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AI·PROFICIENT

Artificial intelligence
for improved production efficiency,
quality and maintenance

Deliverable 6.2

D6.2: Validation analysis of demonstration scenarios

WP6: Use case evaluation and ethical considerations

T6.2: Use case validation analysis and reporting

Version: 2.0

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Executive Summary

Deliverable D6.2 is a public document of the AI-PROFICIENT project delivered in the context of WP6 (Use case evaluation and ethical considerations.), and more specifically T6.2 (Use case validation analysis and reporting),. The aim of this task is to gather and examine data generated from demonstration tasks and scenarios, utilizing the methodology established in Task 6.1. The data obtained from manufacturing assets, plant operators, and personnel is processed to create a validation report, detailing the on-site outcomes achieved by the AI-PROFICIENT.

The validation process involves the evaluation of the different developments made in previous WPs. This validation aims to compare the production performance of pilot sites before and after implementing AI-PROFICIENT.

The deliverable also include documentation about best practices, that which will be shared through the identified dissemination means and reported for exploitation channels in WP7.

1. Introduction

Following the proposed methodology in D6.6, the analysis is carried out at different levels. In this task, the evaluations corresponding to production KPI is covered, leaving for tasks T6.3 and T6.4 the evaluation of the user experience and the level of ethical approach respectively.

The production KPI involves evaluating the performance of the production and the quality of the product, covering the different phases of the product engineering phase.

Production performance and product quality are analyzed at two levels.

- The first level measures the impact of each use case at a specific location in the production line or facility, using a case-by-case approach. Compliance with functional and end-user requirements is also measured at this level. As proposed in the methodology, quantitative criteria is used to objectively measure production performance and product quality within this typology.

- The second level assesses the collective impact of several use cases on the same production line/facility.

The results from these analyses are used as input for various equations that have been created to compare the numerical results from the different levels. This enables a consistent evaluation of the actual impact of each individual use case, as well as the combined impact of all use cases.

Finally, conclusions and best practices are obtained which, together with those obtained in tasks T6.3 and T6.4, help to improve future projects facing similar problems.

2. Measuring results at plant level

Although the methodology described in D6.6 provides instructions on how to measure the impact of various UC implementations on general plant parameters, such as the reduction of low-quality products for CONTI or the decrease in human error rates throughout the year for INEOS, it has not been feasible to comprehensively measure these impacts due to delays in achieving complete functionality required for UC usage in a productive plant. The intricate nature of plant-level KPIs necessitates a minimum six-month measurement period for their results to be meaningful. In this sense, priority has been given to the individualized measurement of the KPIs at UC level, to obtain a more detailed vision of where the best impacts are being produced.
However, experimentations after the end of the project are still in progress to acquire additional measurements and assessing more the impacts of the AI solutions proposed.

3. Measuring the impact on a Use Cases basis

This section, corresponding to the first level, aims to measure AI-PROFICIENT performance at the use case level by measuring its effectiveness in meeting the KPIs, as the models respond directly to the stated objectives. It also measures the degree of compliance with the requirements.

3.1. Production Level – Key Performance Indicators

Following the methodology of D6.6, this section aims to measure the performance of the KPIs using quantitative criteria. For this purpose, in addition to the KPIs described in Deliverable D1.4, additional context was collected in D6.6, such as the variable collection methods and the schedule for monitoring the evolving use case.

The following table compiles the information per use case, determining the quantitative results, including the final metrics and the corresponding achievement percentages.
The percentage of improvement for the current state of the process affected by the use case is calculated using the following method:
Each “Coefficient of adjustment” is assigned a coefficient of adjustment out of a total of 100 as a percentage. It allows adjusting the importance of compliance with a specific KPI compared to the rest in the use case.
Each Coefficient of adjustment is assigned a value representing the achievement percentage.

3.2. Production level KPI Continental

KPI_ID	Description	Reference from D1.4	Target	The baseline value of the KPI /Unit	How is it measured	When is it measured	Final measurement	% of achievement	Coefficient of adjustment	Achievement Adjusted
CONTI 2 UC Specification: Restart Setup										
QT-C-UC2-1	Setup duration.	KPI1_CONTI2	Average reduction of 5-15%	Average attempts made for a satisfactory extrusion (IPOC0 + IPOC3 + Die-Perdie): 1,473	Time when the scrap button is turned off - time when the change is done. The KPI is reframed as potential reduction in number of extrusions which is then measured with historical data. To compute the KPI the history of extrusions is taken and for each extrusion the readiness model is executed to check whether with the model such extrusion would have taken place. In this way it is possible to approximate the number of extrusions that could have been avoided due to low quality conditions for launching the extrusion.	20/09/2023 (historical data)	0,01 attempts in average 0,009 for short extrusion 0,223 for long extrusion	99% reduction 90% reduction 94% reduction	30	28
QT-C-UC2-2	Setup duration after a quick product change.	KPI1_1_CONTI2	Average reduction of 5-15%	Average attempts made for a satisfactory short (IPOC3) extrusion: 0,091						
QT-C-UC2-3	Setup duration after a medium long product change.	KPI1_2_CONTI2	Average reduction of 5-15%							
QT-C-UC2-4	Setup duration after a long product change.	KPI1_3_CONTI2	Average reduction of 5-15%	Average attempts made for a satisfactory long (IPOC0) extrusion: 3,395						
QT-C-UC2-5	System adaption capability. Rework quantity	KPI2_CONTI2	Average reduction of 5-15%	Average time to reach steadiness (IPOC0 + IPOC3 + Die-Perdie): 43,68	Amount of tread (in meter) that is rejected while the scrap button is on. Amount of tread (in meter) that is rejected while the scrap button is on. Currently it is not possible to distinguish medium duration extrusions. Only quick and long ones are considered. The KPI is reframed as estimated rework reduction based on historical data. To compute such magnitude, the rework quantity is assumed to be directly correlated with the extrusion restart time then taking the 3 most used recipes the time to reaching steadiness that would	Historical data	Average time to reach steadiness: 7,72 s. Average time to reach steadiness short extrusion: 8,31 s. Average time to reach steadiness long extrusion: 7,86 s	82% reduction 81% reduction 82% reduction	40	32.9
QT-C-UC2-6	Rework quantity after a quick product change.	KPI2_1_CONTI2	Average reduction of 5-15%	Average time to reach steadiness in short (IPOC3) extrusion: 43,73						
QT-C-UC2-7	Rework quantity after a medium product change.	KPI2_2_CONTI2	Average reduction of 5-15%							

