Product Passport through Twinning of Circular Value Chains

Deliverable D4.1

Impact Assessment Methodology

WP4: Circular Process Industries Demonstration

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Executive Summary

This deliverable presents the work conducted in the scope of developing the evaluation methodology for the Plooto project by providing the evaluation approached used in the overall system as well as the impact that it will have on the pilots that it is applied on. In order to develop the evaluation framework, the theoretical underpinnings of the 5W1H methodology was utilized to develop the overarching evaluation approach and set the process of collaboration towards the creation of the evaluation methodology. Furthermore, work conducted in the scope of WP1, and reported in deliverables D1.1 “Plooto methodological approach and business cases specifications v1”, D1.3 “Sustainability Balanced Scorecard Framework v1” and D1.5 “CRIS Requirements and Specifications v1” was extended and updated to derive to the final KPIs at present time that are eligible to fully cover and assess the impact on all pilots and the system.

For Pilot 1 – CFRP Waste for Drones, the evaluation will take place through five (5) KPIs, for Pilot 2 – WEEE for Magnets, the evaluation will take place through four (4) KPIs, and for Pilot 3 – Citrus processing waste for juice by-products, the evaluation will take place through seven (7) KPIs, which will be monitored through the Plooto platform.

Furthermore, and relevant to the system evaluation of Plooto, both measurements-based and question-based approaches will be followed including evaluation on availability and reliability of the system as well as individual components evaluation through different metrics, evaluation of potential for certification, and end-user evaluations of learnability, usability, user experience, and a cumulative in-depth qualitative evaluation of the overall system through structured interviews.

The Plooto system will be evaluated in two rounds in each pilot with the first iteration (M19-M22) to uncover needs for improvement and status of success in pilot impacts and the second iteration (M31-M36), that will be utilized to evaluate the final integrated and deployed Plooto solution.

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Acronyms and Abbreviations

Acronym	Description
CFRP	Carbon Fiber reinforced polymer
COD	Chemical Oxygen Demand
CPWW	Citrus Peel Wastewater
CRIS	Circular and Resilient information System
DSR	Design Science Research
DT	Digital Twin
IS	Information System
KPI	Key Performance Indicator
SRM	Secondary Raw Materials
VN	Value Network
WEEE	Waste from Electrical and Electronic Equipment
WP	Work Package
5W1H	Who, What, When, Where, Why and How

1 Introduction

1.1 Purpose and Scope

The work conducted in WP1 presented a detailed exploration of the Plooto pilots, including a set of Key Performance Indicators (KPIs) as a result of their respective business needs and requirements. In that direction Plooto system will offer functionalities that cover a wide range of services by combining a number of modules that cooperate with the goal of solving the pilots' pains.

This deliverable focuses on the evaluation methodology to be used in the Plooto project to assess the application of the system on the pilot cases. The evaluation methodology revolves around three axes: (a) the pilot-specific KPIs, which are of quantitative nature, (b) the Plooto system performance, which are of quantitative and qualitative nature, and (c) the qualitative evaluation approach that complements the prior two, enabling a holistic evaluation approach.

In the first dimension, the evaluation KPIs are tailored to each pilot, which arises from the unique attributes of the different pilots' contexts, and in-turn influences how KPIs are defined in different contexts. This led to varied approaches for measuring KPIs, enabled by utilizing carefully chosen test scenarios that match the pilot environment. The selection of the scenarios takes into account the limitations of available pilot data and is influenced by the precise problem definitions and approach employed to tackle the specific challenges inherent in each case.

The second dimension focuses on the evaluation of the Plooto system as a whole, both on a technical as well as end-user perspective. As the different pilots employ different employee types in the production, their role is crucial in evaluating the developed system.

Lastly, the third dimension focuses on the qualitative assessment of the Plooto system from the stakeholders that are involved in the value networks. Their view relies on the business aspects (and envisaged benefits) of the transformation of the factory processes through advanced ICT systems integration.

This document constitutes the initial version of the evaluation methodology. In the course of the project the approach described here will guide the assessment of the Plooto system during the pilot operations. However, as the project progresses further on extensions or updates in the evaluation methodology may occur that will be reflected in the deliverable D4.4 "Pilot assessment report" alongside with the actual evaluation results.

1.2 Relation with other deliverables

This document directly relates with D1.1 "Plooto methodological approach and business cases specifications v1", D1.3 "Sustainability balanced scorecard framework v1", and D1.5 "CRIS requirements and specification v1" as it receives the KPIs directly from the work conducted and reported in the aforementioned deliverables. Furthermore, deliverable D4.4 "Pilot assessment report" will feed the evaluation methodology that will be used during the project in order to conduct the Plooto evaluation.

1.3 Structure of the document

The document is structured as follows:

- **Section 2** presents the methodological approach for the evaluation of Plooto
- **Section 3** describes the Pilot 1 evaluation methodology
- **Section 4** describes the Pilot 2 evaluation methodology
- **Section 5** describes the Pilot 3 evaluation methodology
- **Section 6** describes the evaluation methodology for Plooto
- **Section 7** presents the end-users qualitative feedback evaluation methodology extending the overall Plooto Evaluation
- **Section 8** concludes the document

2 Methodological Approach

2.1 Preliminary KPI Identification

This section presents the methodology to assess the impact of the Plooto platform on the pilots. Overall, the evaluation process relates to the evaluation of the technical, operational and impact assessment through the results that come from the system implementation and the pilot application through various KPIs that will be utilized in the course of the evaluation process.

D1.1 explored the actual business value of Plooto in the different circular value networks and uncovered the first set of KPIs that were of value to the pilots per value network. In order to measure the impact of the overall solutions, the pilots highlighted different KPIs on their business cases. The following table summarizes the findings as reported in D1.1.

Table 1: KPIs per Value Network from D1.1 Plooto methodological approach and business cases specification V1

Value Network #1: CFRP Waste for Drones	Value Network #2: WEEE for Magnets	Value Network #3: Citrus Processing Waste for Juice By-Products
• Increase prepreg shelf life. • Increase the value of uncured prepreg scrap. • Reduce prepreg disposal (reduction of the quantity of prepreg disposal in HPC). • Create new jobs in partner facilities related to exploiting uncured prepreg scraps. • Reduce of the existing unused CFRP waste. • Reduce the amount of unused CFRP waste in the production of composite materials (%). • Reuse material to produce components for drones (% of material reused).	• Reduction of WEEE landfilled. • Increase the usage of Sr-ferrite crushed pellets in magnets production. • Improve the quantity of leftovers and disregarded magnets entered into the transformation process. • Increase the usage of SRM (bonded NdFeB and Sr-ferrite) in PM magnets pellets' production. • Increase the number of types of validated materials.	• Increase production of animal feed components. • Increase production of high-quality molasses. • Reduce COD of CPWW. • Lower volume of CPWW that goes to biological treatment. • Increase revenue from animal feed production. • Improve energy savings. • Improve cost savings.

In parallel and extending the work conducted in D1.1, D1.3 aimed to uncover the KPIs that would be taken under consideration for the Sustainability Balanced Scorecard as well as the process of selection and interoperability of these indicators. Overall, this deliverable aimed to support a high-level set of KPIs as derived also from an industrial perspective to enable the pilots to decide which KPIs of the superset are more suitable for their own industrial domain. The result of the aforementioned work led to four categories of KPIs as presented in the following table and explicated in D1.3.

