AI·PROFICIENT
Artificial intelligence
for improved production efficiency,
quality and maintenance

Deliverable 6.6

D6.6: AI-PROFICIENT Validation methodology (final version)

WP6: Use case evaluation and ethical considerations

T6.1: Validation methodology, ethical and acceptance criteria.

Version: 1.0

Dissemination Level: PU

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Executive Summary

Deliverable D6.6 is a public document of the AI-PROFICIENT project delivered in the context of WP6 "Use case evaluation and ethical considerations" and, more specifically, T6.1: Validation methodology, ethical and acceptance criteria, relating to the creation of a validation methodology. It is the final version of deliverable D6.1, and the aim is to provide a complete procedure and ways to validate the initially proposed methodology.

This Deliverable is providing the required information to support the revision asked by EU for D6.1. (methodology should be more detailed and developed, evaluation KPIs to be provided).

This methodology intends to establish objective measurement criteria for the results obtained in the AI-Proficient project. These criteria will enable measuring the results obtained in the different use cases. We have worked with the information gathered mainly in WP1 "Pilot site characterization, requirements, and system architecture" and, more specifically, in D1.4 "Project requirements and performance assessment KPIs" which incorporates the list and description of the different user requirements related to the use cases.

As it is the final version of deliverable D6.1 already presented, where we explain the purpose of creating a generic methodology that allows measuring the compliance of the different AI modules developed and implemented in an industrial environment, this deliverable will contain information related to it. It also modifies some sections because in these months and during the meetings of task 6.1 with the other partners involved, we have agreed on the best way to measure the different indicators that will validate the use cases.

This deliverable will complete the proposed methodology and the starting point for the rest of the tasks in the WP6 work package. This methodology will be applied at the use case level as part of task T6.2 "Use case analysis and validation report". The user experience and the interaction with the applications developed in the project will be measured in Task 6.3: "Qualitative evaluation of the user experience and feedback." The proposed ethical aspects will be developed in Task 6.4, "Exemplification of the HLEG ethical guidelines and recommendations."

1 Introduction

This deliverable aims to complete the validation methodology proposed in D6.1 for the AI-PROFICIENT project. Although it will only be used in the context of the AI-Proficient project, we wanted to provide a basis for future industrial projects where it is necessary to measure the impact of AI in production environments.

We will measure the impact on three main typologies:

- **Production level:** At this level, production performance and product quality will be evaluated. This evaluation can be carried out at different stages of a product. This will mean being able to cover the product engineering phase through the introduction of new products/tests in production lines, as well as the planning and operation of production lines. In turn, this level can also be measured at two levels.
    - The first level will measure the impact of a use case at a specific location in the production line/facility. It will be a use case by use case approach. At this level, **end-user and functional requirements** compliance will also be measured.
    - The second level will be related to the collective impact of several use cases on the same production line/ facility. This level will measure the effect **as a whole.**
    - Within this typology, we will use **quantitative criteria** that will allow measurement objectively.
- **User-level experience:** It will define the data to be collected, the means to collect it, the roles from which the data should be collected, e.g., operators, plant personnel, etc., and when it should be collected. We will use **qualitative** criteria that will be measured subjectively.
- **Ethical approach leve**l This section will cover both the ethical impact of the results in the workplace and the compliance with the ethical advice given to the different use cases.

Different formulas have been designed to allow a comparative evaluation of the numerical results of the three assessment levels to homogeneously assess the real impact of each use case individually and as a whole.

As mentioned above, the outcome of this task will be a harmonized validation methodology capable of providing an impact assessment procedure at different levels of the application of an AI-based solution, such as AI-PROFICIENT, to both the project plants and possible future industrial cases.

2 Measuring the impact on a use cases basis

This section aims to lay the groundwork for measuring AI-Proficient performance at the use case level. This evaluation will be calculated at different levels. The overall result of a use case will be measured by the quantitative results of compliance with production indicators, user requirements, and functional requirements, the qualitative results of the user experience, and compliance with ethical aspects.

In the initial version, it was proposed to measure the performance of the AI models individually within the use cases. However, after studying the impact of the AI models on the solutions of the different use cases, we have agreed to measure their efficiency within the fulfillment of the KPIs since the models respond directly to the stated objectives.