					elapse according to the model is compared to the time to steadiness that the best solution would reach (again according to the model).					
QT-C-UC2-8	Rework quantity after a long product change.	KPI2_3_CONTI2	Average reduction of 5-15%	Average time to reach steadiness in long (IPOC0) extrusion: 44,72	Number of retrain request/number of retrain needed. Given that no model was deployed before AI-PROFICIENT, it is not possible to measure the ratio of improvement. Instead, the following degrees of automation of retraining are considered: 0: No retraining possible. 0,5: Manual retraining. 1: Automated retraining.	Historical data	0,5: Currently manual retraining only is possible with the intervention of data analysis.		30	30
QT-C-UC2-9	System adaption capability.	KPI2_CONTI2	100%	No baseline because the services related to this UC are not used now						
CONTI 3 UC Specification: Released extrusion optimization										
QT-C-UC3-1	% of the time during which the production respects the relaxed conditions over the time of production.	KPI1_CONTI3	≥70%	54% (from January 2021 to June 2021)	we operate under the assumption that predicting and addressing deviations can restore a relaxed product state within 60 seconds (to be able to work with historical data), with the provided probable causes being accurate 50% of the time. Additionally, to reduce potential errors and information overload, the AI model's predictions are only relayed to the operator when an actual deviation is detected, ensuring that operators are not burdened with unnecessary or premature information.	01/09/2023-30/09/2023 (historical data)	64,18% (based on 50% below)	92%	60	55.2
QT-C-UC3-2	Identification rate of the relevant cause of deviation	KPI2_CONTI3	≥80%	No baseline because the services related to this UC are not used now	We've assigned a provisional value to this KPI. Given the constraints of not having conducted trials on the line, we're unable to empirically validate this rate at present. The choice of 50% serves as a conservative estimate, reflecting a balanced perspective on the system's capability, and acts as a midpoint benchmark until real-world testing can provide a more accurate measure.	01/09/2023-30/09/2023 (historical data)	50% (estimation)	63%	40	25.2
CONTI 5 UC Specification: Tread blade wear										
QT-C-UC5-1	Reduction in number of	KPI1_CONTI5	Average reduction of 25%	22 blades changes in curative mode	Number of interventions in curative mode to compare to the number of intervention in preventive mode. For	Historical data	11 blades changed (estimation)	50%	40	20

	interventions of curative mode.			(100% of the intervention in curative mode) (from February 2021 to July 2021).	the model validation the percentile that was used is employed (given that it gave an extremely good fit of the data). As the percentile is 50, we can assume the blade changes of curative mode would reduce to a half.					
QT-C-UC5-2	Decrease unscheduled reparation times related to the cutting system.	KPI2_CONTI5	Average reduction of 15%	660 minutes of unscheduled reparation time related to the cutting system (from February 2021 to July 2021)	Timer of intervention in curative mode to compare to the time of intervention in preventive mode. For the model validation the percentile that was used is employed (given that it gave an extremely good fit of the data). As the percentile is 50 and assuming a proportional time spent on repairments, the time spent of unscheduled reparation would be reduced to 330. Note, however, that the KPIs that were presented do not cover properly the aim of the UC as the balance between the extra cost for replacing the blades early is not considered.	Historical data	330 minutes elapsed during repairments	50%	40	20
QT-C-UC5-3	Decrease amount tread rejections due to bad cutting quality.	KPI3_CONTI5	Average reduction between 0,1 – 1,5%	No baseline because no profilometer	Number of treads that have a bad shape detected by the profilometer		Not implemented	0%	20	0
CONTI 10 UC Specification: Quality analysis tool										
QT-C-UC10-1	Reduction of the scrap rate	KPI1_CONTI10	≥ 0,05%.	4,55%		17/10/2023 (historical data)	4,6% (supposition: GHO suggested settings could have saved the normally scrapped treads)	100%	50	50
QT-C-UC10-2	Detection rate of the quality analysis tool	KPI2_CONTI10	≥80%.	No baseline because the services related to this UC are not used now.		17/10/2023 (historical data)	59,7%	75%	50	37.5

3.3. CONTI 7 UC Specification: Tread alignment7

The CONTI-7 implementation did not proceed as originally planned. The artificial intelligence (AI) was intended to be used to associate equipment wear with the positional drift of tire treads. A method based on model convergence speed was attempted but did not yield the expected predictions. Subsequently, a traditional time series prediction model was tested, but it was not implemented in the factory due to issues with software integration in the factory setting. These challenges led to the decision not to continue with the project in its original form. The lack of success in prediction with the applied methods and difficulties in integrating the software into the factory environment were determining factors in this decision.