Table 2: KPI categories from D1.3

Environmental	Social	Governance	Economy and Growth
• Carbon Footprint • Resources • Pollution • LCA • Opportunities and Innovation	• Human Capital • Product Assessment • Stakeholders • Opportunities	• Corporate Governance • Corporate Behaviour • Litigation Risks and Corruption	• Financial • Customer • Growth Perspective

As presented in D1.1 and D1.3, KPIs from both research community and industry were analysed out of which a set of KPIs were extracted through requirements elicitation with the goal to have an extended list and select the ones that cover the areas where Plooto can have the greatest impact. In addition to the KPIs that relate to the value network context, KPIs focusing on the Plooto platform and related services performance and usability aspects need to also be taken into consideration. Thus, a further need was to also design a rigorous evaluation that takes into account relevant technics such as surveys, case studies, experiments or workshops (Hevner et al., 2004; Pries-Heje et al., 2008) in parallel with naturalistic evaluations (Carlsson and Johansson, 2010). In particular, for the evaluation of the Plooto system, D1.5 provides the derived requirements for the Plooto system and resulting services in order to be able to meet pilots' expectations and enhance their day-to-day operations in the direction of circularity. Thus, the evaluation will rely upon the ability of the system to meet those specific requirements through the appropriate implementation of the Plooto platform.

The process to define the KPIs and the overall evaluation process in brief was the following:

a) **Evaluation methodology design**: In this step the theoretical underpinnings of the overall evaluation process was examined where the literature was scouted to have a thorough understanding of the process to effectively evaluate a Circular and Resilient Information System (CRIS) as Plooto.
b) **Identification of the KPI**: In this step pilots examined the output of the previous work conducted (and reported in D1.1 and D1.3) in order to uncover the KPIs that will be used to frame the potential impact of Plooto platform on the end-use's' environment and day-to-day operations

c) **Specification of the measurements used**: In this step the selected KPIs were extended to define the approach that will be used to calculate the various KPIs
d) **Specification of the evaluation and validation process**: Having defined the KPIs, the exact settings under which the platform will be demonstrated is presented through the different pilot scenarios

2.2 Evaluation Methodology Design

An effective evaluation methodology design for an ICT system is essential to ensure its functionality, efficiency, and alignment with the overall organizational goals and justify the reason for its development. A robust evaluation framework can enable the identification of its strengths and weaknesses toward guiding improvements and potential adaptations to meet the pilots' needs. Furthermore, a well-structured evaluation methodology fosters accountability and transparency, providing stakeholders with clear insights into the system's value and potential.

Towards developing the evaluation methodology of Plooto, the 5W1H approach was followed to act as a structured approach grounded on theory. In particular, the 5W1H methodology will initially be used for information gathering and problem-solving. The 5W1H tool, an enhanced version of the 5W, answers 6 specific questions (Who, What, When, Where, Why and How) during the initial information gathering stages. Both 5W and 5W1H are being used by researchers in the manufacturing studies (Kuai, 2011; Suhardi et al., 2019; Zhong et al., 2017). This approach also serves as a useful tool for cross-case analysis in the case of multiple pilots (Fratocchi & Costa e Silva, 2018). Additionally, it helps to adapt measures in the improvement phase and thoroughly understand the current situation in detail, following the principle of 5W1H (Jou et al., 2022).

Our methodology will support involved stakeholders to thoroughly understand and then evaluate the system's requirements, functionalities, and areas for improvement by addressing issues such as: i) identifying the people involved or affected (Who), ii) defining what the issue/s or situation is (What), iii) specifying the time frame or when the issue occurs or occurred (the critical times when the system is most needed (When), iv) determining the location or context of the event or problem (the physical and virtual environments in which the system operates) (Where), v) seeking to understand the cause or reason behind the situation (problems it aims to solve, the processes it intends to improve etc.) (Why), and vi) describing the method, solution, or process involved in the situation or problem-solving (How).

Unlike traditional linear models, circular information systems emphasize resource efficiency, closed loop processes and waste minimization. Modgil et al., (2021) refer to the use cases of real-life circular information system paradigms to address circular economy challenges, such as supporting waste management infrastructure, advancing recycling technology, and more. Through this process, quantitative and qualitative techniques are used to evaluate these systems. Moreover, Gregor & Hevner (2013) divided the evaluation of a system – in the context of the DSR framework – into pre-evaluation (functional requirements) and post-evaluation (performance of the developed system). Normative literature contains a plethora of evaluation methodologies for information systems across different stages.

In their seminal research, Petter et al. (2008), by scrutinizing the literature on information systems success models, dimensions and measurements from 1992-2007, reported their findings, part of which strongly match our initial research. Fitting to Plooto's project evaluation information system, Inlrani et al. (2001) propose the "5M" model (Man, Machine, Method, Material, Money) while, in the general context of manufacturing information systems evaluation, several measures have been proposed. Regarding evaluating the success of an implemented information system from the scope of its usage and its benefits, the DeLone and McLean IS Success Model, comes as an established model, having been used extensively in the literature (DeLone & McLean, 1992, 2003a). This model identifies six key dimensions of IS success, developed by DeLone and McLean in 1992 and later updated in 2003 (DeLone & McLean, 2003b). The first dimension is the "System's Quality", where the performance characteristics of the IS (including factors such as reliability, usability, response time and functionality) are being measured. The second dimension is the "Information Quality". Key attributes for evaluation relevant to information quality are accuracy, relevance, completeness and timeliness. The third one is the "Service Quality". This aspect evaluates the quality of the support services provided to users of the information system (user support, training and the support team's responsiveness). The fourth dimension is the "Use", or in some cases "intention to use", in which actual usage can be measured (or the intention to use the IS). The fifth dimension of the success model is the "User Satisfaction" and the sixth dimension is the "Net Benefits" for evaluating the impact of the IS in the organization.

From the scope of information systems usability Mator et al. (2021) systematically presented some of the most eligible approaches for obtaining empirical measurements. The Post-Study System Usability Questionnaire (PSSUQ), and the After-Scenario Questionnaire (ASQ) are some of the commonly used in the literature for IS usability measurement (Lewis, 1992, 1995). Of all the proposed methodologies, the "heuristic evaluation" is mentioned as the most prominent in the 1990s (Nielsen, 10 C.E.). Nevertheless, measuring directly the usability of an information system comes with a high degree of difficulty (Hornbæk, 2006). For Cradle to Cradle (C2C) designed products to maximize the benefits for humans and the environment, Bjørn & Hauschild (2018) suggest the Life Cycle Assessment (LCA) evaluation, as it performs efficiently. C2C product creation is a philosophy focusing on the materials' continuous reuse in a closed-loop system (Bakker et al., 2010). The role of the information system in the data management, analysis and reporting in the LCA evaluation is crucial and the effectiveness of the IS should additionally be evaluated.

Regarding the evaluation of the system's applicability, Rosemann & Vessey (2008) were among the first to systematically approach this issue and noted the importance of further research and methodologies development. Matching the criteria for Plooto's applicability, the evaluation methodology that Jang et al. (2023) followed in their research, based on the pre-evaluation and post-evaluation stages (including evaluations through prototype demonstration, survey, and expert interviews), appears to align with our objectives. Using quantitative and qualitative evaluation criteria is strongly suggested by Mokalled et al. (2019) in their selection process for the most applicable Security Information and Event Management system. Specifically, they divide the evaluation methodology into two phases: i) quantifying each requirement of the information system, and ii) "Measuring the applicability of the solution using a qualitative-based method after defining a list of indicators that enables the evaluation of this applicability". However, as they mention, an installation-testing phase should be conducted at the end to confirm the applicability of the IS further. Lastly, a higher-level system evaluation, addressing issues such as functionality, reliability, performance, scalability, security, interoperability, maintainability, compliance and standards, is described in the ISO/IEC/IEEE 29119-1:2022 software testing, from the International Organization for Standardization and the International Electrotechnical Commission (ISO, 2022).