2.1 General Information

For each of the use cases, the following information will be collected

- **Description** of the use case identifying the current and target situation.
- **Maturity to be achieved**: Initial development validation, experimental (non-functional) pilot, limited pilot, final roll-out.
- **Goal of the use case**: Concise and, if possible, numerical description of the purpose of the use case.

2.2 Production Level – Key Performance Indicators

2.2.1 General information

This section aims to measure the performance of the key performance indicators (KPIs). Quantitative criteria have been defined for them that make it possible to objectify the progress of these indicators. The intention is to establish standards to improve industrial parameters: speed, quality, etc. And later, use these indicators to verify the compliance of the functional and end-user requirements of the project.

For the AI-Proficient project, the KPIs are detailed in Deliverable D1.4, and we have used these to calculate the quantitative compliance criteria.

KPI_ID	ID	Meaning
Quantitative	QT	Quantitative
Identification of the industrial site	C	Continental
	IC	Ineos Cologne
	IG	Ineos Geel
Use Case	UCX	Use Case Number
Identifying ID	X	Number

Table 1 : Identifiers for Quantitative Evaluation

Additional information should also be collected to provide context for the collection process itself. This **context informatio**n is

- **How and when has this variable been collected?** The same use case can be deployed multiple times, so it is necessary to keep track of the results to be able to see the evolution of the use case.
- **Have there been any changes in the plant that may affect the KPI since the Baseline was measured?** If the answer is yes, a new baseline will need to be collected, and a new historical series of results will need to be started.

A table that collects all this information for each use case has been created to determine the quantitative results. Also, it includes the **final value measurement** and the **percentage of achievement** it would have at that time.

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	Changes in the plant	Description of the changes

Table 2 : Quantitative Results Information

The **coefficient of adjustment** of the table above will be the value that allows adjusting the importance of compliance with a specific KPI compared to the rest in the use case. Meanwhile, **achievement adjusted** will be the adjusted percentage on that KPI due by multiplying the achievement percentage with the adjustment coefficient. The **total sum of all the adjusted achievements** will represent the percentage of fulfillment of the use case.

The annexes of this document include in section 6.1 the quantitative information related to each use case of the AI-Proficient.

2.2.2 Quantitative Evaluation Result

The calculation of the percentage of improvement for the current state of the process affected by the use case will be carried out according to the following method:

- Each QTIDX is assigned a **coefficient of adjustment** out of the total 100 in percentage.
- Each QTIDX is assigned a value as an **% of achievement**.
- The **value of achievement adjusted** for each KPI is: QTIDX % of achievement x coefficient of adjustment.

Quantitative Result Value by Use Case =

(QT-C-UCX-1 achievement adjusted) + (QT-C-UCX-2 achievement adjusted) + (QT-C-UCX-4 achievement adjusted) + (…) + (QT-C-UCX-N achievement adjusted)

2.3 Evaluation of End-User Requirements

2.3.1 General Information

The evaluation of the end user's requirements will be carried out by validating compliance with the KPIs. Deliverable D1.4 includes the End-User requirements for each use case. Also, it contains the direct link between the KPIs it satisfies. We have used this information to complete a new table for evaluating end-user requirements.

UR_ID	ID	Meaning
User Requirement	UR	User Requirement
Identification of the industrial site	C	Continental
	IC	Ineos Cologne
	IG	Ineos Geel
Use Case	UCX	Use Case Number
Identifying ID	X	Number

Table 3 : Identifiers for User Requirements Evaluation

The table below contains the information concerning each End-User Requirement defined in D1.4. In this case, the KPI_ID defined in section 2.2.1 will be used to complete the link between

KPIs and UR_ID. If any UR_ID doesn't have a direct KPI to verify its compliance, we have considered one of these options:

- Add one of the existing KPI_IDs to the use case.
- Create a new KPI_ID to satisfy this user requirement and incorporate it into the corresponding table in section 2.2.1.

UR_ID	End User Requirement	Reference From D1.4	Link with KPI ID	RoI description of the validator	When it is validated	Result	Comments

Table 4 : End-User Requirements Evaluation

The corresponding tables to End-User Requirements and the links between these and the KPI_ID will be found in the annexes, section 6.2.

2.3.2 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.

