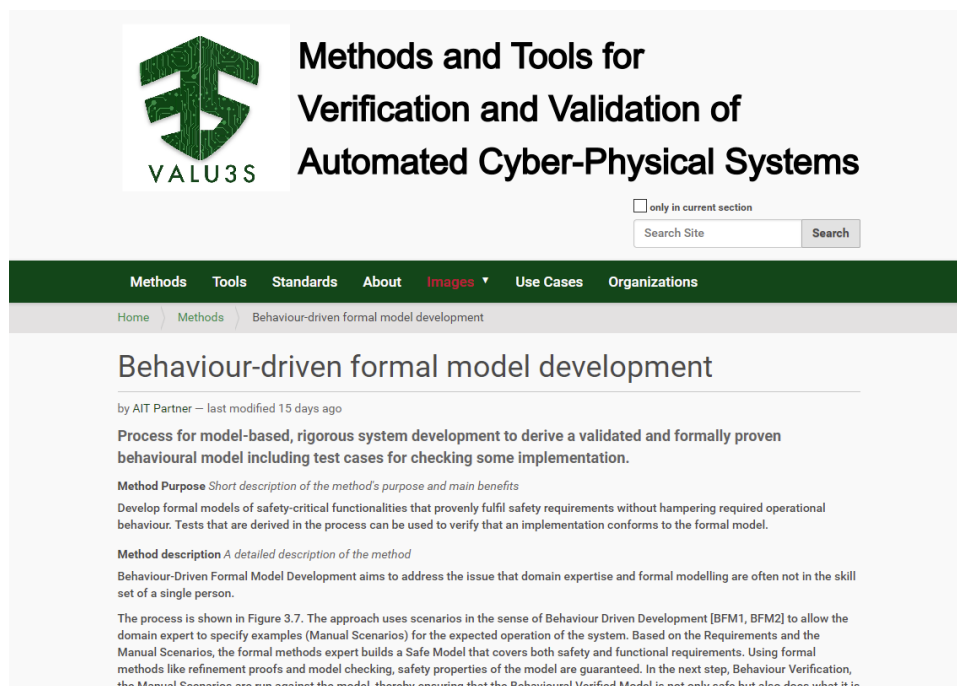
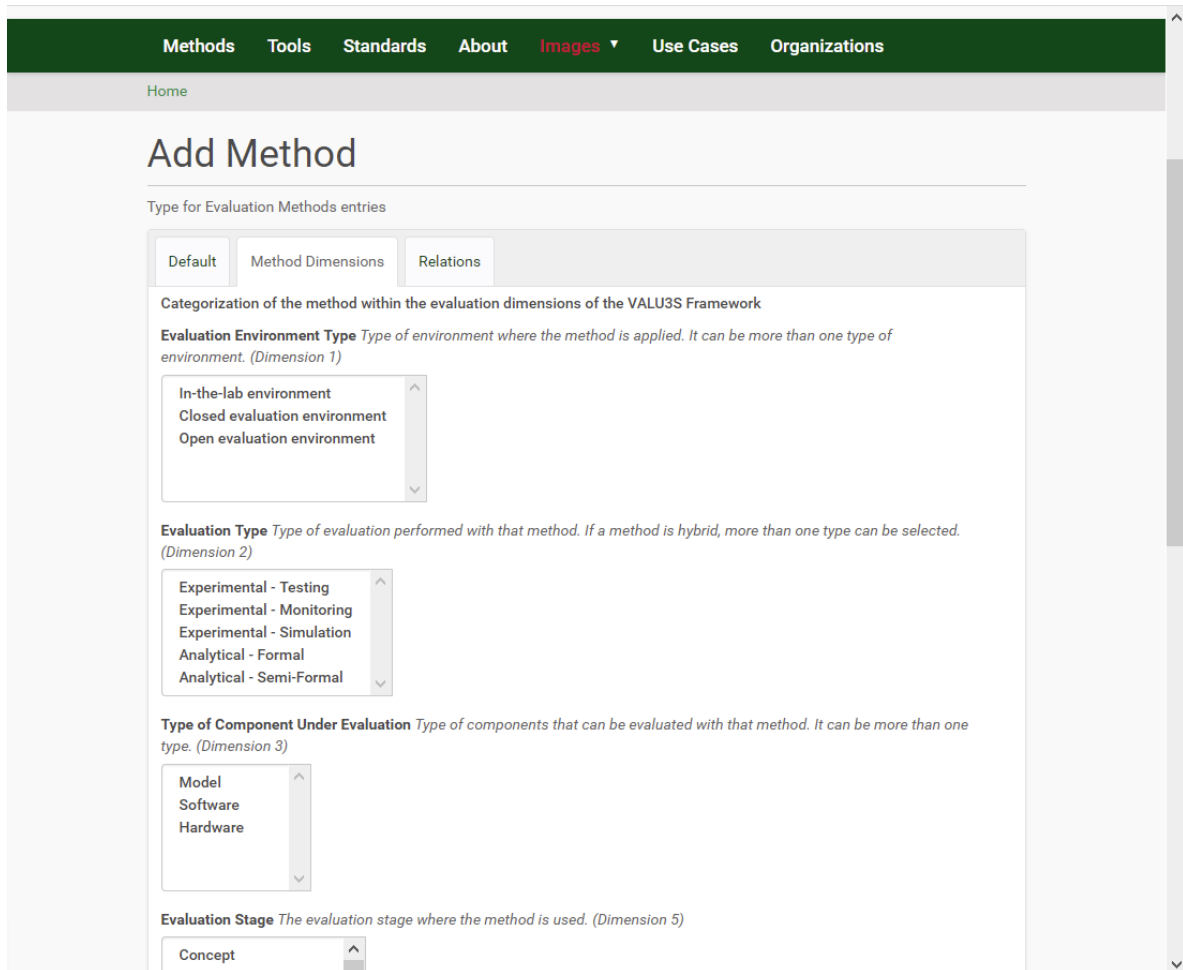


Figure 3.2 Method example - description fields

The framework dimensions have a set of fixed value options in the content type. They can be set in a separate field group. For the layers in the dimensions, also multiple selections are possible. Figure 3.3 shows part of the web form that allows to specify the dimensions and layers of the framework when adding a new method. Figure 3.4 shows how the dimensions and layers of the framework of a method are shown.



The screenshot displays the 'Add Method' web form. At the top, there is a dark green navigation bar with links for 'Methods', 'Tools', 'Standards', 'About', 'Images', 'Use Cases', and 'Organizations'. Below this is a light grey 'Home' link. The main heading is 'Add Method'. Underneath, there are three tabs: 'Default', 'Method Dimensions', and 'Relations'. The 'Method Dimensions' tab is active. The form content is titled 'Categorization of the method within the evaluation dimensions of the VALU3S Framework'. It contains four sections, each with a title and a description, followed by a dropdown menu:

- Evaluation Environment Type** *Type of environment where the method is applied. It can be more than one type of environment. (Dimension 1)*
 - In-the-lab environment
 - Closed evaluation environment
 - Open evaluation environment
- Evaluation Type** *Type of evaluation performed with that method. If a method is hybrid, more than one type can be selected. (Dimension 2)*
 - Experimental - Testing
 - Experimental - Monitoring
 - Experimental - Simulation
 - Analytical - Formal
 - Analytical - Semi-Formal
- Type of Component Under Evaluation** *Type of components that can be evaluated with that method. It can be more than one type. (Dimension 3)*
 - Model
 - Software
 - Hardware
- Evaluation Stage** *The evaluation stage where the method is used. (Dimension 5)*
 - Concept

Figure 3.3 Method entry dialog – framework dimension fields

Method Dimensions

Evaluation Environment Type *Type of environment where the method is applied. It can be more than one type of environment. (Dimension 1)*
 In-the-lab environment, Closed evaluation environment

Evaluation Type *Type of evaluation performed with that method. If a method is hybrid, more than one type can be selected. (Dimension 2)*
 Experimental - Testing, Analytical - Formal

Type of Component Under Evaluation *Type of components that can be evaluated with that method. It can be more than one type. (Dimension 3)*
 Hardware, Model, Software

Evaluation Stage *The evaluation stage where the method is used. (Dimension 5)*
 Acceptance testing, System testing, Integration testing, Unit testing, Detail Design

Purpose of the Component Under Evaluation *The type of purpose that can be evaluated by a method. It can be more than one type. (Dimension 6)*
 Thinking, Acting, Sensing

Type of Requirement Under Evaluation *The type of requirements that a method is able to evaluate. It can be more than one type. (Dimension 7)*
 Non-Functional - Safety, Functional

Evaluation Performance Indicator *The type of evaluation criteria or KPI that a method is able to improve. It can be more than one type. (Dimension 8)*
 V&V process criteria, SCP criteria

Figure 3.4 Method example – framework dimension data

Relationships to other elements in the repository can be added and edited in a third field group, as can be seen in Figure 3.5. Figure 3.6 shows an example of the visual representation of the relations.

Add Method

Type for Evaluation Methods entries

Default Method Dimensions Relations Ownership

Related Methods *A method could be related to other methods.*
 Current path: [Home](#) / method ★ Favorites ▾

Tools *A method can use zero or more tools.*
 Current path: [Home](#) / method ★ Favorites ▾

Part Method *A method (when it is a combination: Combination of method artefact that is a specialization of a V&V Method) could be composed of a set of V&V Methods.*
 Current path: [Home](#) / method ★ Favorites ▾

Test Case or Verification and Validation activity *Test Case or V&V activity performed in a Use Case. We will link to the method to the test cases where the method is used.*
 Current path: [Home](#) / method ★ Favorites ▾

Standards *A method can be linked with standards.*
 Current path: [Home](#) / method ★ Favorites ▾

Context
 Current path: [Home](#) / method ★ Favorites ▾

Workflow
 Current path: [Home](#) / method ★ Favorites ▾

Save Cancel

Figure 3.5 Method entry dialog – relations

Related Methods *A method could be related to other methods.*

- ✚ **Intrusion Detection for WSN based on WPM State Estimation**
- ✚ **Wireless interface network security assessment**
- ✚ **Simulation-based Attack Injection at System-level** Simulation-based Attack Injection at System-level provides an opportunity of injecting attacks on the system level. Different parts of the system and its interconnections can be verified and validated by using this technique. The complete system behaviour can be analysed when a certain sub-system is under the influence of attacks. While conducting field tests could be costly and sometimes life-threatening, simulation-based tests provide a wide range of advantages, such as lower testing costs, adaptation of tests to a variety of traffic scenarios, and avoiding the life-threatening situations. This method could span over various tools such as SUMO (Simulation of Urban Mobility), VEINS (vehicular network simulator) and INET allowing different aspects of the system to be evaluated.