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3.4. Production level KPI INEOS Geel

KPI_ID	Description	Reference from D1.4	Target	The baseline value of the KPI /Unit	How is it measured	When is it measured	Final measurement	% of achievement	Coefficient of adjustment	Achievement Adjusted
INEOS2 UC Specification: Image recognition at Geel plant										
QT-IG-UC2-1	Human error on use of additives	KPI1_INEOS2	Decrease of 50%	1 error per annum	Manual lab Analysis.	Annually	Difficult to measure in a short timeframe. Requires at least 5 years to count the number of times a wrong additive is added and hence derive the no of errors per annum.	Not measured		
QT-IG-UC2-2	Manual adjustment rate	KPI2_INEOS2	< 1%	Not Applicable	Sometimes, the recognized product name or lot number needs to be correct because the label is read wrong or because the lot number is not known to the system. The OCR result is overridden, and this is indicated on the check-in item.	On demand All 244 usages of the latest version 1.3.2 (1/09/2023-30/10/2023)	0%	99% - Though there are no occurrences of manually adjusting the values, considering the short span of testing period, the actual achievement of KPI could be lesser	50	50
QT-IG-UC2-3	Necessary 2nd photo to be taken	KPI3_INEOS2	< 5%	Not Applicable	Sometimes, a second photo is needed because a mistake made that the label could not be recognized (e.g., blurred photo, glare on the label). The check-in item with the bad photo is abandoned in an "uncertain recognition" state.	On demand All 244 usages of the latest version 1.3.2 (1/09/2023-30/10/2023)	16%	33%	50	16.33
QT-IG-UC2-4	Downgraded product due to use of wrong additive	KPI4_INEOS2	0	same as line 6, a human error by default leads to downgraded product	Manual lab Analysis.	Annually	Same as QT-IG-UC2-1 - Difficult to measure in short span	Not measured		

3.5. INEOS Cologne: Challenges with Rheology Drift

The services aimed at addressing rheology drift at the Cologne site have encountered significant setbacks that have hindered their implementation. The main reason is that the current state of these services has not reached the necessary maturity to be effectively deployed in a high-pressure production plant. Despite the progress made during the research and development phase of the AI-PROFICIENT project, the critical confidence required for installation in an operational plant has not been achieved. Extensive collaboration with plant experts and LDPE technology specialists has not yet provided the necessary 100% confidence, thus postponing the implementation of services related to rheology drift at the INEOS Cologne site.

3.6. INEOS Geel: Hurdles in Reactor Stability

Simultaneously, the project in INEOS Geel, focused on overcoming challenges related to reactor stability, has faced equally substantial obstacles. While the AI-PROFICIENT project has yielded valuable insights into the complex dynamics of the horizontal reactor, creating a practical tool for implementation in the plant has proven to be a formidable challenge. The intrinsic complexity of the reactor dynamics has presented significant hurdles in concluding the development work of the digital twin and reactor model. This lack of conclusion currently hinders the feasibility of implementing the solution in the plant.

It is evident that, despite the valuable foundation provided by the AI-PROFICIENT project in both INEOS Cologne and INEOS Geel, specific challenges have impeded progress. The insufficient maturity of services to address rheology drift in Cologne and the persistent complexity in reactor stability in Geel have deferred practical implementation. Hence, further collaboration, review, and refinement are required to overcome these challenges and successfully carry out these projects in the future.

3.7. Results and conclusions

Use Case	Achievement Adjusted
CONTI-2 UC Specification: Restart Setup	90.9 %
CONTI-3 UC Specification: Released extrusion optimization	80.4 %
CONTI-5 UC Specification: Tread blade wear	40 %
CONTI-10 UC Specification: Quality analysis tool	87.5 %
Use Case	**Achievement Adjusted**
INEOS2 UC Specification: Image recognition at Geel plant	66.33 %

Regarding the results obtained in the key performance indicators (KPIs), we can say they are very positive, as on average, 70.27% of the expected outcomes were achieved, with a minimum of 40% obtained, but with 2 UC with more than of 87.5 % of success . These values indicate a solid and consistent performance in their operations, which is essential for the ongoing success of these projects in the market.

3.8. Evaluation of Requirements

3.8.1. End- User Requirement Result

The column Result in the table above contains the validation result for each End-User requirement. An end-user requirement can be validated by more than one KPI simultaneously, so this value represents the percentage sum of each KPI_ID achievement adjusted that satisfies it.

The following formula is applied to calculate compliance with end-user requirements by use case.

Result Value by Use Case = UR_ID1 Result + UR_ID2 Result + … + UR_IDN Result/ n_ Result

To achieve the desired outcome, a rating system has been employed where [0 represents no concrete achievement, and 5 indicates a task completely fulfilled].