Regarding the evaluation of the information system's overall user experience, Laugwitz et al. (2008) seminal research can be used to record the overall experience of the factory employees during the use of the developed system. This questionnaire measures the attractiveness and the perspicuity of the IS, examines the efficiency and the dependability, as well as the stimulation and the novelty of the IS. Lastly, a qualitative approach is considered relevant to the evaluation methodologies for information systems due to its nature of providing in-depth information, mostly through a series of interviews or Delphi studies (Kaplan & Maxwell, 2005). There is a huge body of literature concerning using qualitative research methods in IS research. (Conboy et al., 2012), but to a better degree, in the case of the Plooto Project evaluation, qualitative data analysis via semi-structured interviews will shed light on unknown phenomena and previously unidentified variables.

A plethora of IS evaluation methodologies regarding different aspects, stages and angles have been proposed in the existing body of literature. Most of them include quantitative and qualitative methods, considering pre-existing KPIs, examination and information gathering. In this case, a mixed method approach, with a systematic methodological design for each dimension and each stage, is contemplated for an efficient evaluation of the information system. Thus, the following table presents the results of the W5I1 methodological approach followed to delineate the theoretical grounding of the Plooto evaluation methodology.

Table 3: Plooto W5I1 methodological approach

Value Network	Who	What	When	Where	Why	How
VN1: CFRP waste for drones	Identify the stakeholders involved	• Define the specific goals of the CRIS in	• Specify the critical times when	Determine the physical and virtual environme	• Understand the problems CRIS aims to	• Describe the methods and the processes involved in

Value Network	Who	What	When	Where	Why	How
VN2: WEEE for magnets **VN3:** Citrus processing waste for juice by-products	or affected in VN1, VN2, VN3	VN1, VN2, VN3 • Identify the key features and functionalities of the CRIS in VN1, VN2, VN3 • Specify the data sources used for evaluation in VN1, VN2, VN3	CRIS is most needed or evaluated in VN1, VN2, VN3 • Determine the duration of the evaluation periods	nts where the CRIS operates in VN1, VN2, VN3	solve as also the processes it intends to improve in VN1, VN2, VN3	the implementation and evaluation of CRIS • Define the metrics will be used to evaluate system performance in VN1, VN2, VN3

Having presented the theoretical methodology framework the focus shifts on selecting the most meaningful KPIs for consideration for the different value networks in order to be able to define a list of KPIs per value network that respond to a successful and effective pilot implementation. The set of the pilot-specific KPIs as derived from D1.1 and D1.3 were studied in the following aspects:

- **Validity**: Each KPI was examined for its relevance to the specific value network and pilot context towards gaining additional maturity if the KPI is meaningful for the pilot or an alternative KPI can apply better
- **Computability**: Computability of a KPI can serve as the way to identify if a KPI can be calculated based on the provided data as well as a computation methodology
- **Data Availability**: Data availability on the selected metrics composing the KPIs is a necessity to evaluate the KPIs. Data may stem from the pilots directly or can be produced by the Plooto system.
- **Past Value Availability**: In order to effectively examine the Plooto system ability to assist pilots in their performance, and in the end assess its impact, past values of the selected KPIs also need to be available in either (a) direct provision from the pilots as past data exists or (b) provision of a computation methodology and provision of past values on the referenced metrics
- **Computation methodology**: Based on the availability of data and ability to execute the scenarios in the infrastructure of the pilots, the following approaches can be followed:

- **R-R (Real – Real):** Computing past values on actual historical data and new values on actual data.
- **R-S (Real – Simulated):** Computing past values on actual historical data and new values on a simulated environment – reduced to reality for comparison
- **S-R (Simulated – Real):** Lack of actual past values so past values are computed on a simulated environment and new values are based on actual data.
- **S-S (Simulated - Simulated):** Computation methods that calculate both past and new values in a simulated environment
- **Q:** Qualitative assessment (not measurable) for new capability not existing in the past
- **Qm:** Qualitative assessment (measurable) for new capability not existing in the past

In the course of the Plooto evaluation, in order to enable the reception of initial information towards enabling the refinement of the Plooto system a two-round evaluation approach was selected to be conducted. The first iteration will serve as the first round of pilot validation (M19-M22) with the goal to have the pilots experience the system, validate that their requirements are being covered and lastly identify any improvements needed for the final Plooto system. In the second iteration concluding in M36, the final integrated and deployed Plooto solution will be used by the pilots for its operation and final validation as illustrated in Figure 1.

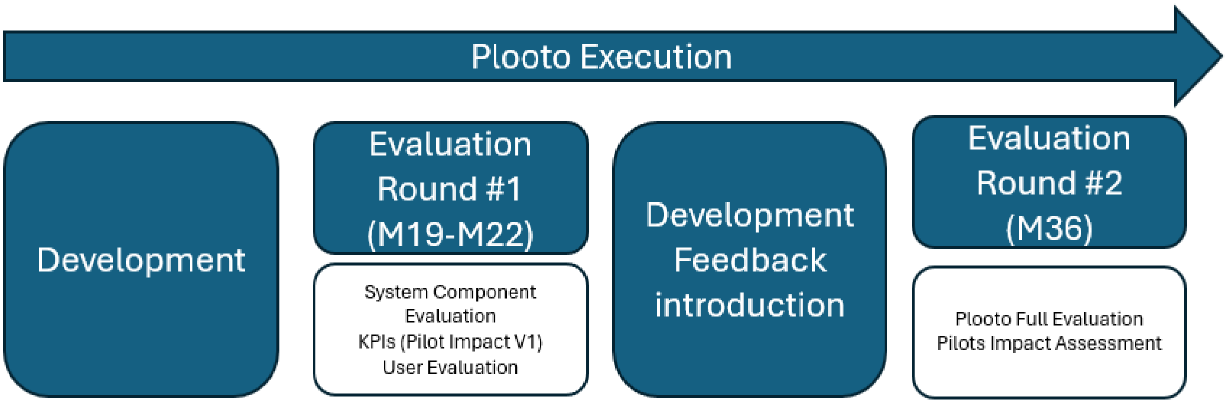

Figure 1: Plooto Evaluation Methodology

The following chapters present the KPIs and instruments used in the process of the Plooto evaluation starting from the pilot KPIs and proceeding with the remaining system – related evaluation approach.

3 Pilot 1: CFRP waste for Drones

3.1 Problem Definition

The overall goal of the pilot as presented in D1.1 is to design a process of reusing carbon fibre waste generated during daily operations. On that account, the requalification for expired prepreg rolls and uncured scraps needs to take place to ensure efficient material processing. The main problem that arises is that this material and waste has a high variability in their properties that eventually may lead to sub-optimal processing. As such KPIs that reflect the success of this processing have been identified to examine and evaluate the effectiveness of Plooto in this new process.