Tools *A method can use zero or more tools.*

- ✚ **MODIFI** The MODIFI (MODeI-Implemented Fault- and attack Injection) tool supports model-implemented fault- and attack injection methods within the MATLAB/Simulink environment allowing the impact of faults and cybersecurity attacks on target systems to be evaluated at early development phases.

Part Method *A method (when it is a combination: Combination of method artefact that is a specialization of a V&V Method) could be composed of a set of V&V Methods.*

Test Case or Verification and Validation activity *Test Case or V&V activity performed in a Use Case. We will link to the method to the test cases where the method is used.*

Standards *A method can be linked with standards.*

- ✚ **ISO/SAE 21434** Automotive Cybersecurity.

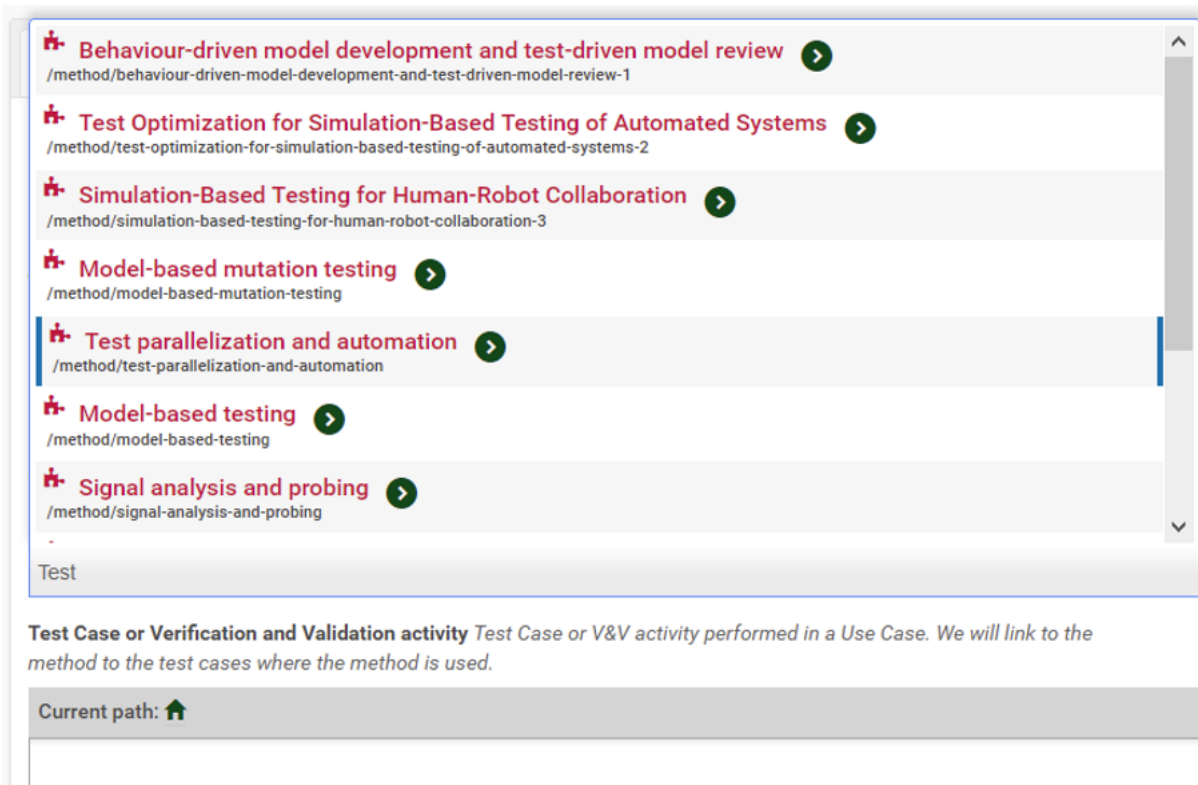
Context

Workflow

- ✚ **Model-Implemented Fault/Attack Injection with Pre-Injection Analysis (MIFI_MIAI)**

Figure 3.6 Method example – relations

The relation target element can be selected from a list that is dynamically filled with the search results for a given search string. Figure 3.7 shows an example from the current content of the repository, using the search term “Test”.



Test Case or Verification and Validation activity *Test Case or V&V activity performed in a Use Case. We will link to the method to the test cases where the method is used.*

Current path: 🏠

Figure 3.7 Method relation target selection with search function



An initial version of a filter-based search feature for methods is available – it allows to filter methods depending on the given values for the framework dimensions. Figure 3.8 shows an example search.

The screenshot displays a search interface with the following components:

- Alphabetic search:** A search bar with 'All' selected and letters A through Z. The letter 'A' is highlighted in orange.
- Table of Results:**

Title	Creator	Type	Last modified
Theorem Proving and SMT Solving	NUIM Partner	Method	Mar 15, 2021 03:46 PM
Deductive Verification	NUIM Partner	Method	Mar 15, 2021 03:45 PM
Behaviour-driven formal model development	AIT Partner	Method	Mar 17, 2021 06:43 PM
V&V of machine learning-based systems using simulators	INFOTIV Partner	Method	Mar 18, 2021 01:03 PM
Fault-Injection in FPGAs	KTH Partner	Method	Mar 16, 2021 02:03 PM
Dynamic Analysis of Concurrent Programs	BUT Partner	Method	Mar 16, 2021 09:09 AM
Source Code Static Analysis	BUT Partner	Method	Mar 16, 2021 09:07 AM
Model-Based Formal Specification and Verification of Robotic Systems	ESOGU Partner	Method	Mar 22, 2021 11:13 AM
- Filters (Right Side):**
 - Evaluation Environment Dimension:** Includes checkboxes for 'Closed evaluation environment', 'In-the-lab environment' (checked), and 'Open evaluation environment'.
 - Evaluation Type Dimension:** Includes checkboxes for 'Analytical - Formal' and 'Experimental - Monitoring'.
 - Evaluation Stage Dimension:** Includes checkboxes for 'Implementation' and 'Integration testing'.
 - Evaluation performance indicator Dimension:** Includes checkboxes for 'SCP criteria' (checked) and 'V&V process criteria'.
 - Purpose of the component under evaluation Dimension:** Includes a checkbox for 'Acting'.

Figure 3.8 Filter-based search for methods

Regarding both content structure and functionality, the repository fulfils the specified requirements but not all relationships are covered yet. Because of the structure of Plone Dexterity content types, where a relation is a one-directional cross-reference from one element to another, it is complex to allow editing of such a relation from both ends. To at least display the relationship on both ends, further customization of the Plone CMS would be necessary.

Moreover, an open task is visually optimizing the representation of the content. Currently, most parts are displayed using Plone’s default representation. Because of Plone’s nature as a CMS, visual representation and content can be easily modified separately – therefore we focused on functionality and content structure for this version of the repository. Minimal customization of the views was performed to ensure consistency of the repository with the VALU3S project’s visual identity, colour schemes and logo.

3.2 Use Case Content Types Design

In order to store the information about the use cases, the data structure defined in the VALU3S framework [1] has been created in the server using Plone [13] Dexterity content types. Also, a folder called 'Use Cases' has been created where the data of the different use cases is stored. The following content types have been created:

1. Use Case
2. Evaluation Scenario
3. Requirement
4. Test Case
5. Organization

Each use case can be linked to its owner organisation and participants. Use cases are composed of several evaluation scenarios. The evaluation scenarios are defined by the requirements it allows to analyse/validate, and the requirements are validated by test cases. Finally, the test cases will have a link to the VALU3S V&V method used in the validation of the requirement. In Figure 3.9, the data types created in Plone regarding VALU3S framework use cases are displayed. Figure 3.9 lists the created content types that are related to use cases.






<input type="checkbox"/>	 Use Case	The purpose of this type of data is to collect information on use cases: Test cases, Components under test and etc. This type of data is defined as a container, so each test case will be placed within a use case. Each Use Case will be described using a name, a description and a number. The Use Case will be associated with a domain, as well as a set of components, a set of companies or partners (an owner and contributors) and a set of evaluation activities performed in the context of the Use Case and the standards that are relevant for this Use Case	13
<input type="checkbox"/>	 Organization	Each of the partners is described using a name and an acronym. The reference to the Use Case that they participate or own is also described. The following properties must be specified: - Name: The name of the organization. - Acronym: The acronym of the partner.	35
<input type="checkbox"/>	 Test Case	A test case or verification & validation activity have an Id, textual description and testability conditions. It is associated to a set of components under evaluation, the requirements to be evaluated, the evaluation criteria used to measure the success of this activity and the context (and environment). This activity is performed using a method defined in the framework. For defining the properties and relationships of the Test Case or Verification & Validation Artefact, the test case template of Task 1.2 has been used and extended	25
<input type="checkbox"/>	 Evaluation Scenario	An Evaluation Scenario is described using an Identifier (Id), name, description, rationale/risk and limitation. The Evaluation Scenario will be associated with the Use Case, the requirements and the Components Under Evaluation that will evaluate. For defining the properties and relationships of the Evaluation Scenario Artefact, the properties used in D1.1 [20] has been taken as input and they have been extended.	15
<input type="checkbox"/>	 Requirement	Each requirement that is evaluated must be described with an id and a description, and with references to the evaluation scenario, the Test case or Verification & Validation activity where it is evaluated and the type of requirement. Two types of requirements could be distinguished: • Product requirements describing properties of a system or product. • Process requirements describing activities to be performed by the developing organization. For instance, process requirements could specify the methodologies that must be followed, and constraints that the organization must obey. This could be linked to standards.	30

Figure 3.9 Use Cases related Content Types

The different types are defined by their fields and field groupings. Figure 3.10 shows the fields of a Requirement content type. Links to other content types can be also defined for each content type. Figure 3.11 shows the link field to Test Cases of a Requirement.