To obtain a more nuanced evaluation, the mean of the assigned scores has been calculated. The mean provides a numerical value reflecting the average level of accomplishment in the assessed task or activity, considering all assigned ratings.

Once the mean is obtained, it has been decided to adjust the result to a scale of 0 to 10. To accomplish this, the calculated mean is multiplied by 2. This multiplication by 2 scales the results proportionally, maintaining the relationship between the scores and providing a broader scale where 0 signifies a total lack of achievement, and 10 indicates a task fully realized. This way, the result more finely reflects the performance or fulfillment of the evaluated task on a broader scale.

3.9. End user Requirements Continental

UR_ID	End User Requirement	Reference from D1.4	Link with KPI ID	RoI description of the validator	When it is validated	Result	Comments
CONTI 2 UC Specification: Restart Setup							
UR-C-UC2-1	Ensure the fastest setup.	UR1_CONTI2	QT-C-UC2-1; QT-C-UC2-2; QT-C-UC2-3; QT-C-UC2-4	Other	20/09/2023	3	Fastest setting to restart the machine are displayed. The ratio of optimized recipe (currently 25%) needs to be improved
UR-C-UC2-2	Propose optimal parameter settings.	UR1_1_CONTI2	QT-C-UC2-1; QT-C-UC2-2; QT-C-UC2-3; QT-C-UC2-4; QT-C-UC2-9	Other	20/09/2023	3	Fastest setting to restart the machine are displayed. The ratio of optimized recipe (currently 25%) needs to be improved
UR-C-UC2-3	Prognosticate the readiness of the Combiline	UR1_2_CONTI2	QT-C-UC2-9	Other	20/09/2023	2	The machine restart time is prognosticated but not displayed
UR-C-UC2-4	Ensure the less rework during the setup.	UR2_CONTI2	QT-C-UC2-5; QT-C-UC2-6; QT-C-UC2-7; QT-C-UC2-8	Other	20/09/2023	3	The ratio of optimized recipe (currently 25%) needs to be improved
UR-C-UC2-5	Propose optimal parameter sets.	UR2_1_CONTI2	QT-C-UC2-5; QT-C-UC2-6; QT-C-UC2-7; QT-C-UC2-8; QT-C-UC2-9	Other	20/09/2023	3	Operator can choose to apply or not the suggested parameter
UR-C-UC2-6	Must be retrainable in case of bad proposition	UR3_CONTI2	QT-C-UC2-9	Other	20/09/2023	2	Currently the model can only be retrained by Tekniker. It is needed for making the service sustainable that Continental can retrain the models
CONTI 3 UC Specification: Released extrusion optimization							
UR-C-UC3-1	Ensure the relaxation of the treads.	UR1_CONTI3	QT-C-UC3-1	Other	20/09/2023	3	The solution provides corrective settings when the extrusion is not any more relaxed
UR-C-UC3-2	Alert when some deviation occurs in the process that may lead to tension in the tread.	UR1_1_CONTI3	QT-C-UC3-1	Other	20/09/2023	4	When a deviation is detected, the information is displayed to the Operator via the HMI
UR-C-UC3-3	Identify the cause of the deviation	UR1_2_CONTI3	QT-C-UC3-2	Other	20/09/2023	3	The solution provides corrective settings when the extrusion is not any more relaxed
UR-C-UC3-4	Give the time remaining until the process reach bad quality product or breakdown.	UR1_3_CONTI3	QT-C-UC3-3	Other	20/09/2023	0	There is no time remaining until the process reach bad quality product or breakdown displayed
CONTI 5 UC Specification: Tread blade wear							
UR-C-UC5-1	Move towards predictive maintenance of the cutting system	UR1_CONTI5	QT-C-UC5-1; QT-C-UC5-2	Other	20/09/2023	4	The solution allows to move towards predictive maintenance
UR-C-UC5-2	Assess wear state of the blade.	UR1_1_CONTI5	QT-C-UC5-1; QT-C-UC5-2	Other	20/09/2023	4	Wear state is displayed

UR-C-UC5-3	Detect other causes of failure in cutting system.	UR1_2_CONTI5	QT-C-UC5-2	Other	20/09/2023	2	Other case of failure are identified (Material Jam, Water Jet)
UR-C-UC5-4	Improve cut quality.	UR2_CONTI5	QT-C-UC5-3	Other	20/09/2023	3	The weariness identification can improve the cut quality
CONTI 10 UC Specification: Quality analysis tool							
UR-C-UC10-1	Ensure the good quality of the production	UR1_CONTI10	QT-C-UC10-1	Other	20/09/2023	3	
UR-C-UC10-2	Detect deviation for the bad quality treads.	UR1_1_CONTI10	QT-C-UC10-1; QT-C-UC10-2	Other	20/09/2023	3	
UR-C-UC10-3	Identify the cause of the quality deviation	UR1_2_CONTI10	QT-C-UC10-1; QT-C-UC10-2	Other	20/09/2023	3	
UR-C-UC10-4	Optimize the current process parameter settings	UR2_CONTI10	QT-C-UC10-1	Other	20/09/2023	3	