3.2 Key Performance Indicators

3.2.1 KPI1.1: Prepreg shelf life

This KPI relates to the shelf life of prepreg (the focal point of Plooto) and reflects the maximum time the prepreg can be stored under specific conditions and continue to remain usable for its intended function. To create the KPI, Plooto aims to monitor the same material code (in terms of lot number) used by CC, while simultaneously tagging the material with the creation date. This way, Plooto can track when CC will use the material and acquire the new expiration date provided by CETMA in order to calculate the KPI. This KPI relies on the specific time frame monitored that should be compatible with the duration of Plooto project.

The formula reflecting this KPI is:

$$KPI1.1 = (N_c - n)/n \times 100$$

N_c: number of days passed from the prepreg production day to the new expiration day (defined through the requalification procedure)

n: number of days passed from prepreg production to the expiration day defined by prepreg manufacturer and indicated in the technical data sheet (baseline shelf life is equal to 365 days)

Note: KPI1.1 will be expressed as a percentage change from the baseline of 365 days (that is the baseline shelf life). For different material dynamic numbers will be considered.

3.2.2 KPI1.2: Prepreg disposal in HP

This KPI relates to the amount of prepreg that is disposed in landfills because it is unusable. Through Plooto the tracked and monitored prepreg will enable us to monitor the overall quantity of prepreg that HP disposes in landfill for a specific time period (e.g. monthly). Following that and relative to the amount of time the pilot is operational in the different rounds, an extrapolation of the results will reflect the potential of Plooto in the Prepreg disposal.

The formula reflecting this KPI is:

$$KPI1.2 = \frac{N}{month}$$

N: the quantity of prepreg in kg to landfill.

3.2.3 KPI1.3: Value of uncured prepreg scraps for HPC

This KPI relates to the identified economic benefits derived from the Plooto application on the material constituting the focal point (prepreg). This is reflected by the value of uncured prepreg scraps that can be calculated through tracking of the respective material and transforming them into their monetary equivalent for the given time period. Similar with KPI1.2, this KPI relies on the specific time frame that we choose to monitor.

The formula reflecting this KPI is:

$$KPI1.3 = \frac{N}{monthly}$$

N: cost of Prepreg in Euro that ends up in the Landfill

3.2.4 KPI1.4: New jobs in partners facilities related to exploiting uncured prepreg scraps

This KPI relates to the benefit of new employment possibilities made available by the application of Plooto. With the system, the prepreg will be utilized in new forms leading to the need for new positions. This KPI is composed by measuring all new positions involved in using the Plooto system as well as shopfloor positions for processing / transferring / etc. on all partners of the value network.

The formula reflecting this KPI is:

$$\begin{aligned} KPI1.4 = {} & \text{No of Employee positions relative to Plooto} - \text{Prepreg Processing in HPC} \\ & + \text{No of Employee positions relative to Plooto} - \text{Prepreg Processing in CETMA} \\ & + \text{No of Employee positions relative to Plooto} - \text{Prepreg Processing in CC} \end{aligned}$$

Note: This KPI will be calculated in Round #2 of evaluation after the complete implementation of the Plooto platform.

3.2.5 KPI1.5: Unused CFRP waste in the production of composite materials (%)

This KPI relates to the value network wide process evaluation that involves the quantity of CFRP waste coming from HP and the quantities that were successfully requalified and lastly the ones actually used in production having been successfully repurposed from being discarded in a landfill.

The formula reflecting this KPI is:

$$KPI1.5 = \frac{(HPC - C) + (C - CC)}{\text{HPC}} \text{x}100$$

C: The quantity in kg of the CFRP that CETMA requalifies.

CC: The quantity in Kg that CC used from the material obtained after the requalification.

HP: the quantity in Kg that HPC is sending to CETMA, instead disposing it to landfill.

Note that the reason we are not simplifying the numerator of the KPI is for comprehensive reasons and to highlight the fact that, in order to calculate it, we will need to monitor the same batches of CFRP that will be sent to CETMA for requalification, and then the outcome of the requalification to CC for production.

3.3 Test Scenarios (measurement)

As presented in the evaluation methodology chapter, this scenario reflects the Production Related evaluation conducted in two rounds, Round #1 (M19-M22) and Round #2 (M31-M36).

3.3.1 TS1.1: Test Scenario #1 (Production)

Round #1: In this evaluation round the selected KPIs in the pilot will be evaluated in the pilots in parallel with KPIs from the Balanced Scorecard. Furthermore, the evaluation of the technical solution in its V1 will be evaluated towards receiving the feedback of the users and conducting further development and updates towards the final Plooto system. In particular for Round #1 of TS1.1 there will be utilization of historic data from the pilot and current data (while Plooto operates on its V1.0) and services will be evaluated as follows: Dashboard / UI (at least 3: 1 generic UI, 1 UI for Admin and 1 per each user), Balanced Scorecard (Sustainability and Circularity performance assessment of the value network), Process modeler and simulation tool (Representation (replica) of the actual physical value network, modelling of the whole production line and subsequent flows, Calculation of all the required flows for the required KPIs), Analytics service (early version of Forecasting and Anomaly Detection), Digital Twins modeler (3 - one per user: HPC, CETMA and CC), Value Network modeler (1), Optimization service (Optimized Production Plan generation + Costs in deterministic environment), on metrics from a technical perspective. Additionally, from the user perspective an evaluation will take place relevant to user experience.

Round #2: In the final evaluation round (M31-M36) the integrated Plooto system will be evaluated on the respective KPIs where similarly to the previous round utilization of historic data from pilots will be used in parallel to current data on all KPIs / metrics and evaluate the Plooto Impact.

Relevant KPIs: KPI1.2, KPI1.3, Balanced Scorecard KPIs, User Experience KPIs, Plooto System KPIs

3.3.2 TS1.2: Test Scenario #2 (Value Network)

Round #1: In this evaluation round, the goal is to examine the platform-enabled cooperation among partners (Registration, Sending/Receiving materials, Requalification) and viewing and monitoring of the value network through the digitization of steps to enter Plooto and partners can see their value network and operate on it. The selected KPIs will be evaluated for their impact in the pilots in parallel with selected KPIs from the Balanced Scorecard. In particular for Round #1 of

TS1.2 there will be utilization of historic data from the pilots and current data (while Plooto operates on its V1.0) and services will be evaluated as follows: Dashboard / UI (same as above), Sustainability Balanced Scorecard (Sustainability and Circularity performance assessment of the value network), Process modeler and simulation tool (Representation (replica) of the actual physical value network, modelling of the whole production line and subsequent flows, Calculation of all the required flows for the required KPIs), Analytics service (Product Quality Explorer, Forecasting and Anomaly Detection), Digital Twins modeler (same as above), Value Network modeler (same as above), Optimization service (same as above), on metrics from a technical perspective. Additionally, from the user perspective an evaluation will take place relevant to user experience.

Round #2: In the final evaluation round (M31-M36) the integrated Plooto system will be evaluated on the respective KPIs where similarly to the previous round utilization of historic data from pilots will be used in parallel to current data on all KPIs / metrics and evaluate the Plooto impact.

Relevant KPIs: KPI1.1, KPI1.4, KPI1.5 Balanced Scorecard KPIs, User Experience KPIs, Plooto System KPIs

4 Pilot 2: WEEE for Magnets

4.1 Problem Definition

The overall goal of this pilot as presented in D1.1 is to refine processes with minor adjustments focusing on Ferimet's operations. Whist EUT will support the automated dismantling of magnets and IMDEA will optimize magnet processing and examine requalification, IMA will focus on proprietary production optimization. The problem in this case is that there are complexities in the specific properties of magnets that can highly influence the final output and the to-be designed requalification process for contaminated sintered Sr-ferrite magnets and bonded NdFeB. As such, KPIs that reflect the success of this process refinement have been identified to examine and evaluate the effectiveness of Plooto in this new process.