For example, if we have a UR_ID with four KPI_IDs, we will assume that the percentage value of the four for the fulfillment of the requirement is the same, and the result would be:

Result UR-C-UC2-1 = KPI_ID1 achievement adjusted * 0.25 + KPI_ID2 achievement adjusted * 0.25 + KPI_ID3 achievement adjusted * 0.25 + KPI_ID4 achievement adjusted * 0.25

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

The following formula will be 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.

2.4 Evaluation of Functional Requirements

2.4.1 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.

FR_ID	ID	Meaning
Functional Requirement	FR	Functional Requirement
Identification of the industrial site	C	Continental
	IC	Ineos Cologne
	IG	Ineos Geel
Use Case	UCX	Use Case Number
Identifying ID	X	Number

Table 5 : Identifiers for Functional Requirements Evaluation

The way to validate the functional requirements is the same as in the previous section because we find in D1.4 a direct relationship between the end user requirements and these. Thus, the following table represents the link between FR_ID and UR_ID, through which it will, in turn, have an indirect relationship with the KPIs.

FR_ID	Functional Requirement	Reference From D1.4	Link with UR_ID	RoI description of the validator	When it is validated	Result	Comments

Table 6 : Functional Requirements Evaluation

In this case, we will also complete the table with the results presented in D1.4, and if any end-user requirement doesn't cover a functional requirement, we will add one of those already created for the use case. In the annexes, section 6.3 contains the corresponding tables of functional requirements tables for each use case. It is important to note that some use cases can redefine some KPI or user requirements so that these tables may be modified throughout the project's development.

2.4.2 Functional Requirement Result

The Functional Requirement Result has the same behavior as section 2.4.2. In this case, 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.

If we have a FR_ID with three UR_IDs, we will 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 will be applied to calculate compliance with functional requirements by use case.

Result Value by Use Case = FR_ID1 Result + FR_ID2 Result + … + FR_IDN Result.

2.5 Evaluation of User Experience

2.5.1 General Information

The section aims to repeatedly and continuously measure the users' perceptions of the application and their interaction with it. The criteria to be measured will be usability, usefulness, learning curve, etc.

To carry it out, various surveys will be carried out among the different users who interact with the HMI. These questions will focus on the impact of the developments on daily work, the easy use of the applications, their usefulness in solving day-to-day problems, etc. Some of these questions could be:

- Does the proposed AI-based solution provide information on the estimated cause of a specific product feature?
- Are these recommendations and the estimation of the potential cause presented in an understandable and user-friendly way?

Additional information should also be collected to provide context on the collection process:

- **Frequency of collection**. A priori, these questions will be asked the first time once the solution is deployed in an industrial process. Once the first survey has been carried out, other surveys will be carried out periodically (monthly, bimonthly, quarterly). These repeat surveys will determine whether implementing corrective actions improves user perception in case of negative feedback after a study and whether the changes improve user use of the solution.
- **Which Tools are used to display the survey?** Mail, web.
- **TimeLine.** It is necessary to define when the different survey phases are carried out. These phases are:
    - Invitation
    - Survey Phase
    - Evaluation Phase
    - Results Sharing. At this stage, it is necessary to define the template of actions and the information to share the results.
- **Actions**. The results of the surveys will be communicated to selected roles within a set timeframe. Where the survey reveals user dissatisfaction, the results will be complemented with an action plan to improve the user experience with the solution.
- **Date** when it was measured.
- **Role**. Although it is not necessary to know who has filled in the survey, it is advisable to know the worker's role within the plant (operator, maintenance, quality, manager, etc.).

Role-ID	RoI Description	Description of the interaction

Table 7 : Roles involved in User Experience Evaluation

The following table shows which codes will be used to construct the identifiers.

UX_ID	ID	Meaning
Qualitative	QUA	Qualitative
Identification of the industrial site	C	Continental
	IC	Ineos Cologne
	IG	Ineos Geel
Use Case	UCX	Use Case Number
Identifying ID	X	Number

Table 8 : Identifiers for User Experience

An instance of the following table will be filled in with information about the qualitative results at different times: first deployment, successive deployments, after training workers, etc. This will make it possible to measure the impact that changes in the use case have on the users' perception concerning the use case. It will be collected when and by whom the information is collected.