3.10. End user Requirements INEOS

UR_ID	End User Requirement	Reference from D1.4	Link with KPI ID	RoI description of the validator	When it is validated	Result	Comments
INEOS2 UC Specification: Image recognition at Geel plant							
UR-IG-UC2-1	Ensure that the right additive big bag is used.	UR1_INEOS2	QT-IG-UC2-1; QT-IG-UC2-4	Production manager		5	till now tool performs well; longer testing period needed to get full confidence
UR-IG-UC2-2	Check the labels of the big bag.	UR1_1_INEOS2	QT-IG-UC2-1; QT-IG-UC2-2; QT-IG-UC2-3; QT-IG-UC2-4	Production manager		5	till now tool performs well; longer testing period needed to get full confidence
UR-IG-UC2-3	Have a friendly and fully reliable tool.	UR1_2_INEOS2	QT-IG-UC2-1; QT-IG-UC2-2; QT-IG-UC2-3; QT-IG-UC2-4	Production manager		4	scoring in line with operator survey described in D6.3; tool is OK, though potentially room for further improvement

3.11. Formula and conclusions

Use Case	Achievement Adjusted [0-5]	Achievement Adjusted [0-10]
CONTI- 2 UC Specification: Restart Setup	2.6	5.33
CONTI-3 UC Specification: Released extrusion optimization	2.5	5
CONTI-5 UC Specification: Tread blade wear	3	6
CONTI-10 UC Specification: Quality analysis tool	3	6
Use Case		**Achievement Adjusted**
INEOS2 UC Specification: Image recognition at Geel plant	4.66	9.33

The obtained results reflect the performance in different use cases, evaluated in terms of achievement and adjusted to a scale of 0 to 10. In the case of CONTI 2, an average of 2.6 out of 5 has been achieved, equivalent to an adjustment of 5.33 out of 10. CONTI-3, focused on extrusion optimization, received a rating of 2.5 out of 5, adjusting the score to 5 out of 10. Additionally, CONTI-5 and CONTI-10, related to tread blade wear and the quality analysis tool, achieved scores of 3 out of 5, adjusted to 6 out of 10.

However, outstanding performance is evident in the case of INEOS2, specifically in the use of image recognition specification at the Geel plant. This case has scored 4.66 out of 5, adjusted to an impressive figure of 9.33 out of 10. It is important to note that, despite these positive evaluations, a minimum score of 0 has been recorded in another use case. Immediate attention to this low score is crucial to avoid potential negative consequences, as there is no time remaining before the process reaches a low-quality product or breakdown. Addressing these results promptly will help maintain and improve process quality and prevent future issues.

3.12. Evaluation of Functional Requirements – General Information

The AI-PROFICIENT project has Functional Requirements that provide different functionalities to satisfy the end-user requirements. As in the previous section, these functional requirements are detailed in D1.4. A functional requirement can be validated by more than one UR_ID simultaneously, so this value represents the percentage sum of each UR_ID Result.

For example, if we have a FR_ID with three UR_IDs, we assume that the percentage value of the three for the fulfillment of the requirement is the same, and the result would be:

Result FR-C-UC2-1 = UR_ID1 Result * 0.33 + UR_ID1 Result * 0.33 + UR_ID3 Result * 0.33

If it is determined that any of the UR_IDs doesn't have the same weight to compliance of FR_ID, it can be added as a comment in the corresponding column and calculated with the specific value.

The following formula is applied to calculate compliance with functional requirements by use case.
A further explanation about the methodology is explained in D6.6