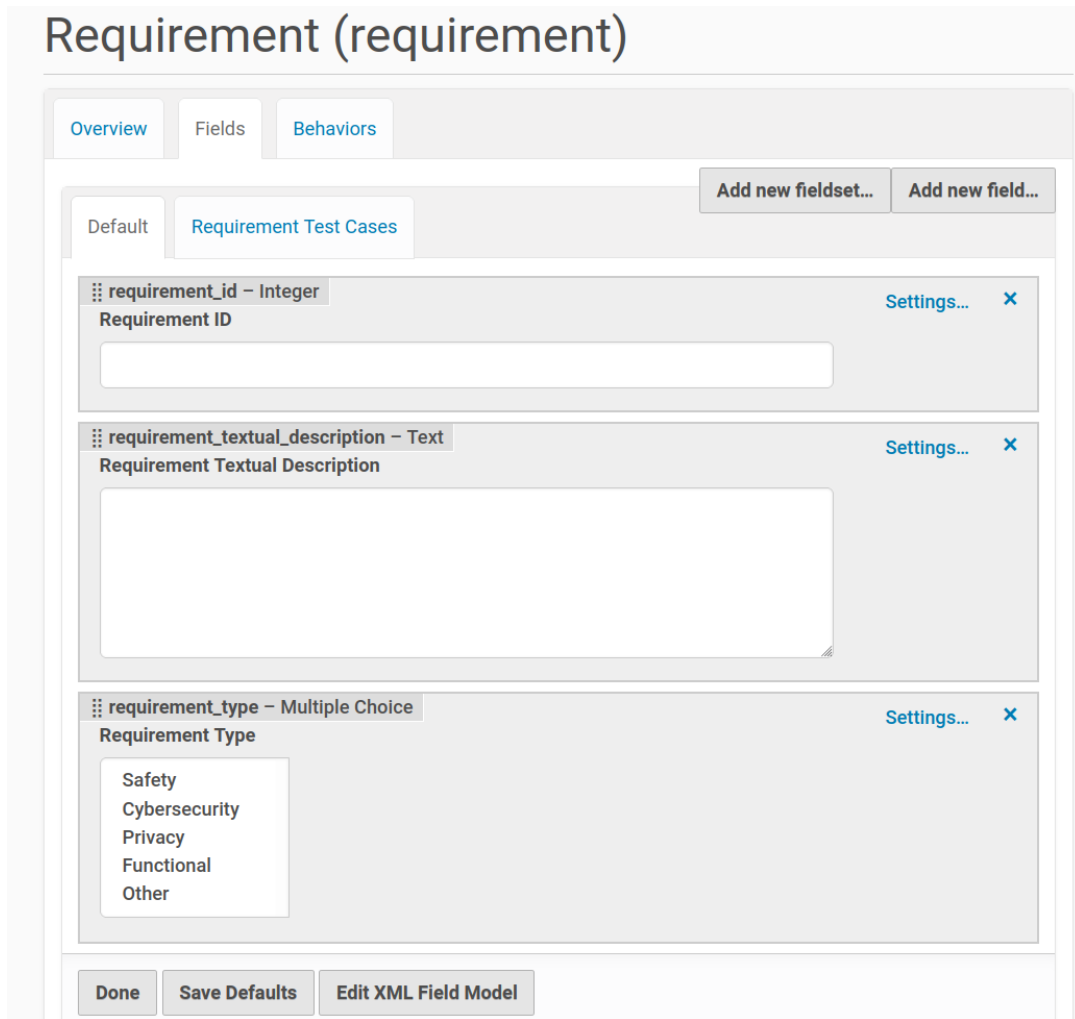


Figure 3.10 Requirement Dexterity type design. Default fields.

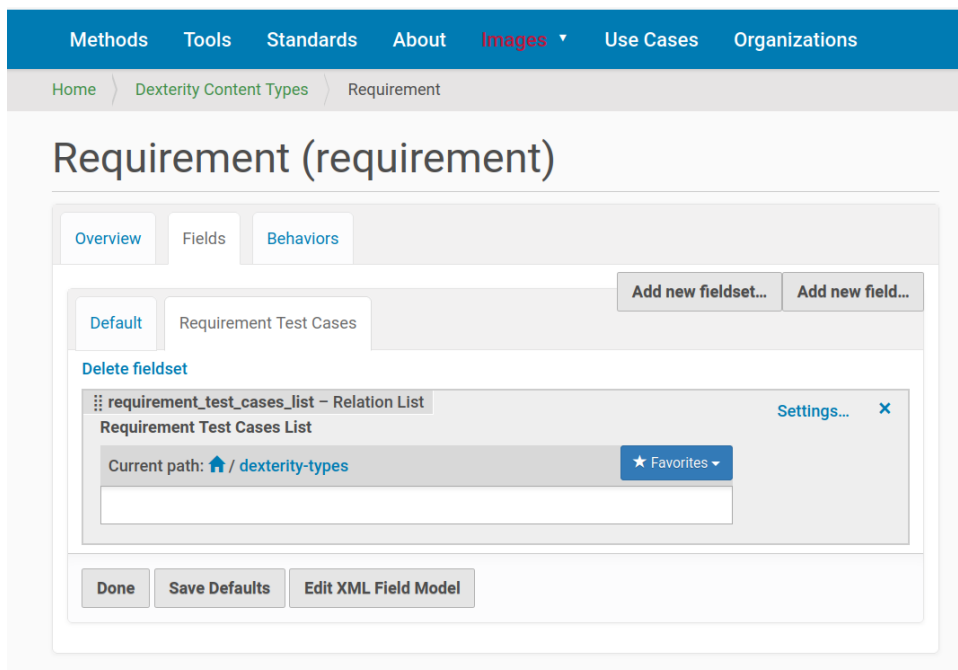


Figure 3.11 Field of relation to test cases of Requirements



3.2.1 Creation of Use Cases Data

To create the use case information, it is required to navigate to the Use Cases folder. Once located in the folder, a use case can be added via the context menu 'Add New'. Once located in the folder, a use case can be added via the 'Add context' menu. Then the fields are filled in. Once the fields have been added to the use case, an evaluation scenario is added via the context menu 'Add New'. Finally, the link to the evaluation scenario is added to the use case Evaluation scenarios list field. And this will be done with all the hierarchy that make up the data structure of the usage charges. Figure 3.12 shows the initial page of the use case folder. Figure 3.13 and Figure 3.14 show examples of use cases. Finally, Figure 3.15 shows the use case editing window that allows to relate the use case with the different evaluation scenarios.

Title	Creator	Type	Last modified
UC12 - Tool Knee Arthroplasty navigation system	ALDAKIN Partner	Use Case	Mar 22, 2021 11:21 PM
UC 9 - Autonomous train operations	ALDAKIN Partner	Use Case	Mar 22, 2021 11:23 PM
UC 6 - Agriculture robot (lawn mower)	ALDAKIN Partner	Use Case	Mar 22, 2021 11:24 PM
UC3 - Radar System for ADAS	ALDAKIN Partner	Use Case	Mar 22, 2021 11:24 PM

Figure 3.12 View of the list of created use cases

Methods Tools Standards About Images Use Cases Organizations

Home Use Cases UC2 - Car Teleoperation

UC2 - Car Teleoperation

by ROBO Partner – last modified 6 hours ago

Roboauto's main focus in VALU3S framework within the car teleoperation use case will be on safety of transmission line and on the routers. In cooperation with our partners we derived evaluation scenarios from these 2 areas, and plan to verify them on both simulator (our laboratory vehicle -Breach mobile robotic platform), and open environment vehicle (car or towing vehicle).

Use Case Number
UC2

Use Case Domain Use Case target domain
Automotive

Use Case Provider

- **Roboauto s.r.o.** Roboauto develops and integrates comprehensive remote control for a wide range of industrial vehicles. It provides teleoperation for any industry and any vehicle, be it a submarine or an excavator.

Partners

- **RISE Research Institutes of Sweden**
- **Brno University of Technology** (Faculty of Information Technology, Czech republic) with expertise (among others) in automated analysis and verification
- **Fraunhofer IESE** The Fraunhofer IESE is an applied research institute in the area of software and systems engineering. The institute develops innovative solutions for the design and validation of dependable digital ecosystems in the domains of