The rating of the results will range from

- Strongly disagree 1
- Disagree 2
- Neutral 3
- Agree 4
- Strongly agree 5

A set of questions has been developed to use as a quiz, and initially, it would be the same for each use case. However, these can be customized. For example, for Ineos Geel, it has been modified as a suggestion from the partner himself. The questionnaires are detailed below:

UX_ID	Description	Result
QUA-C-UCX-1	Do you think that AI displays helpful information for your job?	
QUA-C-UCX-2	Do you think the AI provides information at an optimal periodicity?	
QUA-C-UCX-3	Do you think AI provides enough information in advance to be useful?	
QUA-C-UCX-4	Does the solution capture the feedback from the user?	
QUA-C-UCX-5	Does the solution display information to the relevant user in an understandable way?	
QUA-C-UCX-6	Do you believe that AI provides accurate information?	
QUA-C-UCX-7	Does the proposed solution reduce the number of corrective actions to be taken by the operators?	
QUA-C-UCX-8	Do you think that the information provided by AI improves the process in any significant way?	
QUA-C-UCX-9	Do you think the recommendations provided by AI could negatively impact another segment of the production process?	
QUA-C-UCX-10	Do you think that the information provided by the AI helps to understand the line's functioning better?	
QUA-C-UCX-11	Does the system offer explanations of the recommendations so that trustworthiness in the AI system is ensured?	

Table 9 : Qualitative Evaluation Result of Continental

UX_ID	Description	Result
QUA-IG-UC1 -1	Do you think that AI offers display information useful for your job?	
QUA-IG-UC1 -2	Do you think the AI provides information at an optimal periodicity?	
QUA-IG-UC1 -3	Do you think AI provides enough information in advance to be useful?	
QUA-IG-UC1 -4	Does the solution capture the feedback from the user?	
QUA-IG-UC1 -5	Does the solution display information to the relevant user in an understandable way?	
QUA-IG-UC1 -6	Do you believe that AI provides accurate information?	
QUA-IG-UC1 -7	Do you think that the information provided by AI improves the process in any significant way?	
QUA-IG-UC1 -8	Do you think that the information provided by the AI helps to understand the line's functioning better?	
QUA-IG-UC1 -9	Does the system offer explanations of the recommendations so that trustworthiness in AI system is ensured?	

Table 10 : Qualitative Evaluation Result INEOS Geel UC1

UX_ID	Description	Result
QUA-IG-UC2-1	Is the AI Proficient tool easy to handle/manipulate on the work floor?	
QUA-IG-UC2-2	Is the AI Proficient tool reliable ('photo first time right')?	
QUA-IG-UC2-3	Does the AI Proficient tool reduce human errors?	
QUA-IG-UC2-4	Would you be in favor of deploying the AI Proficient tool in other similar use cases?	
QUA-IG-UC2-5	Do you trust the AI Proficient tool?	

Table 11 : Qualitative Evaluation Result INEOS Geel UC2

UX_ID	Description	Result
QUA-IC-UC3-1	Do you think that AI displays helpful information for your job?	
QUA-IC-UC3-2	Do you think that the AI feedback is provided in a tolerable timeframe?	
QUA-IC-UC3-3	Do you think AI provides enough information in advance to be useful?	
QUA-IC-UC3-4	Does the solution capture the feedback from the user?	
QUA-IC-UC3-5	Does the solution display information to the relevant user in an understandable way?	
QUA-IC-UC3-6	Do you believe that AI provides accurate information?	
QUA-IC-UC3-7	Does the proposed solution reduce the number of corrective actions to be taken by the operators?	
QUA-IC-UC3-8	Do you think that the information provided by AI improves the process in any significant way?	
QUA-IC-UC3-9	Do you think the recommendations provided by AI could negatively impact another segment of the production process?	
QUA-IC-UC3-10	Do you think that the information provided by the AI helps to understand the line's functioning better?	
QUA-IC-UC3-11	Does the system offer explanations of the recommendations so that trustworthiness in the AI system is ensured?	

Table 12 : Qualitative Evaluation Result INEOS Cologne UC3

Considering the possibility of customizing the user experience for each use case, a table has been included for all the new proposed questions.