3.13. Functional Requirements Continental

FR_ID	Functional Requirement	Reference from D1.4	Link with UR_ID	RoI description of the validator	When it is validated	Result	Comments
CONTI 2 UC Specification: Restart Setup							
FR-C-UC2-1	Early anomaly detection on extruder restart (duration/setup).	FR1_CONTI2_EAR	UR-C-UC2-1; UR-C-UC2-4	Other	23/10/2023	3	
FR-C-UC2-2	Root cause identification of anomalies during past extrusion restart processes.	FR2_CONTI2_ROO	UR-C-UC2-2; UR-C-UC2-5	Other	23/10/2023	3	
FR-C-UC2-3	Extrusion restart model.	FR3_CONTI2_HYB	UR-C-UC2-1; UR-C-UC2-2; UR-C-UC2-3; UR-C-UC2-4; UR-C-UC2-5	Other	23/10/2023	3	There is no information about the variables and disturbance that affect the process
FR-C-UC2-4	Explainable decision support for operators	FR4_CONTI2_ETD	UR-C-UC2-1; UR-C-UC2-2; UR-C-UC2-3; UR-C-UC2-4; UR-C-UC2-5	Other	23/10/2023	4	Proposal of optimal parameter settings is done via the HMI. The operator can accept to follow or not the proposition and can indicate if the proposition was correct or not.
FR-C-UC2-5	Predictive production readiness assurance	FR5_CONTI2_PRE	UR-C-UC2-3	Other	23/10/2023	3	
FR-C-UC2-6	Human feedback on restart settings suggestion.	FR6_CONTI2_HUM	UR-C-UC2-1; UR-C-UC2-2; UR-C-UC2-4; UR-C-UC2-5; UR-C-UC2-6	Other	23/10/2023	4	
FR-C-UC2-7	Lifelong self-learning systems.	FR7_CONTI2_LSL	UR-C-UC2-1; UR-C-UC2-2; UR-C-UC2-4; UR-C-UC2-5	Other	23/10/2023	2	
FR-C-UC2-8	Display setting suggestion through interface	FR8_CONTI2_HUM	UR-C-UC2-1; UR-C-UC2-2; UR-C-UC2-3; UR-C-UC2-4; UR-C-UC2-5	Other	23/10/2023	5	Setting suggestion are displayed through the interface
CONTI 3 UC Specification: Released extrusion optimization							
FR-C-UC3-1	Monitor the components of the process that induce tension in the tread.	FR1_CONTI3_MON	UR-C-UC3-2; UR-C-UC3-3; UR-C-UC3-4	Other	23/10/2023	2	
FR-C-UC3-2	Detect deviation that may induce tension in the tread.	FR2_CONTI3_DIA	UR-C-UC3-2	Other	23/10/2023	3	
FR-C-UC3-3	Diagnosticate the potential component causing the deviation.	FR3_CONTI3_DIA	UR-C-UC3-3	Other	23/10/2023	3	
FR-C-UC3-4	Prognosticate the remaining useful life before tension in the tread reach unacceptable threshold or breakdown.	FR4_CONTI3_PRO	UR-C-UC3-4	Other	23/10/2023	0	
FR-C-UC3-5	Display information to the relevant user.	FR5_CONTI3_HUM	UR-C-UC3-2; UR-C-UC3-3; UR-C-UC3-4	Other	20/09/2023	3	
CONTI 5 UC Specification: Tread blade wear							
FR-C-UC5-1	Monitor quality of the cuts.	FR1_CONTI5_MON	UR-C-UC5-4; UR-C-UC5-5	Other	23/10/2023	0	Profilometer is not implemented
FR-C-UC5-2	Monitor cutting system.	FR2_CONTI5_MON_OPP	UR-C-UC5-1	Other	23/10/2023	0	Profilometer is not implemented
FR-C-UC5-3	Estimate cutting blade's health status.	FR3_CONTI5_HEA_OPP	UR-C-UC5-1; UR-C-UC5-2	Other	23/10/2023	3	Current wear state of the blade is displayed to the operator via the

							AI-PROFICIENT Human Machine Interface
FR-C-UC5-4	Diagnosticate causes of failure other than wear in the blade system.	FR4_CONTI5_DIA	UR-C-UC5-1; UR-C-UC5-3	Other	23/10/2023	2	
FR-C-UC5-5	Prognosticate the wear based on planned cuts.	FR5_CONTI5_PRO_OPP	UR-C-UC5-1	Other	23/10/2023	3	Weariness is prognosticated
FR-C-UC5-6	Display information to the relevant user in an understandable way.	FR6_CONTI5_HUM	UR-C-UC5-1	Other	23/10/2023	4	
FR-C-UC5-7	Integrate human feedback on algorithm development.	FR7_CONTI5_HUM	UR-C-UC5-1; UR-C-UC5-4	Other	23/10/2023	2	
CONTI 10 UC Specification: Quality analysis tool							
FR-C-UC10-1	Process monitoring	FR1_CONTI10_MON	UR-C-UC10-1	Other	23/10/2023	3	SDMM SPAA
FR-C-UC10-2	Root cause identification	FR2_CONTI10_ROO_GEN_ETD	UR-C-UC10-3	Other	23/10/2023	2	SPAA, PEAA
FR-C-UC10-3	Early anomaly detection	FR3_CONTI10_EAR	UR-C-UC10-2	Other	23/10/2023	3	SDDM, SPAA
FR-C-UC10-4	Quality metrics prediction	FR4_CONTI10_HYB_ETD	UR-C-UC10-3	Other	23/10/2023	3	SDDM
FR-C-UC10-5	Decision support regarding retuning of control parameters in the process (based on holistic generative optimization approach)	FR5_CONTI10_GEN	UR-C-UC10-1; UR-C-UC10-4	Other	23/10/2023	3	GHO
FR-C-UC10-6	User interface	FR6_CONTI10_HUM_ETD	UR-C-UC10-1	Other	23/10/2023	3	HMI
FR-C-UC10-7	Human feedback on provided recommendations	FR7_CONTI10_HUM	UR-C-UC10-1	Other	23/10/2023	2	SPAA

3.14. Functional Requirements INEOS

FR_ID	Functional Requirement	Reference from D1.4	Link with UR_ID	Rol description of the validator	When it is validated	Result	Comments
INEOS2 UC Specification: Image recognition at Geel plant							
FR-IG-UC2-1	Detect when the label on the big bag and therefore the additive does not match the one to be used in the quality system.	FR1_INEOS2_DIA	UR-IG-UC2-1; UR-IG-UC2-4		20/10/2023	5	
FR-IG-UC2-2	Display information to the relevant user in an understandable way.	FR2_INEOS2_HUM	UR-IG-UC2-3		20/10/2023	4	Potentially some room for further optimization
FR-IG-UC2-3	Integrate human feedback.	FR3_INEOS2_HUM	UR-IG-UC2-3		23/10/2023	5	