Figure 3.13 Visualisation of use case number 2: Part 1

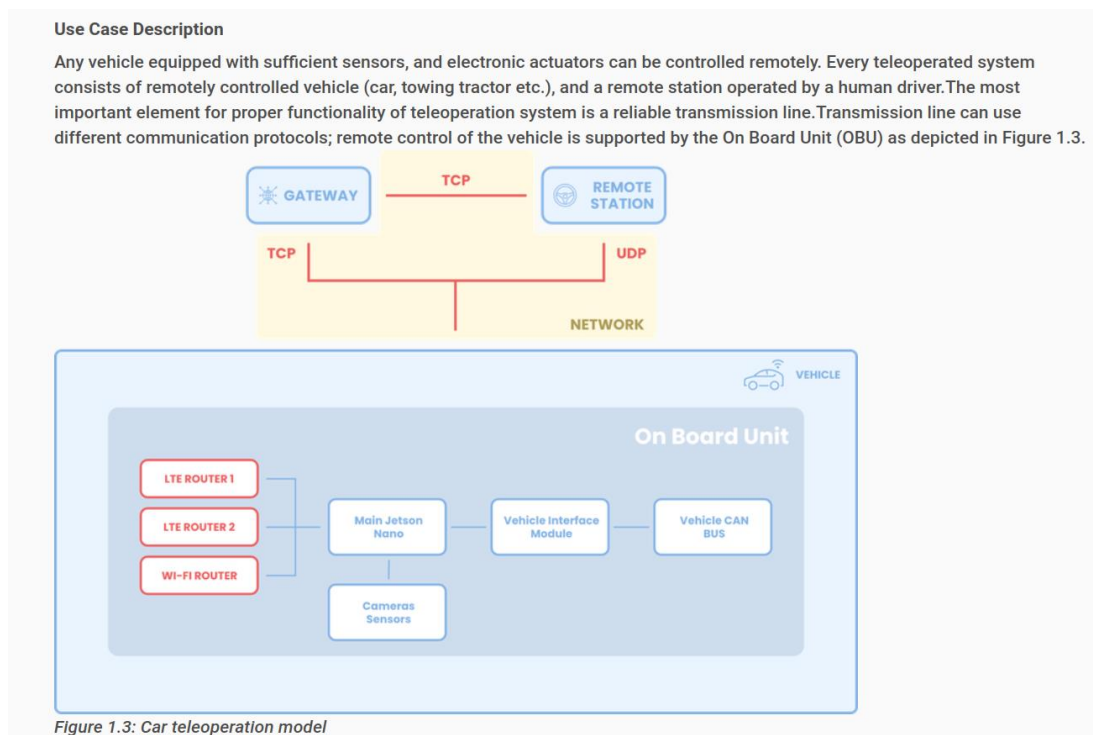


Figure 1.3: Car teleoperation model

Figure 3.14 Visualisation of use case number 2: Part 2

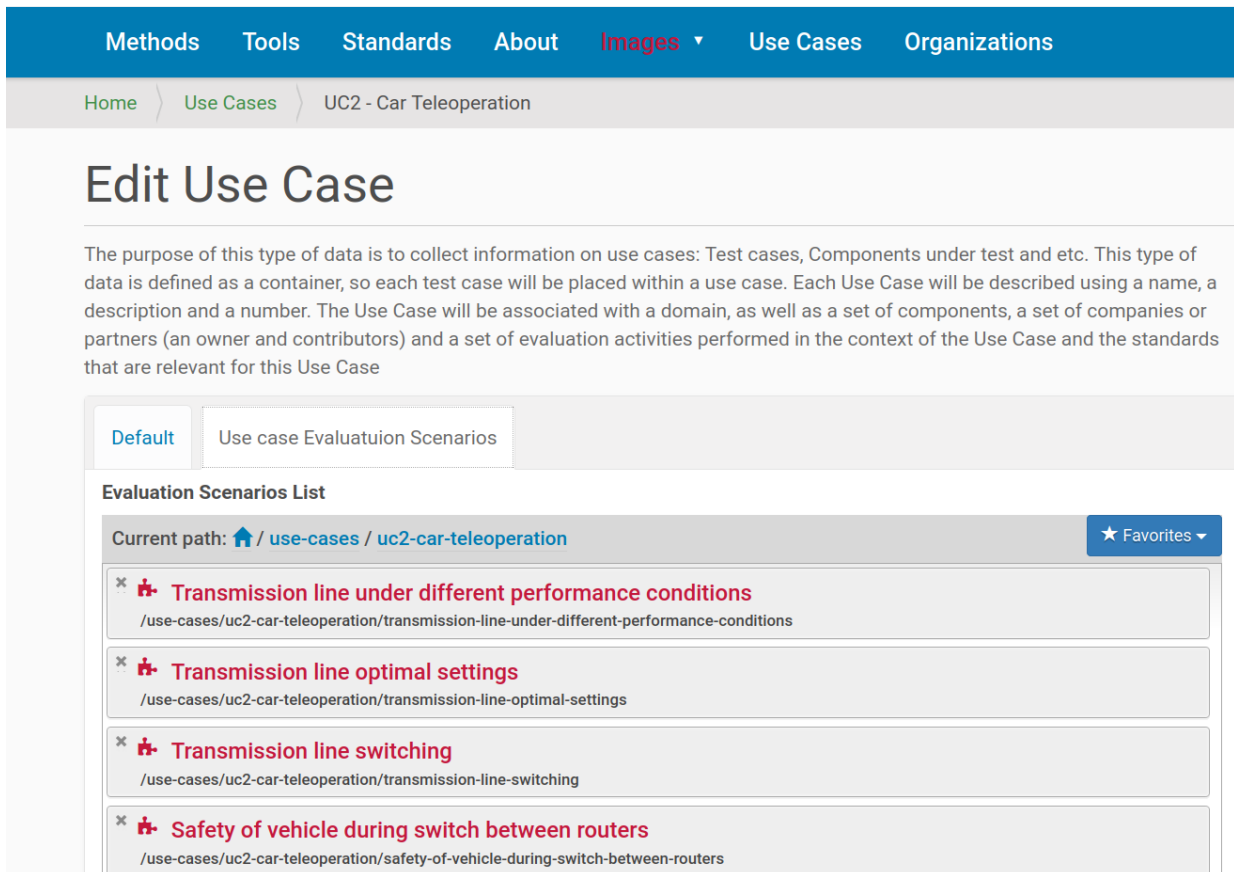


Figure 3.15 Use case 2 evaluation scenario list editing view

3.3 V&V Tools Content Types Design

One of the objectives of the VALU3S project is to develop and improve V&V tools and evaluation criteria. This objective is partially covered in WP4 - *Implementation of tailored Verification and Validation process workflows and tools*. This WP has the aim to design and implement a set of process workflows with tools for continuous simulated V&V of software systems architectural design and implementation. One of the tasks of WP4 has been to update the web-based repository with the data of the V&V tools developed, improved, or used as a support for the implementation of the workflows designed during the VALU3S project. The web content types that permit uploading V&V tools information are described in this section.

The tools are distinguished in two classes in the repository: *“Improved/Developed Tools”* and *“Supporting Tools”*. The *“Improved/Developed Tools”* folder contains the tools presented in D4.9 [14], which are the V&V tools that have been developed or improved by project partners during the project according to the use cases’ needs. The *“Supporting Tools”* folder contains the tools presented in D4.10 [15], which are the external tools improved/newly developed ones are based on, or the external tools that are used as a support in the improved process workflows. The main steps followed to insert or update the information about the V&V tools in the web-based repository are different for the two mentioned tool classes: *“Supporting Tools”* and *“Improved/Developed Tools”*.

3.3.1 Supporting Tool Content type

The supporting tools are the ones that have not been developed or improved under the VALU3S but are used or required in a V&V toolchain or Workflow, or they are technically needed by the *Improved/Developed Tools*. The web content created to store the information of a supporting tool is composed of 6 fields. The purpose of this type of content is to have the minimum information about the tool used. In the following list are the fields of the content type:

1. Tool title.
2. Text indicating the owner of the tool.
3. Tool description. This field is of the rich text.
4. A list of VALU3S partners who are using the tool.
5. Logo of the tool.

The steps that should be followed for the insertion of the “*Supporting Tools*” on the web-based repository are the following:

1. Visit the repository (<https://repo.valu3s.eu/> ; Figure 3.16) and log in (Figure 3.17).
2. Go to the “Tools” tab and select the “Supporting tools” folder (Figure 3.18).
3. Add a new supporting tool (Figure 3.19).
4. Add the following information: Title, Summary (optional), Logo (optional), Owner, Link to the tool (optional), Contributing partner (optional) and Tool description.
5. Save your changes.
6. The new supporting tool will appear as in Figure 3.20.

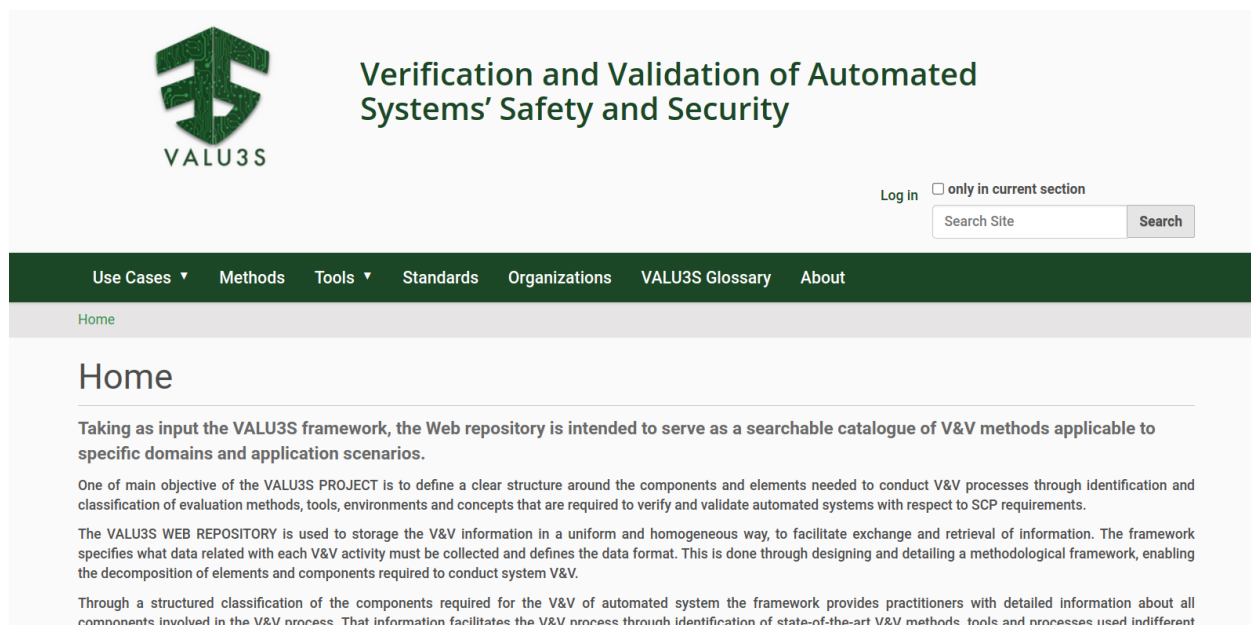


Figure 3.16: Homepage of VALU3S web-based repository



Updated/redesigned web-based repository with respect to the feedbacks obtained from D3.3, D3.7, D4.12 and D5.7