ID	USE-CASE-ID	Question	Rol-ID	Result

Table 13 : Questions Proposed for User Experience Evaluation

2.5.2 Qualitative Evaluation Result

The following method is proposed to calculate the percentage of qualitative compliance, assuming that each question will have the same weight in the qualitative evaluation. If this is not fulfilled, a 'Weight' column will be added to the previous tables, indicating the corresponding value. In the formula, the result of each question would be multiplied by the weight in question.

Qualitative Result Value by Use Case =

(QUA-C-UCX-1 Result *1/NQ) + (QUA-C-UCX-2 Result *1/NQ) + (…) + (QUA-C-UCX-11 Result *1/NQ)

*__NQ__ number of questions

2.6 Ethical approach

2.6.1 General Information

This section aims to determine AI solutions' ethical impact on operators and their working practices. The approach proposed will be designed to be used by industrial partners.

As part of WP6, Deliverable 6.4 will be developed and will not be limited to completing this questionnaire. Still, it will include a more detailed approach to the ethical impact of AI in real-life scenarios. It will aim to support ethicists who may be involved in future projects.

The following table shows which encodings will be used to construct the identifiers, which will allow distinguishing the different elements of the tables.

Eth_ID	*ID*	*Meaning*
Ethics	ETH	Ethics
Identification of the industrial site	C	Continental
	IC	Ineos Cologne
	IG	Ineos Geel
Group	GAI	General AI/Operator(s) interaction
	ERRH	Error Handling
	WkL	Identification and minimization of (additional) workload
	IN	Facilitate interaction/engagement with the AI system
	EtbD	Ethics by Design Developer and Industrial Partner Engagement
Identifying ID	X	Number

Table 14 : Identifiers for Ethical outcomes

If necessary, this information can be collected on more than one occasion for the same technological development, reflecting the impact of possible deployments of the technical developments in the different phases of a specific industrial process, such as design, engineering, production, etc.

Not all questions apply to all situations in an industrial process. Therefore, during task 6.4, they will be adapted to the casuistry of each development by filling in those deemed necessary.

Additional information should also be collected to provide context on the collection process. This **context informatio**n is

- **Date** when it is carried out: This procedure can be applied at different stages in the life process, from engineering to series production. It can be deployed at different maturity levels.
- **Responsible Partner(s)** who are the partners involved in the development.

2.6.2 Ethical Questionnaire

The Ethical questionnaire will be divided into five main groups, which will make it possible to assess the different ethical impacts will have the deployment of the project. Each group will have a specific weight. Each question will get a value of 0 or 1, depending on whether it has been fulfilled. The compliance's final value in a group will be the percentage of the sum of all the results concerning the total number of questions in the group. The column Method Used indicates how the information will be validated: survey, by the person in charge, etc.

The following subsections show ethical questionnaires, taking Continental's use cases as an example. The tables referring to the ethical questionnaires of the INEOS use cases have been found in annexes section 6.4.

2.6.2.1 General AI/Operator(s) interaction

Total weight of Group 1: X%

ID	Description	Result (Y/N)	Method Used
ETH-C-GAI-1	Are the limits of the AI and the operators' actions clear?		
ETH-C-GAI-2	Is there more than one human role involved? If so, has the chain of responsibility been clearly defined?		
ETH-C-GAI-3	Is it defined who/when/how receives the information from the AI system?		
ETH-C-GAI-4	Is it defined which the degree of flexibility of the operators?		
ETH-C-GAI-5	If not, is the operator expected always to follow the AI approach?		
ETH-C-GAI-6	Are there situations where the default control is only human, e.g., alerts?		
ETH-C-GAI-7	Have the risks of the user giving a default acceptance been assessed?		
ETH-C-GAI-8	Has it been considered who (e.g., operator, process engineer, maintenance) is best placed to undertake the new AI-related task based on the time and space considerations of the work context?		
ETH-C-GAI-9	Where used, have the targets of control concepts been specified, e.g., if HITL, who is the human?		
ETH-C-GAI-10	When the AI use is exploratory and engaging processes beyond operator/engineer human capacity, are the related limitations to responsibility formally clarified?		