3.15. Formula and conclusions

Use Case	Achievement Adjusted [0-5]	Achievement Adjusted [0-10]
CONTI- 2 UC Specification: Restart Setup	3.375	6.75
CONTI-3 UC Specification: Released extrusion optimization	2.2	4.4
CONTI-5 UC Specification: Tread blade wear	2	4
CONTI-10 UC Specification: Quality analysis tool	2.71	5.428
Use Case	**Achievement Adjusted**	
INEOS2 UC Specification: Image recognition at Geel plant	4.66	9.33

The obtained results showcase the performance in different use cases, evaluated in terms of achievement and adjusted on a scale from 0 to 10. In the case of CONTI-2, an average of 3.375 out of 5 has been achieved, equivalent to an adjustment of 6.75 out of 10. In comparison, CONTI-3, focused on extrusion optimization, received a rating of 2.2 out of 5, adjusting the score to 4.4 out of 10. Similarly, CONTI-5 and CONTI-10, related to tread blade wear and the quality analysis tool, achieved scores of 2 out of 5, adjusted to 4 out of 10, and 2.71 out of 5, adjusted to 5.428 out of 10, respectively.

Noteworthy is the exceptional performance in the case of INEOS2, specifically in the use of the image recognition specification at the Geel plant. This case scored 4.66 out of 5, adjusted to an outstanding figure of 9.33 out of 10. It is relevant to mention that, despite these positive evaluations, a minimum score of 0 has been recorded in other use cases, such as CONTI-3 and CONTI-5. This contrast emphasizes the importance of addressing identified areas for improvement, as these low scores could negatively impact overall performance. Consideration of these results will aid in optimizing and strengthening the implementation of use cases in the future.

4. General overview

Use Case			
CONTI-2 UC Specification: Restart Setup			**Final value 6.825**
	Value	Importance	
Qualitative Results (End user requirements, Functional requirements	5.975	30%	1.7925
Quantitative Results (KPI)	9.09	20%	1.818
Human Feedback	6.4	35%	2.24
Ethical approach	6.5	15%	0.975
CONTI-3 UC Specification: Released extrusion optimization.			**Final value 6.064**
Qualitative Results	4.7	50%	2.35
Quantitative Results	8.04	10%	0.804
Human Feedback	6.6	10%	0.66
Ethical approach	7.5	30%	2.25
CONTI-5 UC Specification: Tread blade wear			**Final value 6.05**
Qualitative Results	5	25%	1.25
Quantitative Results	4	10%	0.4
Human Feedback	7.6	50%	3.8
Ethical approach	4	15%	0.6
CONTI-10 UC Specification: Quality analysis tool			**Final value 7.21**
Qualitative Results	5.714	35%	1.99
Quantitative Results	8.75	20%	1.75
Human Feedback	6.6	20%	1.32
Ethical approach	8.6	25%	2.15
INEOS2 UC Specification: Image recognition at Geel plant			**Final value 7.349**
Qualitative Results	9.32	25%	2.33
Quantitative Results (	6.6	25%	1.66
Human Feedback	6.4	25%	1.6
Ethical approach	7	25%	1.75

The results of the use cases exhibit significant variability in the final ratings, reflecting the weighted evaluation of various key aspects, as the overall mean of the obtained results has been 6.6996. Furthermore, the lowest result is recorded in CONTI 5 with a final value of 6.05, while the highest result is obtained in the case of INEOS, with a final value of 7.349. These variations reflect differences in the weighting of criteria and offer valuable insights to prioritize areas for improvement and strengths in each use case.