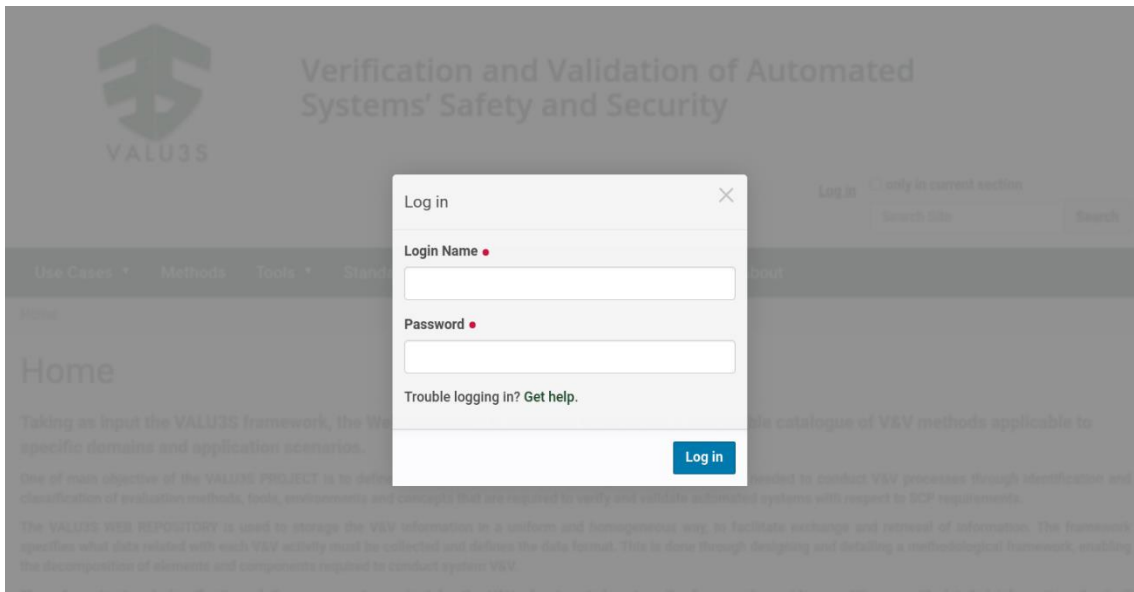


Figure 3.17: User login into VALU3S web-based repository



Figure 3.18: Selection of the proper folder in the "Tools" tab

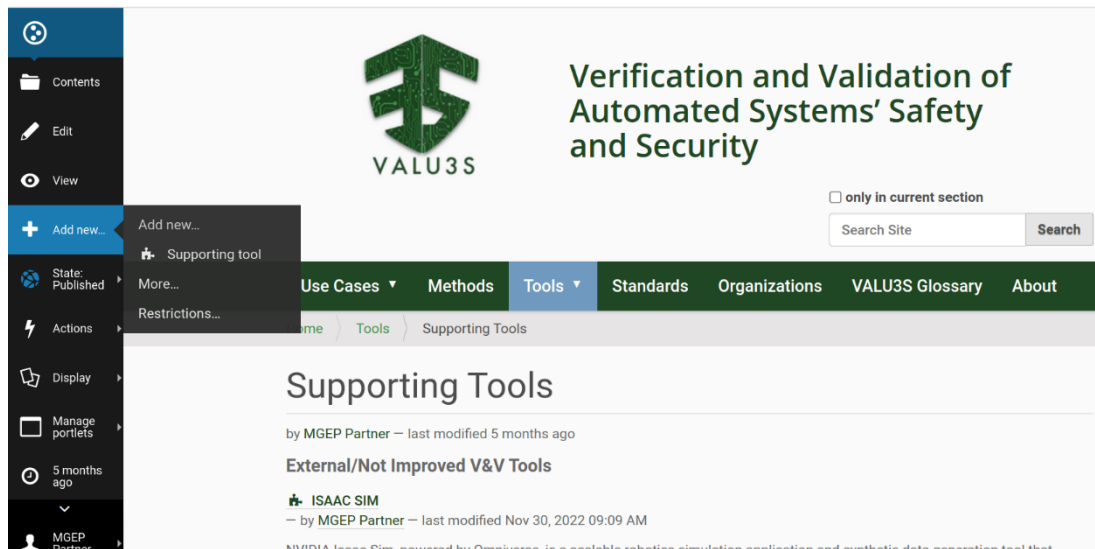


Figure 3.19: Addition of a new "Supporting tool"

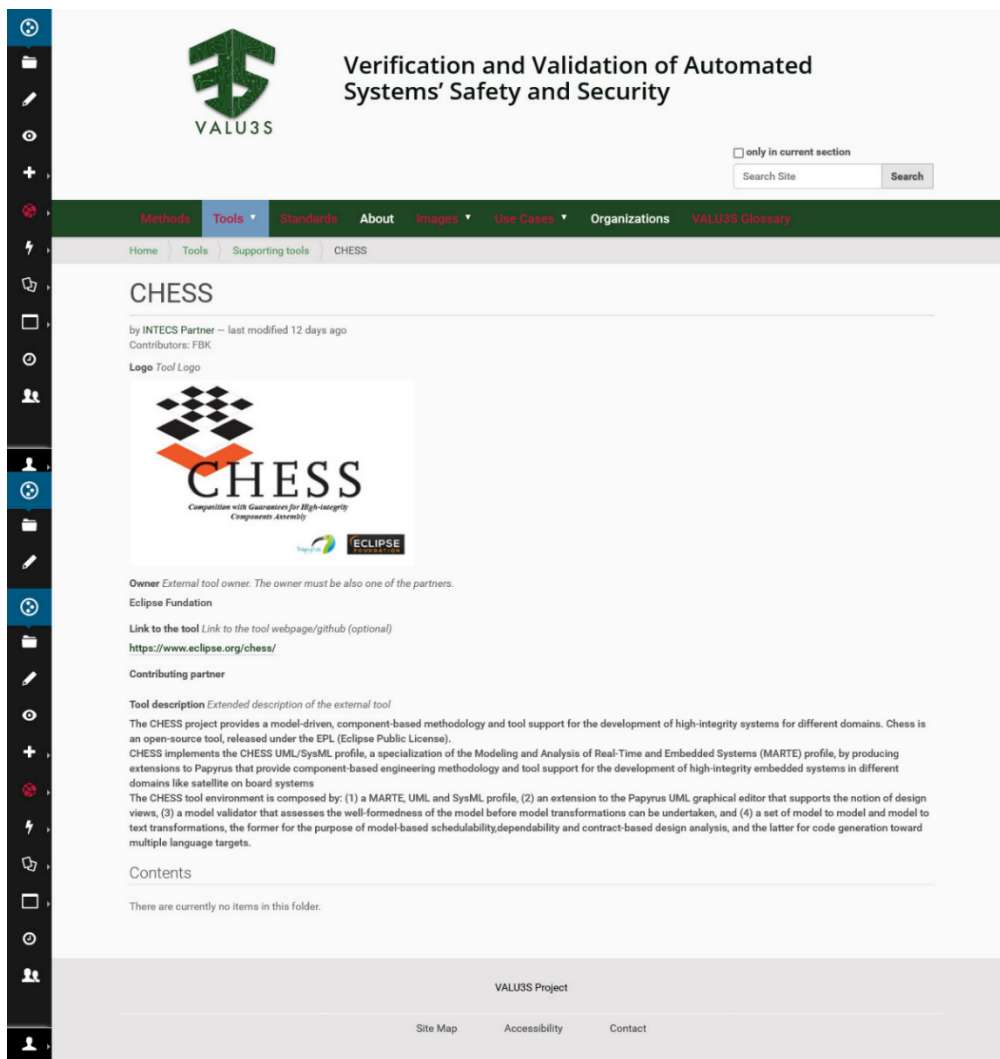


Figure 3.20: "Supporting Tool" appearance on the web-based repository



3.3.2 Improved/Developed Tool Content Type

To store the information of the tools developed and/or improved in the VALU3S project, a web content type called "Improved/Developed Tool" has been created. This content type has 4 field sets: 1) Main properties, 2) Relationships with other repo elements, 3) Improvement classification and 4) Open Source-Goals. In the next list, all the fields of the content type are summarized:

1. Main properties
 - a. Tool Title.
 - b. Logo.
 - c. Link to website/GitHub (URL) with more detailed information.
 - d. Tool developer/owner.
 - e. Tool partners. Non-owner organizations associated with the tool (partners/distributors).
 - f. A choice field to indicate if the tool is new or improved.
 - g. A rich text for tool description.
 - h. A relational list to specify technical connection of the tool with its supporting tools.
 - i. Improvement/Implementation date.
 - j. New improvements (To be filled in the future).
 - k. References (Related papers, journals, articles).
2. Relationships with other repo elements
 - a. Related V&V methods (A tool could be based on several V&V methods).
 - b. A relational list to standards.
 - c. A relational list that links the tool with VALU3S use cases.
 - d. A list that specifies connections to other Improved/Developed tools. Functional connection of tools for the implementation of a specific evaluation scenario/workflow.
3. Improvement classification
 - a. A multiple-choice field to specify the Evaluation criteria for Safety, Cybersecurity and Privacy that can be validated or improved using the tool.
 - b. A multiple-choice field to specify the Evaluation criteria for V&V Process that is improved using this tool.
4. Open Source-Goals
 - a. A field to specify if the tools is open source or not.
 - b. A field to specify if the tool is used to Validate Non-Functional Requirements (SCP) or functional requirements.

The steps that should be followed for the insertion of the "*Improved/Developed Tools*" on the web-based repository are the following:

1. Same as Section 2.1: visit the repository and log in.
2. Go to the "Tools" tab and select the "Improved/Developed Tools" folder (Figure 3.18).
3. Add a new improved/developed tool (Figure 3.19).
4. Add the required information in the "Default" tab:
 - a. Title, Summary (optional), Logo (optional), Main partner/Developer, Tool link (optional), Tool contributing partners (optional, if the tool has been developed with

- other VALU3S partners), Tool description, Improvements description and References (optional).
- b. Select if it is a newly developed tool or an improved one.
 - c. Specify if there is a technical toolchain(s).
 - i. A “Technical toolchain” is a connection between two tools in which one of them (in the VALU3S specific case it is the improved/developed tool) requires the installation of the other (typically the supporting tool, in VALU3S specific case) in order to be run. An example of technical toolchain is the relation between a plug-in and its core tool.
5. Add the required information in the “Relationships with other web-repo artefacts” tab:
 - a. Connect the tools to the other artefact(s) present on the web-repo: methods, standards, other tools connected in a Functional toolchain, use cases.
 6. Add the required information in the “Improvement Classification” tab:
 - a. Map the improvements of this new improved/developed tool on the evaluation criteria defined in the VALU3S project.
 - i. For selecting more than one criterion, press Ctrl and click with your mouse.
 7. Add the required information in the “Open Source - goals” tab:
 - a. Select if this tool is open source or not and which goal(s) it satisfies.
 - i. To select more than one goal, press Ctrl and click with your mouse.
 8. Save your changes.

3.4 V&V workflow Content Type

A content type has been also created to specify V&V workflows used in the different evaluation scenarios. The workflows must be added to each of the use cases under the workflows folder, and can be directly linked to the method they support. There is a view to list all the workflows under the main use cases folder. A workflow is specified in the web-based repository with the next fields:

1. Title.
2. Workflow description.
3. Workflow figure.
4. Workflow model file. An XML file containing the VVML model defining the workflow.



3.5 Demonstrator Results Content Types Design

In coordination with WP5, and in the scope of deliverable D5.7 - *Upload of Evaluation Results to the Web Repository* [5], a set of new content types were created in the web-based repository. Following the conceptual separation of result types described in deliverable D5.6 - *Evaluation report including the evaluation of the improved V&V processes as well as framework limitations* [16], this section firstly describes the data types and upload instructions created for quantitative results, which deal with the concrete V&V process and SCP improvements obtained in the different use cases throughout the project. Then, the content types and upload instructions of qualitative results are described, with these corresponding to the results acquired through use case and demonstrator-based questionnaires that assessed the perceived usefulness of the methods and tools collected and defined within VALU3S.

3.5.1 Quantitative Results

Quantitative results refer to the measurable improvements in V&V workflows and SCP-related criteria fulfilment as assessed by partners through their demonstrators. As built demonstrators provide a platform to run tests and measure project driven improvements in these evaluation criteria, appropriate Plone dexterity types were defined to house their description in the web-based repository.

The following subsections describe those data types created and present the upload instructions shared with partners to populate the repository with quantitative results related data.

3.5.1.1 Demonstrator Evaluation Result

Demonstrator Evaluation Result provides a description of Demonstrators created by each use case and lists the various V&V and SCP that are associated with it.

The data type contains the fields described in Table 3.1.

Table 3.1: Fields defined for the dexterity type Demonstrator Evaluation Result

Field Name	Type	Description
ID	String	Unique identifier of demonstrator.
Short description	Text	Description of demonstrator purpose and implementation overview.
Responsible Contacts	Link	List of "Organization" instances on the repository that are responsible for the demonstrator.
Use Case	Choice<String>	Associated use case.
TRL	Number (1-9)	Technology Readiness Level of the demonstrator.
Transferability	Number (1-5)	5-point scale of transferability level (1=Very bad; 5=Very good).