Table 15 : General AI/Operator(s) interaction

2.6.2.2 AI Errors handling

Total weight of Group 2: X%

ID	Description	Result (Y/N)	Method Used
ETH-C-ERRH-1	Is there an AI error-handling protocol?		
ETH-C-ERRH-2	If so, which role should manage each process step has been defined?		
ETH-C-ERRH-3	Is it defined which are the guidelines to continue the production process in case of an AI error?		
ETH-C-ERRH-4	Is it defined as what feedback the human should give the system in case of an error?		
ETH-C-ERRH-5	Is it defined how to handle incorrect feedback from the operator to the system as the origin of the failure?		

Table 16 : AI Errors Handling

2.6.2.3 Identification and minimization of (additional) workload

Total weight of this Group 3: X%

ID	Description	Result (Y/N)	Method Used
ETH-C-WkL-1	Has a maximum reaction time been defined for the testing period / normal working period?		
ETH-C-WkL-2	Has it been determined which role the end-user of the tool is?		
ETH-C-WkL-3	Has the additional workload of using the tool been estimated?		
ETH-C-WkL-4	Has resistance to the use of AI been assessed and measured?		
ETH-C-WkL-5	Have measures been considered to minimize this resistance?		
ETH-C-WkL-6	Is the user forced to accept the outcome of the tool?		
ETH-C-WkL-7	Have the operator's previous workload/task expectations been formally adjusted in view of additional time required for new tasks		
ETH-C-WkL-8	Has it been clarified who will undertake processing tasks for AI training and feedback: e.g., marking images?		

Table 17 : Identification and minimization of (additional) workload

2.6.2.4 Facilitate interaction/engagement with the AI system

Total weight of Group 4: X%

ID	Description	Result (Y/N)	Method Used
ETH-C-IN-1	Has a phased deployment approach been considered?		
ETH-C-IN-2	Will operator involvement be gradual and phased?		
ETH-C-IN-3	Will there be a specific training period?		
ETH-C-IN-4	If the system involves the use of specific hardware, is there an assessment of the ergonomic impact of its use?		

ETH-C-IN-5	Are the interfaces redundant?		
ETH-C-IN-6	Has fatigue in the use of automatic decision-making tools been assessed? Have any mitigation measures been considered?		
ETH-C-IN-7	Have choices of XAI been tailored to the primary user?		

Table 18 : Facilitate interaction/engagement with the AI system

2.6.2.5 Ethics by Design Developer and Industrial Partner Engagement

Total weight of this category 5: X%

ID	Description	Result (Y/N)	Method Used
ETH-C-EtbD-1	Have tech developers worked directly with operators from the prototype stages to understand their needs in HMIs and XAI terms? (Y/N)		
ETH-C-EtbD-2	Do diagrams and figures in Deliverables specify which people are carrying out tasks? (Y/N)		
ETH-C-EtbD-3	Has written content avoided anthropomorphizing the AI?		
ETH-C-EtbD-4	Has the work team cohesion been monitored after AI integration?		
ETH-C-EtbD-5	Have operators and process engineers been formally notified about how their roles will change after AI integration?		

Table 19 : Ethics by Design Developer and Industrial Partner Engagement

2.6.3 Ethical Recommendations Validation Format for Deliverable 6.4

2.6.3.1 Discussion of Deliverable 6.4 Validation Strategy

Ethical validation in Deliverable 6.4 will follow the spirit of the ethical approach adopted throughout the project. That approach, as outlined in Deliverable 1.2[1], has been centered around the embeddedness of the ethics team, working from the ground up and favoring applied ethics practices with direct formal recommendations to AI-Proficient project partners.

Embeddedness means that we have striven to work directly with the project partners as they developed the AI service solutions, reviewing them and discussing issues as they arose. This included visits to the industrial partner plants to observe the operators and to attend as many technical meetings as was feasible.[2] The meetings included weekly technical meetings between developer partners, but also special meetings requested by developer or industrial partners, in person or over the video, to review particular aspects and ask our opinion.

Ground-up means that we have not tried to impose high-level principles upon the project partners but instead have tried to draw the ethical issues out of the solution development contexts. From there, we have highlighted the links to higher level principles, e.g., the GDPR, or HLEG, when possible, by providing written discussions of our reasoning about why particular design solutions might need to be changed, rethought, clarified, abandoned, etc.