4.2 Key Performance Indicators

4.2.1 KPI2.1: Reduction of WEEE landfilled (for the bonded materials' part)

This KPI relates to the potential of reducing WEEE landfilled from magnets that would become unusable if not processed through Plooto thus showcasing the reduction of magnets that are destroyed from WEEE landfilled by the total quantity of magnets extracted.

The formula reflecting this KPI is:

$$KPI2.1 = \text{ Kgs of magents extracted by Ferimet}$$

4.2.2 KPI2.2: Usage of SRM (bonded NdFeB, Sr-Ferrite) in PM magnet pellets' production origin (%)

This KPI relates to the potential of reducing WEEE landfilled from magnets that would become unusable if not processed through Plooto thus showcasing the reduction of magnets that are destroyed from WEEE landfilled by the total quantity of magnets extracted.

The formula reflecting this KPI is:

$$KPI2.2 = \frac{\text{Kg of recycled pellets in IMA}}{\text{Kg of total pellets used in IMA}}$$

4.2.3 KPI2.3: Number of types of validated materials

This KPI is a wider Value Network KPI that relates to the different materials considered for Plooto and thus utilized successfully in Plooto. The initial target is 3 so as to include Bonded Neodimium and Ferrite magnets and sintered ferrite magnets.

The formula reflecting this KPI is:

$$KPI2.3 = \text{ No of Magnet Types succesfully introduced in Plooto}$$

4.2.4 KPI2.4 Minimisation of raw materials insertion PLES08

This KPI relates to the identified need of recycle pellets that it might be necessary to add raw magnetic material to obtain the desired magnetic properties in the end product. Thus, the objective is to minimize the quantity of raw material by a value lower than 5%.

The formula reflecting this KPI is:

$$KPI2.5 = \text{Percentage of Raw Magnetic Material in recycled pellets}$$

4.3 Test Scenarios (measurement)

As presented in the evaluation methodology chapter, this scenario reflects the Production Related evaluation conducted in two rounds, Round #1 (M19-M22) and Round #2 (M31-M36)

4.3.1 TS2.1: Test Scenario #1 (Production)

Round #1: In this evaluation round the selected KPIs in the pilots will be evaluated in parallel with selected KPIs from the Balanced Scorecard. Furthermore, the evaluation of the technical solution in its V1 will be evaluated towards receiving the feedback of the users and conducting further development and updates towards the final Plooto system. In particular for Round #1 of TS2.1 there will be utilization of historic data and current data (while Plooto operates on its V1.0) and services will be evaluated as follows: Dashboard / UI (at least 3: 1 generic UI, 1 UI for Admin and 1 per each user), Sustainability Balanced Scorecard (Sustainability and Circularity performance assessment of the value network), Process modeler and simulation tool (Representation (replica) of the actual physical value network, Modelling of the whole production line and subsequent flows, Calculation of all the required flows for the required KPIs), Analytics service (Computing the energy from the different processes), Digital Twins modeler (4 – one per user: FERIMET, EUT, IMDEA and IMA), Value Network modeler (1), Optimization service (Optimized Production Plan generation + Costs in deterministic environment), IMF model of the value network and knowledge graph of the value network on metrics from a technical perspective. Additionally, from the user perspective an evaluation will take place relevant to user experience.

Round #2: In this final evaluation round (M31- M36) the integrated Plooto system will be evaluated on the respective KPIs where similarly to the previous round utilization of historic data from pilots will be used in parallel to current data on all KPIs / metrics and evaluate the Plooto Impact.

Relevant KPIs: KPI2.1, KPI2.2, KPI2.4, Balanced Scorecard KPIs, User Experience KPIs, Plooto System KPIs

4.3.2 TS2.2: Test Scenario #2 (Value Network)

Round #1: In this evaluation round, the goal is to examine the platform-enabled cooperation among partners in the value network from having the magnets scrapped to pellets made to bonded magnets made (Registration, Sending/Receiving materials, Magnetic properties infusion, Supply Chain visibility) and viewing and monitoring of the value network through the digitization of steps to enter Plooto and partners can see their value network and operate on it. The selected

KPIs will be evaluated in the pilots in parallel with selected KPIs from the Balanced Scorecard. In particular for Round #1 of TS2.2 there will be utilization of historic data and current data (while Plooto operates on its V1.0) and services will be evaluated as follows: Dashboard / UI (see above), Sustainability Balanced Scorecard (Sustainability and Circularity performance assessment of the value network), Process modeler and simulation tool (Representation (replica) of the actual physical value network, Modelling of the whole production line and subsequent flows, Calculation of all the required flows for the required KPIs), Blockchain (No of hashed contracts processed, Transaction latency), Digital Twins modeler (see above), Value Network modeler (see above), Optimization service (see above), IMF model of the value network and knowledge graph of the value network, on metrics from a technical perspective. Additionally, from the user perspective an evaluation will take place relevant to user experience.

Round #2: In the final evaluation round (M31-M36) the integrated Plooto system will be evaluated on the respective KPIs where similarly to the previous round utilization of historic data from pilots will be used in parallel to current data on all KPIs / metrics and evaluate the Plooto Impact.

Relevant KPIs: KPI2.3, Sustainability Scorecard KPIs, User Experience KPIs, Plooto System KPIs

5 Pilot 3: Citrus processing waste for juice by-products

5.1 Problem Definition

The overall goal of the pilot as presented in D1.1 is to enhance the by-product transformation for the cattle feed and involves Molasses, d-Limonene and COD. In this pilot the main process of transforming waste to animal feed is already active however the problem relies in optimizing the end product and creating a proof of value of the by-products to the cattle feed industry. As such KPIs that reflect the success of this processing have been identified to examine and evaluate the effectiveness of Plooto in this new process.

5.2 Key Performance Indicators

5.2.1 KPI3.1: Production of animal feed

This KPI corresponds to the total production of animal feed following the completion of Plooto.

The formula reflecting this KPI is:

$$KPI3.1 = \sum number\ of\ produced\ animal\ feed/year$$

5.2.2 KPI3.2: Production of high-quality molasses

This KPI corresponds to the total production of high-quality molasses following the completion of Plooto. The formula reflecting this KPI is:

$$KPI3.2 = \sum number\ of\ produced\ high\ quality\ molasses/year$$

5.2.3 KPI3.3: Production of d-Limonene

This KPI corresponds to the total production of d-Limonene following the completion of Plooto.

The formula reflecting this KPI is:

$$KPI3.3 = \sum number\ of\ produced\ d - Limonene/year$$

5.2.4 KPI3.4: Volume of CPWW

This KPI corresponds to the reduction in the volume of the generated CPWW following the completion of Plooto project.

The formula reflecting this KPI is:

$$KPI3.4 = \frac{\boldsymbol{\Sigma}\ volume\ of\ CPWW\ before\ Plooto\ Project - \boldsymbol{\Sigma}\ Volume\ of\ CPWW\ after\ Plooto\ project}{\boldsymbol{\Sigma}\ Volume\ of\ CPWW\ before\ Plooto\ Project}$$

5.2.5 KPI3.5: COD of CPWW

This KPI corresponds to the reduction of COD in the CPWW following the completion of Plooto.