Field Name	Type	Description
Transferability comment	Text	Further information about transferability evaluation.
Link to Use Case	Link	Link to use case instance on the repository.
Measurement of SCP improvement	Link	List of links to “Measurement of SCP Improvement” instances on the repository associated with this demonstrator.
Measurement of V&V process improvement	Link	List of links to “Measurement of V&V Process Improvement” instances on the repository associated with this demonstrator.

3.5.1.2 Measurement of V&V Process Improvement

This data type provides concrete measurements of V&V process-related evaluation and links these measurements with the use case’s test cases, requirements, and evaluation scenarios, as well as involved V&V methods and tools. A description field also allows the contextualization of measurement methodologies used.

It contains the fields presented in Table 3.2:

Table 3.2: Fields defined for the dexterity types Measurement of V&V Process Improvement and Measurement of SCP V&V Improvement

Field Name	Type	Description
Description	Text	Description of measurement methodology and context.
UC ID	Choice<String>	Associated Use Case
Test Cases	Link	List of “Test Case” instances on the repository that this measurement covers.
Requirements	Link	List of “Requirement” instances on the repository that this measurement covers.
Evaluation Scenarios	Link	List of “Evaluation Scenario” instances on the repository that this measurement covers.
V&V Methods	Link	List of “Method” instances on the repository that this measurement uses.
V&V Tools	Link	List of “Tool” instances on the repository that this measurement uses.
Eval_criteria	Choice<String>	Evaluation Criteria used in this measurement
Quantitative results	Text	Description of the formulas used to compute the criteria’s value.



Field Name	Type	Description
Long description	Text	Detailed description of how the criteria value was obtained, including the setup of various tests performed to obtain it.

3.5.1.3 Measurement of SCP V&V Improvement

This data type provides concrete measurements of SCP-related evaluation and links these measurements with the use case’s test cases, requirements, and evaluation scenarios, as well as involved V&V methods and tools. A description field also allows the contextualization of measurement methodologies used.

The data structure of this data type is identical to the Measurement of V&V Process Improvement, with the only difference being the set of evaluation criteria each can represent.

3.5.1.4 Upload Instructions

To successfully upload a set of results, partners had to follow this set of instructions:

1. Login into the VALU3S web-based repository and select “Demonstrator Results” on the “Use Cases” dropdown menu:

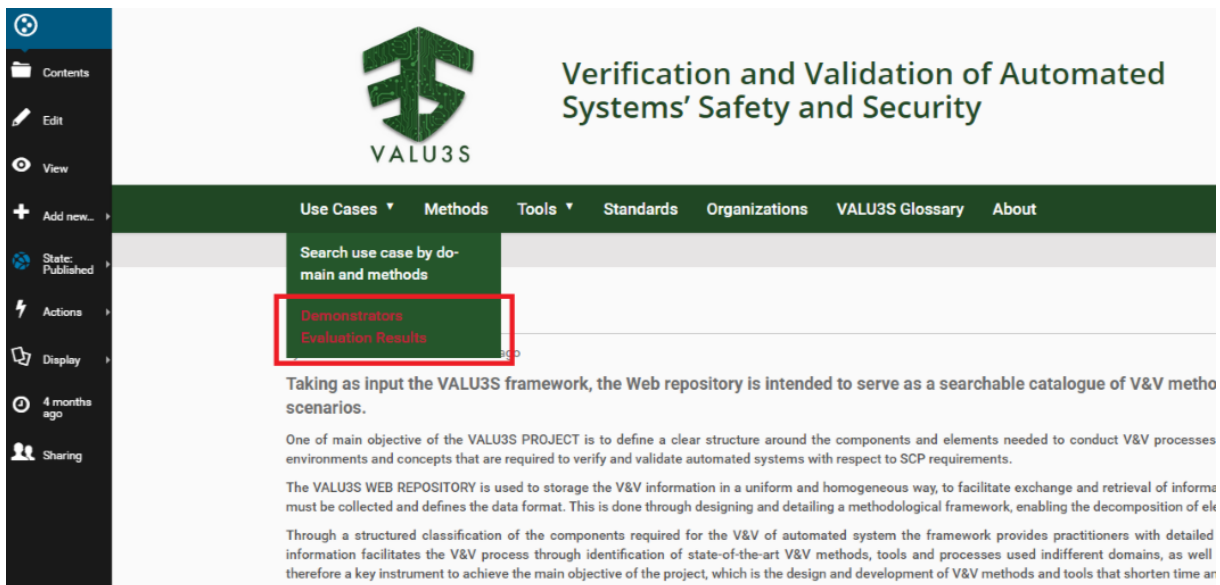


Figure 3.21: Where to find the Demonstrators Results tab

2. Select “add new” > “Demonstrator Evaluation Result”:

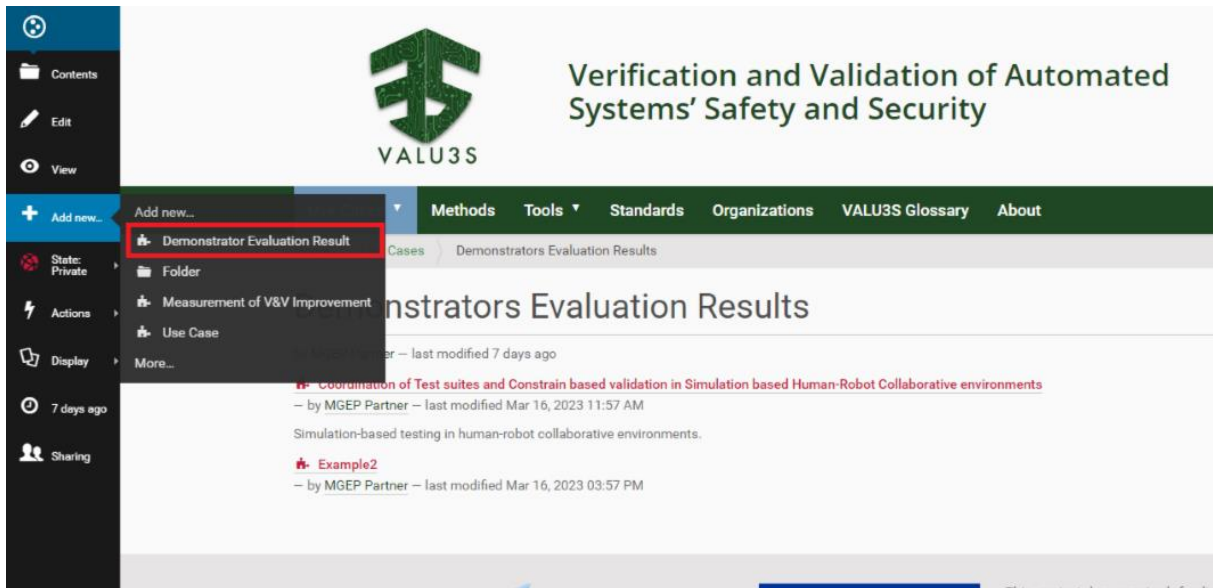


Figure 3.22: Create a new "Demonstrator Evaluation Result" item

3. Fill all information fields **except for the links** and save (base information on "Demonstrators" tab in WP5 progress monitoring excel sheet).

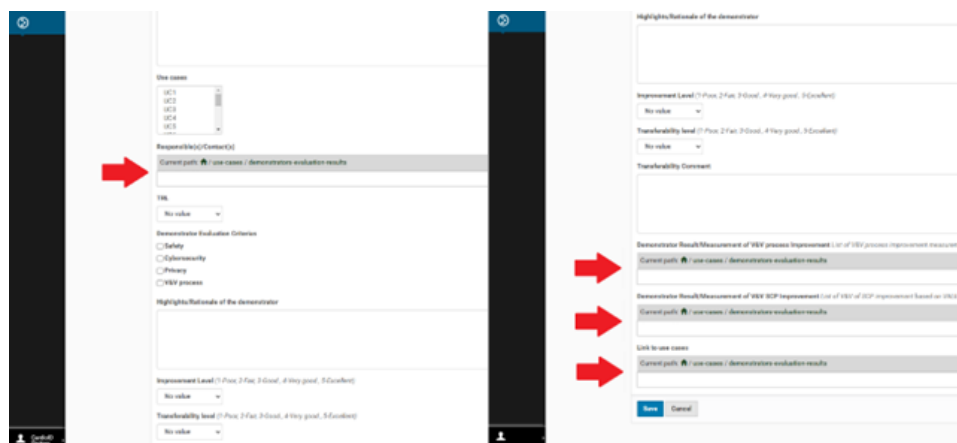


Figure 3.23: Link type fields that should not be filled yet

4. Inside the newly created "Demonstrator Evaluation Result" select "add new" > "Measurement of SCP V&V improvement":

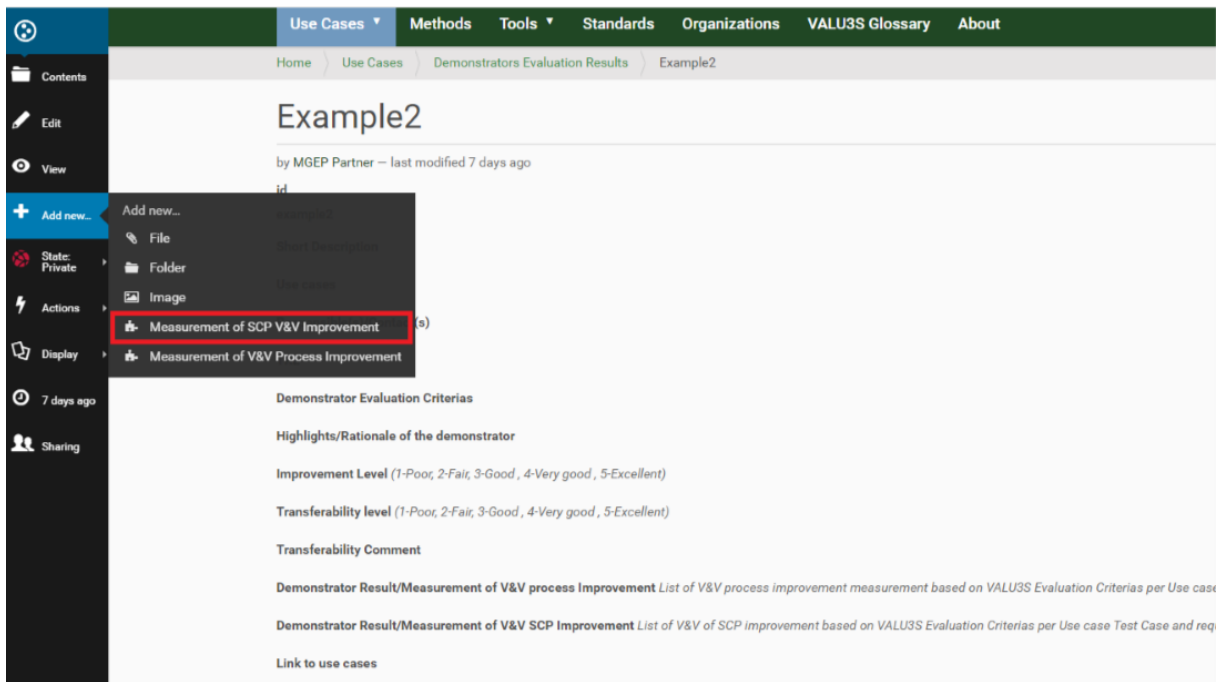


Figure 3.24: Create a new "Measurement of SCP V&V improvement" item

5. Fill all information fields **except for the links** and save (base information on "Mapping-3" of WP5 progress monitoring excel sheet).