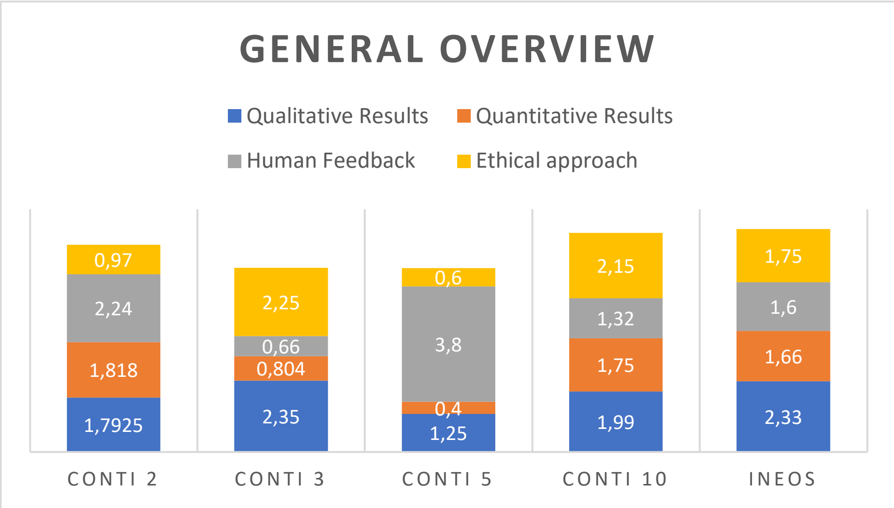
5. Lessons learnt

DESCRIPTION	AI-PROFICIENT
Stablish strong baseline before implementing any changes	To accurately measure the results of software that improves plant productivity, it is important to have a solid baseline with sufficient time depth that allows measurements to be made based on either actual production measurements or statistical measurements based on history.
Collecting and homogenizing data from the previous year allows for a clear comparison of the impact of AI interventions.	To accurately test the outcomes of software, it is crucial to determine if there is temporality in production and the features being modelled by ML. This ensures that measurements are precise and avoids temporal biases. Additionally, it is essential to reflect upon any alterations in the plant's production during the period in question, which could distort the data obtained.
Ensure that production technicians are involved throughout the project to provide valuable insight into the practicalities of implementation and to assist in extrapolating short-term results to long-term impacts	Feedback from operators who will use the product is crucial, both to increase their satisfaction with the product and to measure its usefulness under production conditions.
Develop different use cases, each targeting specific problems in the production process. This approach allows for a more targeted implementation of AI, leading to a more significant overall impact	In interconnected industrial processes, it is crucial that the UCs tackle specific parts of the process, which can be isolated from the rest to measure the impacts obtained. In this regard, for example, Continental decided to develop several UC over the same production line (Combiline) , thus obtaining much more specific results than if a single, more complex case of use had been planned.
Close collaboration between researchers and industrial partners is critical to ensure that the project's objectives align with the business's long-term goals and that the proposed solutions are practical and feasible for implementation in an industrial setting.	To avoid the development of ideas that, although academically and technologically relevant, lack practical application in the production line, it is crucial to orient them with use cases. This has been successfully achieved in the case of AI-PROFICIENT . There needs to be a technical co-leadership between developers and potential industrial end-users, in this case Continental and INEOS, to provide valuable feedback on the results obtained and their potential use in production in the future.
Build explainable AI models: Transparency and interpretability are vital in industrial settings. When using AI, aim to build models that provide explanations for their decisions and recommendations. This enables operators and decision-makers to understand the reasoning behind AI-driven suggestions and make informed choices	It is very important that the plant operators who are going to use the tools understand how to use them and what the recommendations are and why they are being made. In this sense, within AI-PROFICIENT , different efforts have been made to have a common HMI, which facilitates a common way of interacting with the basic parameters of the models in the case of CONTI, which is where several use cases interact. In addition, different XAI explainability efforts have also been carried out, in which work has been done both

	from a technological and functional point of view in joint teams. The results of the end-user perception corroborate that the efforts made have had a positive impact on the users' perception of the results obtained.
Successful AI implementation in industrial processes requires collaboration across different teams and departments. Encourage communication, knowledge sharing, and cross-functional collaboration to ensure that AI solutions are effectively integrated into the existing workflow and embraced by the workforce.	In order to achieve adequate technological solutions, it is necessary to have an interaction between the different roles of the project. In this sense, AI-PROFICIENT has worked in a trilateral way, with both industrial partners' personnel and software developers' representatives working together, supported by ethics experts, to ensure that the alignment between these pillars of the project is maintained. This unconventional collaboration was one of the keys to the project's success.
Manage expectations: Set realistic expectations regarding the capabilities and limitations of AI technologies, avoiding overpromising or underdelivering.	In software projects, especially those like AI-PROFICIENT which are RIA, it is crucial to manage expectations as industrial partners may require very high TRL to deploy in the field, which the developed solutions do not provide. To address this, various meetings were held during the project to explain what will be delivered. However, these expectations remain one of the biggest challenges faced by AI-PROFICIENT.

6. Conclusions

The comprehensive evaluation of use cases (UC) within the AI-PROFICIENT project has revealed significant variations in final ratings, highlighting the nuanced assessment of qualitative and quantitative factors. The thorough analysis yielded a global average score of 6.6996, indicating moderately positive performance across a diverse range of scenarios.
Delving into specific use cases, CONTI 5 emerged with the lowest final value of 6.05, shedding light on areas that require attention and improvement. The inability to implement the profilometer in this case resulted in a notable decrease in the functional requirements section, carrying substantial weight of 25% in the overall rating.
In stark contrast, INEOS demonstrated the highest level of performance with an outstanding final value of 7.349, emphasizing its efficiency in various evaluated aspects. Particularly noteworthy was its proficiency in the functional requirements section, where it received multiple ratings of 5 for its ability to detect errors according to expected labels within the quality system.



Similarly, CONTI 2 stood out with exceptional results in the Key Performance Indicators (KPI) section, ensuring a notable score of 9/10. The final measures of 0.01 on average, 0.009 for short extrusion, and 0.223 for long extrusion showcased an impressive level of operational efficiency.
However, CONTI 3 slightly deviated from anticipated results, falling short in the qualitative results segment. The inability to foresee the remaining lifespan before the belt tension reaches an unacceptable threshold or fails, coupled with insufficient time to address issues before the production process results in low-quality outcomes or breakdowns, contributed to this deviation.
Finally, turning our attention to CONTI 10, the results were generally commendable, particularly standing out in the section measuring quantitative outcomes. Achieving a score of 8.75 out of 10, the project successfully met its goal of reducing waste by 100%, indicating a robust and effective implementation.
In summary, this comprehensive evaluation aligns perfectly with the predefined objectives outlined in Deliverable D6.6, a publicly accessible document within the AI-PROFICIENT project framework, specifically located in WP6. This deliverable, situated in T6.2, focuses on meticulous validation analysis of use cases and the comprehensive development of detailed reports. The methodology was established in Task 6.1 , and it has proven instrumental in systematically collecting and examining data derived from various tasks and demonstration scenarios, providing valuable insights for the overall assessment of project outcomes.

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