The formula reflecting this KPI is:

$$KPI3.5 = \frac{\boldsymbol{\Sigma}\, amount\ of\ COD\ in\ CPWW\ before\ Plooto\ Project - \boldsymbol{\Sigma}\, amount\ of\ COD\ in\ CPWW\ after\ Plooto\ project}{\boldsymbol{\Sigma}\, amount\ of\ COD\ in\ CPWW\ before\ Plooto\ Project}$$

5.2.6 KPI3.6: Volume of CPWW that goes to biological treatment

This KPI corresponds to the reduction in the volume of the CPWW that goes to biological treatment following the completion of Plooto project

The formula reflecting this KPI is:

$$KPI3.6 = \frac{\boldsymbol{\Sigma}\, volume\ of\ CPWW\ to\ biological\ treatment\ before\ Plooto\ Project - \boldsymbol{\Sigma}\, volume\ of\ CPWW\ to\ biological\ treatment\ after\ Plooto\ project}{\boldsymbol{\Sigma}\, volume\ of\ CPWW\ to\ biological\ treatment\ before\ Plooto\ Project}$$

5.2.7 KPI3.7: Revenues from animal feed

This KPI corresponds to the total revenues from selling animal feed following the completion of Plooto Project.

The formula reflecting this KPI is:

$$KPI3.7 = \sum Revenues\ from\ animal\ feed, animal\ feed\ components/year$$

5.3 Test Scenarios (measurements)

5.3.1 TS3.1: Test Scenario #1 (Production)

Round #1: In this evaluation round the selected KPIs in the pilot will be evaluated in parallel with selected KPIs (minus KPI3.7) from the Balanced Scorecard. Furthermore, the evaluation of the technical solution in its V1 will be evaluated towards receiving the feedback of ASPIS and conducting further development and updates towards the final Plooto system. In particular for Round #1 of TS3.1 there will be utilization of historic data and current data (while Plooto operates on its V1.0) and services will be evaluated as follows: Dashboard / UI (at least 3: 1 generic UI, 1 UI for Admin and 1 per the user), Sustainability Balanced Scorecard (Sustainability and Circularity performance assessment of the value network), Process modeler and simulation tool (Representation (replica) of the actual physical value network, modelling of the whole production line and subsequent flows, Calculation of all the required flows for the required KPIs), Analytics service (Combine Synthetic and Simulated Data with Actual Measurements. Compute the Energy Consumed during Processes and Identify Anomalies in Measured Attributes), Life Cycle Assessment (environmental impact assessment), Digital Product Passport (TBA by MAG), on metrics from a technical perspective. Additionally, from the user perspective an evaluation will take place relevant to user experience.

Round #2: In the final evaluation round (M31-M36) the integrated Plooto system will be evaluated on the respective KPIs where similarly to the previous round utilization of historic data from pilots will be used in parallel to current data on all KPIs / metrics and evaluate the Plooto Impact.

Relevant KPIs: KPI3.1, KPI3.2, KPI3.3, KPI3.4, KPI3.5, KPI3.6, KPI3.7, Balanced Scorecard KPIs, User Experience KPIs, Plooto System KPIs

5.3.2 TS3.2: Test Scenario #2 (Value Network)

In this pilot, the focal point is only one company and as such there are no test scenario for value network.

6 Plooto System Evaluation

Plooto envisages the creation of a circular and resilient information system (CRIS) that consists of various components and provides respective services. As can be seen in deliverable D1.5, the overall architecture of Plooto consists of several modules which in unison constitute the CRIS. In the context of the overall evaluation of the developed solution and the examination of the envisaged benefits, Plooto will also undergo evaluation in various aspects to enable (a) its update based on the results of the first round of evaluation and (b) its final evaluation in the second round of evaluation.

As Plooto is a software solution, several evaluation approaches can be utilized. As presented in Figure 1, Hosseini et al. (2024) have identified five categories of architectural analysis and evaluation methods towards examining the quality of an IS.

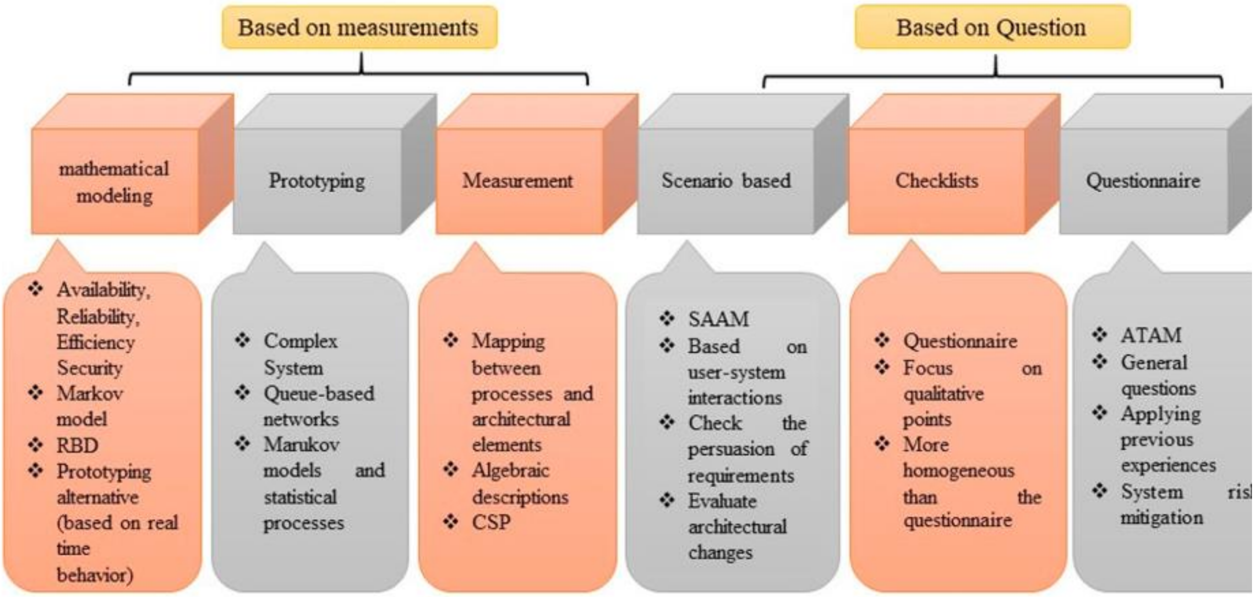

Figure 2: Software architecture evaluation approaches, Source: Hosseini et al 2024

In order to enable a rigorous evaluation approach, Plooto opted to address the system evaluation through both the measurement-based as well as the questionnaire-based approach namely through Mathematical modelling, Measurement, Scenario based and Questionnaire. The reason behind utilizing both measurement-based and question-based approaches is that, it is essential to evaluate its actual performance using a combination of KPIs and qualitative data from interviews. KPIs provide quantifiable metrics that offer objective insights into specific aspects of system performance, such as availability and reliability. However, relying solely on these numerical indicators may overlook nuanced user experiences and contextual factors. Therefore, integrating qualitative data from interviews allows for a deeper understanding of user perspectives, challenges, and suggestions that are not captured by KPIs. This triangulation of data (Denzin, 2017)—combining quantitative KPIs with qualitative feedback—ensures a comprehensive evaluation, identifying both measurable outcomes and underlying issues, thus guiding more informed development decisions. The following chapters explicate on the approach.