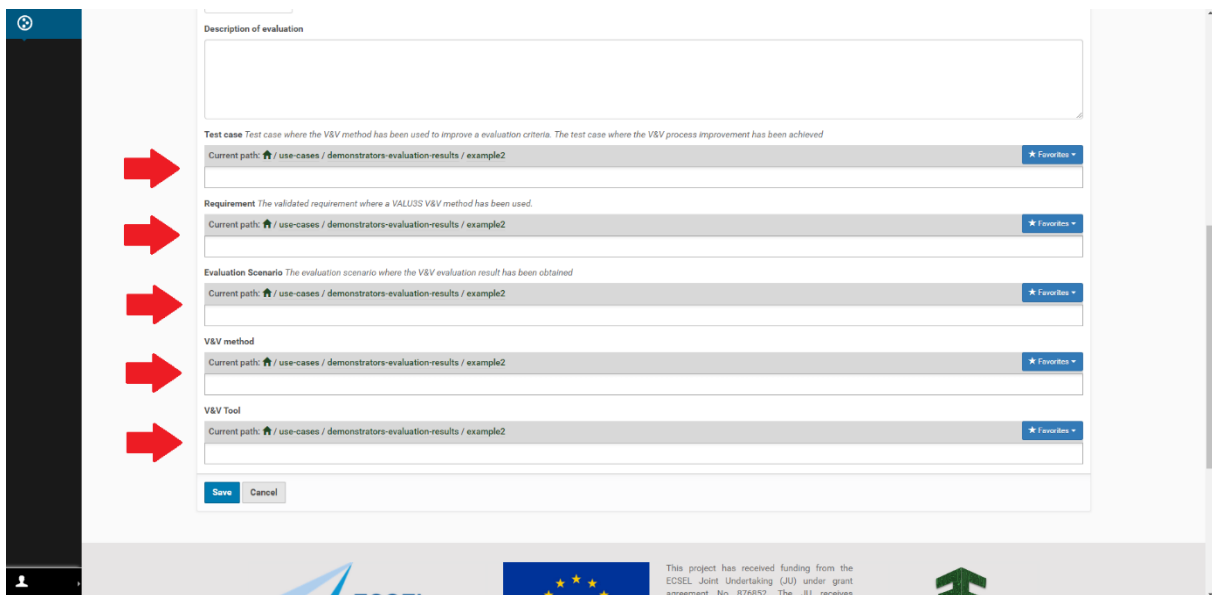


Figure 3.25: Link type fields that should not be filled yet

6. Inside the newly created "Measurement of SCP V&V improvement" select "Edit" and add the links (those marked in Figure 3.25; base information on links established through Mappings 1, 2, and 3 on the WP5 progress monitoring excel sheet).
7. Repeat 4 to 6 for all SCP evaluation results associated with the demonstrator.
8. Inside the created "Demonstrator Evaluation Result" select "add new" > "Measurement of SCP V&V improvement".

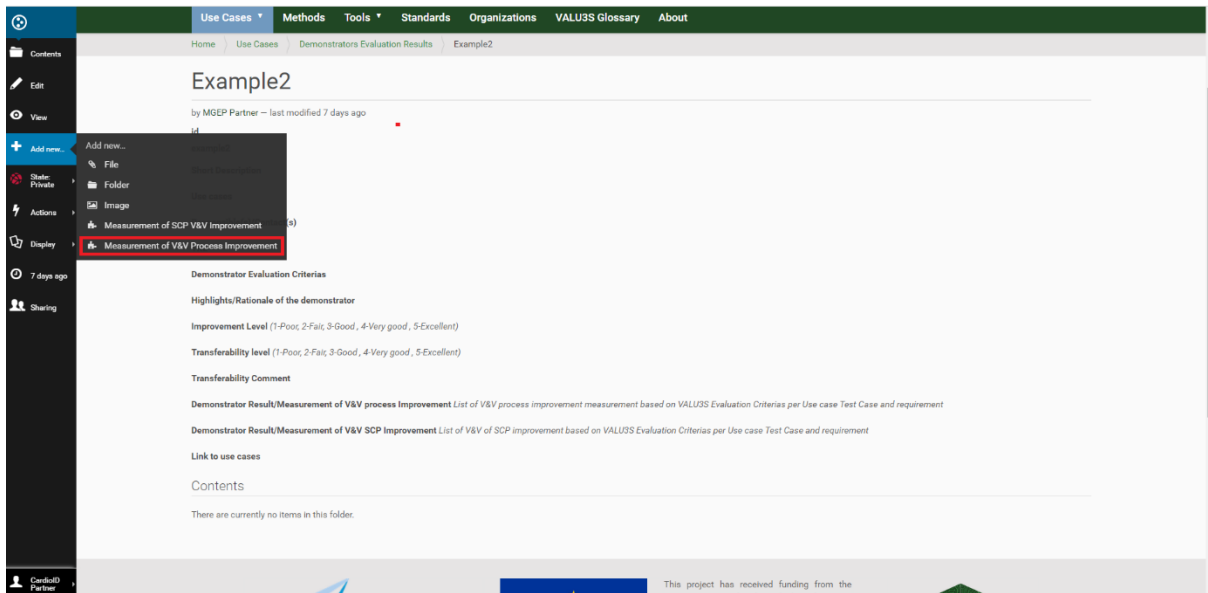


Figure 3.26: Create new "Measurement of V&V process improvement" item

9. Repeat 4 to 6 for all SCP evaluation results associated with the demonstrator.
10. Inside the created "Demonstrator Evaluation Result" select "Edit" and add the links to the Use Case, Responsible contacts, Measurement of V&V process improvements, and Measurement of SCP V&V improvements (those marked in Figure 3.23).

3.5.2 Qualitative Results

Qualitative results are described in D5.6 [16] and are produced through the analysis of questionnaires filled by consortium partners under task T5.3 - Demonstration/evaluation of framework usability. These questionnaires apply the proposed QAM (Quality Acceptance Model) and provide information on the perceived impact of the VALU3S framework in both users and organization viewpoint.

Given the highly structured format of these questionnaires analysis outputs, and their static nature (these results are computed only once from the set of collected responses), an image is used to represent the qualitative results.

This image is embedded in a qualitative results section in the demonstrator's description page. For that reason, no additional dexterity types are defined. Instead, a template was prepared, which is presented in Figure 3.27, which will be populated with each demonstrator's results.

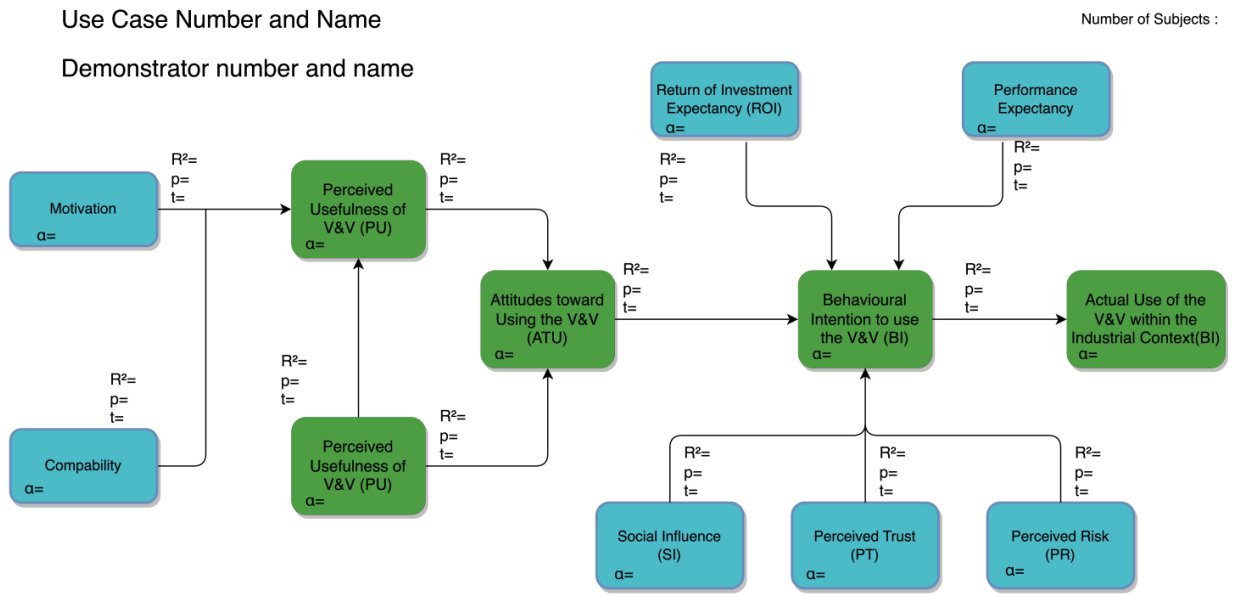


Figure 3.27: Proposed template image to present qualitative results for each demonstrator in the web-based repository

Chapter 4 Validation

D2.2 [1] defines the framework stakeholders and potential user types that may exist in the web-based repository. The potential users of the web-based repository are divided in two main groups: 1) VALU3S Project Members and 2) Community members. Community members are understood to be all those users who are not involved in the VALU3S project, but who are active in the domain of V&V of automated systems. The objective of defining the community stakeholder is to offer a public access to the VALU3S web-based repository. It was planned to make the repository public at the end of the project, but finally the repository was made public (<https://repo.valu3s.eu/>) on November 30, 2022. At that time, the repository contained information about use cases, methods and tools. At the conclusion of the project, it will also contain data on the results of the demonstrators.