Direct recommendations to project partners mean written practical guidance at the CO level to address issues we have uncovered: i.e., "we recommend that you do x." These

recommendations aimed to be clear, thorough, and specific in order to minimize the possibility of the project partners not being able to understand them.[3]

We wish to center the implementation (or not) of recommendations primarily upon the technical ability and willingness to carry them out and thus to eventually draw insights in Deliverable 6.4 about the feasibility of our approach. In that regard, we are categorizing our recommendations by consensus discussion within the Ethics Team to understand better what types of recommendations are implemented. We are also allowing for the severity of the issue addressed by the recommendation and full, partial, or not-at-all implementation. This graded validation – when possible – is our effort to integrate a quantitative ethical aspect in line with the quantitative technical validation efforts in WP6. In addition, we will attempt to decide upon the allocation of responsibility for implementation, attain consensus verification by several partners of the implementation results, and – very importantly – gather specific feedback on why the recommendation was not implemented, or only partially implemented, in case this happens.

Thus, our Deliverable 6.4 validation methodology is not only about checking whether a particular recommendation was implemented in the way that more technical KPIs were implemented, for example. The record of the implementation comes after the fact, ethically, of the practical value of the recommendation, some of which were given in the project's first months. Our validation methodology is primarily about gathering the information we need to reflect upon our ethical approach and generate practical suggestions for those who might adopt our approach in the future.

[1] Note that the Ethics Team approach has been evolving since the initial overview in Del. 1.2

[2] Approximately 40 meetings in the nine months between 1st January and 1st October 2022.

[3] The Ethics Team has given 127 recommendations to date (Deliverable 6.6 submission), for all Use Cases, at Use Case Level or Task Level. Some recommendations contained several sub-recommendations.

2.6.3.2 Deliverable 6.4 Ethics Recommendations Table Format

Below we give the intended format of the table of ethics recommendation results to be added to Deliverable 6.4, with several actual examples chosen from the project Use Cases or Tasks based on their being already addressed, e.g., implemented already or rendered not applicable because the project solution was changed.[1] The reason for merely exemplifying results at this stage is that the ethical recommendation implementations are ongoing and will only be completed much nearer to the actual submission deadline of Deliverable 6.4 in M32.

[1] Note that in most cases, the recommendations in the table are cut-down versions of those given in formal CO-level documents.

ID	Category	Recommendation	Severity (low /medium /high)	Full implementation	Responsible for implementation	Verification	Solved (0-1-2) (recommendation implemented?: 0=no, 1=partial, 2=yes fully, NA + which aspects if partial)	Reasons (if incomplete implementation)
ETH-C-UC2-TASK1.3-3	Ethical Re-Wording	Clarify who is represented by the human symbol in the diagram + designate the extruder separately	low	Deliverable 1.3 changes	Lead partner Task 1.3 (TEK)	Ethics Team verifies deliverable(s)	2	
ETH-C-UC3-4	Protocol	Create a protocol for AI errors specific to diemakers	medium	Deliverable(s)statement + written instructions	Continental, Lead partner	Ethics Team verifies deliverable(s)	NA	Diemaker's role in solution changed
ETH-C-UC5-TASK1.3-2	Responsibility Workload	*Vision Model images*: estimate who will label; how many to label; whether experienced is better here; how long it will take; can tech partners do it	high	Additions to Deliverable	Lead partner 1.3 (TEK)	Ethics Team + Lead partner verify	2	
ETH-TASK1.5-3	Human Centering	Categorize the platform into stable, variable-stable, and variable components (and include the various operator and process engineer contributions in terms of physical action and knowledge or experience in these categories), i.e., view the operators and p. engs. In terms of flexible processes rather than components.	low	Deliverable 1.3 changes	Lead partner Task 1.3 (IMP)	Ethics Team verifies deliverable(s)	2	

Table 20 : Specific Ethics Considerations

2.6.4 Ethical approach formula

The calculation of the percentage of compliance with the ethical recommendations will be carried out according to the following method:

Ethical approach value =

(Group1 [(ETH_IDX Result) + … + (ETH_IDX Result)] * 100/ NQ * (Total WEIGHT of Group 1) +

(Group2 [(ETH_IDX Result) + … + (ETH_IDX Result)] * 100/ NQ * (Total WEIGHT of Group 2) +