6.1 System evaluation – functionalities

In order to evaluate the system as a whole, various approaches both of qualitative and quantitative nature will be utilized. Starting from Mathematical modelling approaches, Availability and Reliability will be evaluated as follows.

- **Reliability**: Defined as the likelihood that a system or system component is functional at a specific moment in time under a particular set of environmental conditions. As such it is the probability of the survival of a component until time t, being complement to the probability of failure before (or at time) t. On that account if T= time to failure, then: $R(t) = P(T>t) = 1- F(t)$ where R(t) is the reliability and F(t) is the failure probability[1].
- **Availability**: Availability refers to a component's/ system's readiness for immediate use at any given time. Its mathematical formulation is *Total time – Downtime / Full time × 100%.*

Furthermore, a Mapping between processes and architectural elements of Plooto will enable the identification of the completeness of the system and its ability to meet the requirements of the different pilots/end users and respective processes needed in the CRIS. In particular and stemming from deliverable D1.5 the following checklist of components to pilots will be utilized with the respective measurements to evaluate the Plooto system.

Table 4: Plooto Modules / VNs / Metrics Reporting

Component	Processes Supported in Value Networks	Metrics
Dashboard / UI	[ALL Pilots] Viewing of VC specific KPIs. Adding deleting users etc… Execution of 3rd parties' services Monitoring of internal processed Monitoring of VC	No of users designing their own dashboard
Sustainability Balanced Scorecard	[ALL Pilots] Viewing of current status relevant to sustainability	No of metrics on Environmental, Societal, Economy & Growth, Governance and Pilot-specific pillars, according to pilots' preferences per use case.
Analytics Service	[Greek Pilot] for energy consumption monitoring,	Reliability of the service to perform real-time analysis when new data is incorporated to the system.

[1] System Reliability, Availability, and Maintainability - SEBoK (sebokwiki.org)

Component	Processes Supported in Value Networks	Metrics
	environmental footprint monitoring and anomaly detection	[Greek Pilot] Forecasting Accuracy (Mean absolute error, Root mean squared error, Bias) Anomaly Detection Precision / Recall / F1 score (perceived ability of the system to correctly identify anomalies) System Performance (processing time per dataset, system throughput)
Blockchain	[Spanish Pilot] Collaboration establishment support in a trustworthy environment	No of hashed contracts processed Transaction latency
Digital Twins modeler	[ALL Pilots] Creation / Update of DTs	No of DT modelled
Value Network modeler	[Spanish / Italian pilots] Viewing / acting on Value Network	No of Companies introduced / depicted
PSM Tool	[ALL Pilots] Creation of the Process Models	No of control variables for the whole value network
Optimization Service	[Italian / Spanish Pilots] Optimization of Production Planning Processes	No of Production Plans created
Guidelines for Certification	Plooto system - Evaluation of compliance for certification	No of Guidelines per Value Network

6.2 System evaluation – learnability

Learnability is a critical aspect of the usability of an Information System (IS) and as such of high importance to Plooto as well. It refers to the ease with which new users can begin to effectively interact with Plooto and achieve a reasonable level of proficiency. Evaluating learnability involves assessing how quickly and efficiently a user can become proficient with the system. On that account and driven from the Learnability evaluation subsection of "Software Evaluation: Criteria-based Assessment" of the Software Sustainability Institute (Jackson et al., 2011) a dedicated section of the questionnaire that will be utilized to evaluate Plooto will also include relevant questions as follows:

1. Is a getting started guide, outlining a basic example of using the software, provided?
2. Are instructions provided for many basic use cases?

3. Are instructions provided supporting all use cases?
4. Are reference guides provided for all command line, GUI and configuration options?
5. Is API documentation provided for developers?

6.3 End-user evaluation

In order to enable the development of system that will assist the factory employees in their day-to-day activities the PLOOTO system should also be evaluated by its actual end users. In the PLOOTO case, end users of two main categories are the potential users of the system: (i) factory workers at the shopfloor that will utilize the system and (ii) employees at a company level with the authority and role to introduce the system in the factory – the ones that are to decide for its use in the factory who are expected to benefit from PLOOTO outcomes from the business side. In the following sections, the evaluation methodology of these user groups' experience is presented focused on the first type of users where a different evaluation methodology is presented in chapter 8 for the decision makers. The evaluation by the interested stakeholders, described in this chapter, will be conducted in the two pilot setup iterations for the first type and once at the end for the second type as the decision makers need to experience the full deployed system to evaluate its benefits for digitally transforming their factories.

Overall PLOOTO, besides its technical infrastructure that supports the different operations within the pilot scope that are transparent to the end-users, consists also of touchpoints with the end users (e.g., the web interface utilized by the factory workers). As a result, these touchpoints that are utilized to feed the users with valuable information relevant to their work, will be assessed by the end-users for their offered experience during interact use. In order to enable the assessment of PLOOTO from the end users' perspective, different aspects of the system in relation to the users will be examined as: (i) usability, (ii) understandability, (iii) documentation, (iv) learnability and (v) overall user experience. The evaluation methodology for these specific aspects is presented in the following sections.

6.4 Usability evaluation

To facilitate evaluating from the employees' perspective, we will involve actual potential end users in the pilots' factories. The process of evaluation will employ the widely utilized System Usability Scale (SUS). SUS was developed by Brooke (1996) as a "quick and dirty" survey scale that quickly and easily assess the usability of a given product. Its ease of use and reliable results have set the SUS to become an industry standard in terms of usability evaluation as it has been reported as the prime instrument for usability evaluation in over 2300 individual surveys in over 200 studies (Bangor, Kortum and Miller, 2008). In particular the SUS has reached such wide acceptance in the field and the academy as it is easy to administer to the participants (even at a small sample size) with reliable results as well as it has a proven validity on identifying usable and unusable systems. This instrument will thus, effectively gauge the usability of the PLOOTO user-system interaction with the goal is to identify any issues (during pilot round #1) and improve the usability of end-user touchpoints to ensure they reach an acceptable usability standard before becoming operational following the evaluation of the pilots on Round #2. In order to administer the instrument the participants, after having experienced the developed system in the field, are invited to score the following ten (10) items in a 5-point Likert scale anchored at "strongly agree" to "strongly disagree":

1. I think that I would like to use this system frequently.
2. I found the system unnecessarily complex.
3. I thought the system was easy to use.
4. I think that I would need the support of a technical person to be able to use this system.
5. I found the various functions in this system were well integrated.
6. I thought there was too much inconsistency in this system.
7. I would imagine that most people would learn to use this system very quickly.
8. I found the system very cumbersome to use.
9. I felt very confident using the system.
10. I needed to learn a lot of things before I could get going with this system.

Their scores per question are recoded to a new number, added together and then multiplied by 2.5, leading to the conversion of an original score of 0-40 to a score of 0-100 with a SUS score above 68 to be considered above average and below 68 below average. Our aim for PLOOTO is to be able to reach a usability score of above 70% by the release of the final PLOOTO system after the second round of evaluation.