All the VALU3S partners have login functionalities and are able to manage their own profile. In addition to the login functionality, users can perform actions grouped into the following four groups:

1. Characterize V&V method
2. Characterize V&V tool
3. Search and Compare V&V methods
4. Search and Compare V&V tools

Currently public access only allows reading the information in the repository. In order to add information about V&V tools and methods, it is required to be part of the VALU3S project. Figure 4.1 summarizes the framework and web-based repository use cases. In the future the idea is that community members will be able to perform the same actions as VALU3S project members, but there is a difference in use. When a public user adds information to the repository, for example a tool or a method, a revision process will be initiated that will eventually lead to the acceptance or rejection of the contribution. The acceptance process will be managed by a VALU3S project member. This scenario is defined in the 18th user story of the framework [1]. In the VALU3S project, a review process for public contributions has not yet been defined. Besides, this functionality will require some resources and financing in the future to be able to manage the public contributions. Due to all this, and also to speed up and not hinder the implementation of the web-based repository the review process will not be implemented. With the aim of having the possibility of adding it later, the function of reviewing contributions as a state property will be added to V&V Tool and Method elements. This attribute can have the following values: pending, accepted or rejected.

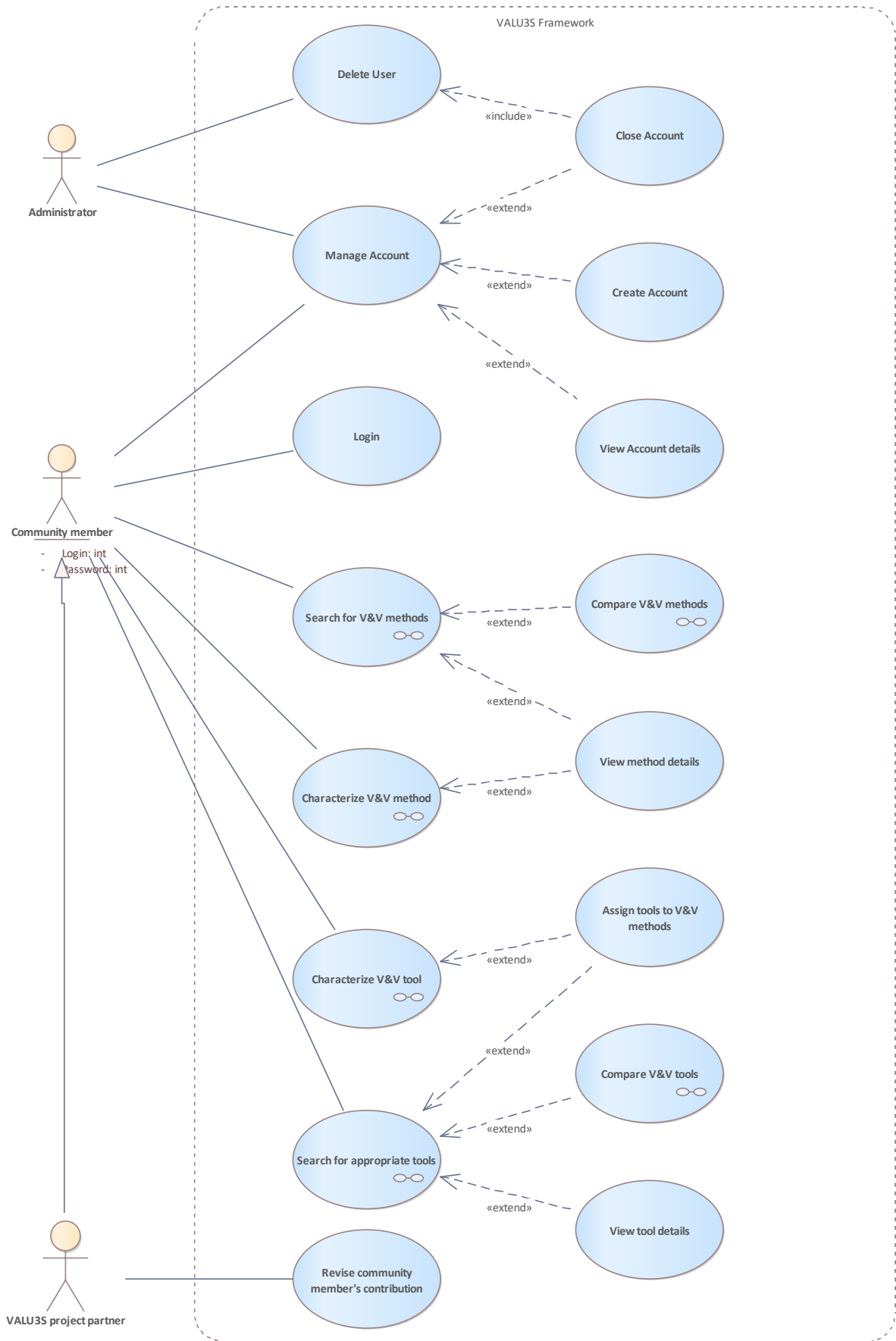


Figure 4.1 Use Case Diagram for framework User stories

To ensure the correctness and usability of the web-based repository the next testing activities were conducted:

1. review of the repository design,
2. exploratory testing,
3. data population sessions (done by different project partners), and
4. usability testing (planned to be performed by VALU3S 2023 Summer School students)

The review of the repository design was done at the early implementation phase with the focus on the data structures – it was verified that all the relevant data from WP1 – specifically deliverable D1.2 [17] , WP3 deliverable D3.1 [8] and WP4 deliverable D4.12 can be stored in the repository. Checks were also made that all the necessary relations between the stored data can be created. The repository has been used by project partners and populated with 13 use cases, 90 methods and 100 tools. Information about the evaluation results of the 15 demonstrators of WP5 are also being updated to the web-based repository at the time of writing this document. The table below describes, which repository functionalities were covered by which testing approach.

Table 4.1: Repository test coverage

Repository Use Case	Test Coverage (done by # of Partners)
Administrator – Manage account – create	Data population sessions (Partners with Administrator account)
Administrator – Manage account – view details	Data population sessions (Partners with Administrator account)
Administrator – Delete user – close account	Exploratory testing
Login	Exploratory testing Data population sessions (All Partners)
Search for V&V methods	Exploratory testing
Characterize V&V methods	Exploratory testing Data population sessions (All Partners)
View method details	Exploratory testing session Data population sessions (All Partners)
Compare V&V methods	None
Characterize V&V tools	Exploratory testing Data population sessions (All Partners)
View tool details	Exploratory testing session Data population sessions (All Partners)
Assign tools to V&V methods	Data population sessions (All partners)
Search for appropriate tools	Exploratory testing



Repository Use Case	Test Coverage (done by # of Partners)
Compare V&V tools	None
Characterize use cases	Repository design review Exploratory testing Data population sessions (All Partners)
View use case details (including evaluation scenarios)	Repository design review Exploratory testing Data population sessions (All Partners)
Characterize use case evaluation scenarios	Repository design review Exploratory testing Data population sessions (All Partners)
View detail of use case evaluation scenario (including use case requirements)	Repository design review Exploratory testing Data population sessions (All Partners)
Characterize use case requirements	Repository design review Exploratory testing Data population sessions (All Partners)
View detail of use case requirement (including test cases)	Repository design review Exploratory testing Data population sessions (All Partners)
Characterize use case test cases	Repository design review Exploratory testing Data population sessions (All Partners)
Assign test cases to V&V methods	Repository design review Exploratory testing Data population sessions (All Partners)
Revise community member's contribution	None, this use case is not implemented yet. It should, nevertheless, be covered by the existing mechanism for awaiting approval before publication.
Characterize demonstrator results	Repository design review (At the time the document was being written WP5 demonstrator results were not yet uploaded)

Updated/redesigned web-based repository with respect to the feedbacks obtained from D3.3,
D3.7, D4.12 and D5.7



The main objective of the web-based repository has been to host all the information related to the different V&V Workflows implemented during the VALU3S project. In order to define actions to improve the usability of the web-based repository new functionalities it is planned to perform a one-hour usability test with the students of the VALU3S Summer School that will be held in July 2023.

Chapter 5 Conclusion

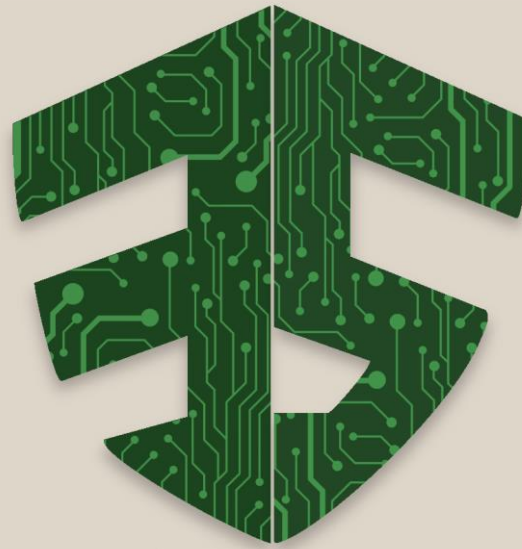
This document details the efforts undertaken in the context of WP2 to create a web-based repository intended for storing components of the VALU3S framework. The objective was to construct a repository that comprises a searchable catalogue of V&V methods that are relevant to specific domains and application scenarios. The software is now available for use and all partners have been granted institutional accounts. It has also been publicly launched in November 2022, during the 8th General Assembly held in Hamburg, and is considered to be a key exploitable result from the project.

The team progressed through an initial conceptualization phase, moving from user interface mock-ups to a web-based prototype, and ultimately to a functional version of the repository. Considerable effort was dedicated to ensuring that the project's requirements and design constraints, as described in earlier deliverables, were adhered to. To serve as the foundation for the repository, the Plone CMS was chosen and then customized by the team to meet the specific needs of the project. This process involved organizing the data and developing custom content types to store the outputs of all other work packages, which includes WP1, WP3, WP4 and WP5.

Throughout the project, data from various work packages was collected and added to the repository. In 2022, the repository was migrated to its permanent location and made available to the general public (<https://repo.valu3s.eu>). As of writing, the repository contains 13 use cases, 90 methods and 100 tools. Additionally, information regarding the evaluation results of the 15 demonstrators of WP5 will be added to the repository. At the time of writing, the mapping of WP5 results is ongoing and expected to be completed toward the end of the project.

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ECSEL Joint Undertaking
Electronic Components and Systems for European Leadership



This project has received funding from the ECSEL Joint Undertaking (JU) under grant agreement No 876852. The JU receives support from the European Union's Horizon 2020 research and innovation programme and Austria, Czech Republic, Germany, Ireland, Italy, Portugal, Spain, Sweden, Turkey.