6.5 User experience evaluation

In order to evaluate the overall user experience of the end users of PLOOTO, the widely utilized and validated instrument of User Experience Questionnaire (UEQ) by Laugwitz et al (2008) will be used to record the overall experience of the employees of the factories during using the developed system on the basis of its:

- **Attractiveness:** Measuring the overall impression of PLOOTO
- **Perspicuity:** To identify if it is easy to get familiar with PLOOTO
- **Efficiency:** To examine if a user can conduct their tasks with PLOOTO without unnecessary effort
- **Dependability:** To examine if the factory employees feel in control during their interaction with the system
- **Stimulation:** To examine if it is exciting and motivating to use PLOOTO and
- **Novelty:** If they perceive PLOOTO as innovative

The questionnaire presented in the following table consists of pairs of contrasting attributes that may apply to any product or service, thus eligible to be used in PLOOTO. Through blank circles, that represent gradations between the opposites, the users can express their agreement with the attributes by ticking the circle that most closely reflects their impression. Overall PLOOTO will be by selecting one of the circles from 1-7 per line.

Table 5: User Experience Instrument for data collection

	1	2	3	4	5	6	7		
annoying	o	o	o	o	o	o	o	enjoyable	1
not understandable	o	o	o	o	o	o	o	understandable	2
creative	o	o	o	o	o	o	o	dull	3
easy to learn	o	o	o	o	o	o	o	difficult to learn	4
valuable	o	o	o	o	o	o	o	inferior	5
boring	o	o	o	o	o	o	o	exciting	6
not interesting	o	o	o	o	o	o	o	interesting	7
unpredictable	o	o	o	o	o	o	o	predictable	8
fast	o	o	o	o	o	o	o	slow	9
inventive	o	o	o	o	o	o	o	conventional	10
obstructive	o	o	o	o	o	o	o	supportive	11
good	o	o	o	o	o	o	o	bad	12
complicated	o	o	o	o	o	o	o	easy	13
unlikable	o	o	o	o	o	o	o	pleasing	14
usual	o	o	o	o	o	o	o	leading edge	15
unpleasant	o	o	o	o	o	o	o	pleasant	16
secure	o	o	o	o	o	o	o	not secure	17
motivating	o	o	o	o	o	o	o	demotivating	18

meets expectations	o	o	o	o	o	o	o	does not meet expectations	19
inefficient	o	o	o	o	o	o	o	efficient	20
clear	o	o	o	o	o	o	o	confusing	21
impractical	o	o	o	o	o	o	o	practical	22
organized	o	o	o	o	o	o	o	cluttered	23
attractive	o	o	o	o	o	o	o	unattractive	24
friendly	o	o	o	o	o	o	o	unfriendly	25
conservative	o	o	o	o	o	o	o	innovative	26

The aforementioned presented aspects of PLOOTO evaluation that relate to the end-users' point of view (the factory employees) and is to be administered and evaluated at the point in time that the end-users' touchpoints (user interfaces) will be available during the rounds of pilots.

6.6 Ensuring compliance and Sustainability in Data Exchange

As part of the Plooto project, TÜV AUSTRIA will implement a comprehensive certification methodology to ensure the integrity, security, interoperability, accessibility, and sustainability of the data exchanged through the platform. This document outlines the detailed methodologies and key regulatory frameworks TÜV AUSTRIA will use to support the Plooto project, focusing on compliance with European regulations and best practices.

Data integrity and security focus on ensuring data confidentiality, integrity, and availability. This involves protecting data from unauthorized access, maintaining data accuracy, and ensuring data is accessible when needed. Interoperability entails compliance with data exchange standards and supporting API integration to facilitate seamless data sharing. User accessibility and usability requires an intuitive user interface and adherence to accessibility standards to ensure the platform is usable by all intended pilot users. Compliance and standards involve adhering to legal requirements like GDPR and implementing robust quality assurance processes. Sustainability emphasizes optimizing resource use, ensuring recyclability, and minimizing environmental impacts.

Methodology for collecting references: TÜV AUSTRIA will conduct a comprehensive literature review using academic databases such as IEEE Xplore, Google Scholar, and Scopus. This will include identifying key authors and publications in the field and tracking references cited in these key papers for additional relevant studies. TÜV AUSTRIA will review industry standards and guidelines from ISO, IEC, ASTM, and regulatory bodies like the European Commission. Engaging with industry experts through interviews, surveys, and attending conferences and webinars will provide practical insights and keep the team updated on current trends.

Methodology for creating a checklist: TÜV AUSTRIA will start by defining the objectives of the checklist, ensuring they align with the goals of data integrity, interoperability, user accessibility, compliance, and sustainability. Key areas will be identified based on these objectives, breaking down the main pillars into specific assessment categories. Detailed criteria for each key area will be developed to ensure they are measurable and actionable. Pilot testing the checklist with a small group of technicians and pilot users will help identify any issues or gaps. Feedback will be collected through surveys and focus groups, and the checklist will be revised and finalized based on this feedback. The final checklist will be user-friendly and formatted for easy use.

Methodology for creating Final Guidelines: TÜV AUSTRIA will develop an initial draft of the guidelines based on insights from collected references and results from the pilot testing of the checklist. This draft will be shared with key stakeholders, including platform developers, pilot users, and regulatory experts (internally), for review and feedback. Review sessions will be conducted to gather detailed feedback and suggestions for improvement. The guidelines will be validated through practical application and pilot testing on the platform to ensure they are practical and effective. Necessary adjustments will be made based on the validation results, addressing any practical challenges encountered. The guidelines will be finalized by integrating all feedback and will be distributed to all relevant parties using both digital and physical formats as appropriate. TÜV AUSTRIA will organize training sessions and workshops – if it is deemed necessary - to ensure that all pilot users and technicians understand and can implement the guidelines effectively.

7 End-Users qualitative feedback

Extending the evaluation of the Plooto project, and toward receiving additional input having completed the two rounds of piloting activities a final additional round of interviews with the pilots' executives will enable to shed light on the final business-related value post the project lifecycle. On that account a series of unstructured interviews will be conducted following a developed interview guide as suggested in the literature (Bhattacherjee, 2012).

The interviews will be conducted either online or in person through the following overall methodology

1. Research Ethics: Prior to conducting the interviews each participant will be informed on the content, process and interview goals and a formal Assent and Consent Form will be produced and signed.
2. Interview Guide: The interview will take place following the Interview Guide that will be developed in the course of the project.
3. Interviewers: Three trained individuals will conduct the interviews with one being the main interviewer and the other two being responsible for note-keeping and further processing.
4. Interviews:
    a. Transcription: Automatic transcription will take place in the course of the interview. After the interview, the researchers will revisit the transcription in parallel with the audio to ensure an error free dataset
    b. Familiarization: Having the error-free transcription, the researchers will identify patterns, themes and recurring topics independently
    c. Coding: The three researchers will utilize the common assigned codes in order to categories the data
    d. Theme development: Themes based on the data will be developed to answer the selected research questions
    e. Data Interpretation: The developed themes will be analysed towards producing the outcomes of the interviews.
5. Reporting: The output of the Interviews will be presented to the consortium and will be introduced in the respective deliverable.

Conclusions

This deliverable presents the work conducted in the scope of developing the evaluation methodology for the Plooto project. The next steps include the continuation of work towards enabling the developed evaluation methodology to be materialized in the Plooto system towards presenting the benefits of Plooto in the pilot partners. As this evaluation methodology is designed to utilize the overall system and the pilots needs thus far in the project timeframe in the case additional evaluation dimensions occur that may be of benefit to the pilot users a revision / extension of the evaluation methodology will take place and be reported at later stages of the project and in particular in D4.4 Pilot assessment report (M36).

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