(Group3 [(ETH_IDX Result) + … + (ETH_IDX Result)] * 100/ NQ * (Total WEIGHT of Group 3) +

(Group4 [(ETH_IDX Result) + … + (ETH_IDX Result)] * 100/ NQ * (Total WEIGHT of Group 4) +

(Group5 [(ETH_IDX Result) + … + (ETH_IDX Result)] * 100/ NQ * (Total WEIGHT of Group 5)]

*__NQ__ number of questions

2.7 Use Case Formula

The formula for the global estimation of the impact of the use case on the production process is detailed hereafter. Each use case shall adjust the formula to its specific needs. The general formula will include the result of the five modules of the methodology, which are the following:

- KPI - Quantitative Result
- User Requirement Result
- Functional Requirement
- User Experience – Qualitative Result
- Ethical approach

We will convert all these results into a value between 0 - 100, representing the percentage of compliance for each category. They will additionally have a coefficient to adjust the impact of that partial result on the final result. The final result will also be in the range of 0-100 and will indicate the percentage of fulfillment of the use case.

Overall Estimation Use Case =

[[KPIs % Compliance * KPI - Quantitative result Coefficient] +

[End-User Requirements % Compliance * End-User Requirement Result Coefficient] +

[Functional Requirements % Compliance * Functional Requirement Result Coefficient] +

[User Experience % Compliance * User Experience – Qualitative Result Coefficient] +

[Ethical Approach %Compliance * Ethical Approach Coefficient]]

For example, suppose the values below correspond to the evaluation of a use case. After applying the methodology, we would have completed the use case by 72.94%.

Category	Final Result	% Compliance	Coefficient of Adjustment	% Adjusted
Production Level KPI	84	84	0.30	25.2
User Requirements	80	80	0.25	20
Functional Requirements	72	72	0.20	14.21
User Experience	3.77	75.4	0.15	11.31
Ethical Approach	42	42	0.10	4.2

Table 21 : Example of validation of a generic Use Case

3 Production Level Impact of AI-PROFICIENT at Site-Level

This section of the methodology aims to measure the impact of the application of AI-PROFICIENT results at the plant level. This approach allows measuring positive and negative effects, which are the result of various interventions implemented.

SL_ID	*ID*	*Meaning*
Site Level	SL	Site-level impact
Identification of the industrial site	C	Continental
	IC	Ineos Cologne
	IG	Ineos Geel
Identifying ID	X	Number

Table 22 : Identifiers for Site-Level

1. The first step will be determining what production improvement targets have been set for each site.

The objectives that have been set for the Continental Sarreguemines site are:

- Objective 1 System breakage: reduction by 50%
- Objective 2 Production of scrap: reduction by 0.05%
- Objective 3 Low-quality products: reduction by 50%
- Objective 4 Extrusion line speed: improvement by 2%
- Objective 5 Number of trial loops before release: improvement by 12,5%

The target for the plant of INEOS Cologne:

- Off-spec production: 1M€ saving per annum

Targets for the plant of INEOS Geel:

- Reduction of human errors: reduction by at least 50%

- Plant availability: improvement by at least 0,5%

2. **Baseline**. To measure the combined impact of the developments made in AI-PROFICIENT when are deployed simultaneously in an industrial plant, it is necessary to capture a baseline that reflects the current values of the variables to be optimized. For this purpose, the values corresponding to the last year of these variables will be collected and homogenized.

3. **Metering after the installation of the developments.** Subsequently, the different use cases will be applied jointly. As detailed in the previous chapters, the quantitative measurement of the impact of use cases on the variables to be optimized will be carried out.

4. **Coefficient of adjustment**. Given that the application of the use cases will not lead to real production over a long period, it is essential to count on the production technicians of the plants to extrapolate the impact over long periods of application based on the quantitative results of the different models over time. They will determine a coefficient to adjust the impact measured during the tests to long-term periods.

A table with all this information has been created for each industrial site. Also, it includes the **final value measurement** and the **percentage of achievement** it would have at that time.

SI_ID	Description	Target	The baseline value of the KPI /Unit	How is it measured	Final measurement	% of achievement	Coefficient of adjustment	Achievement adjusted

Table 23 :Site-Level Evaluation Information

The **achievement adjusted** will be the adjusted percentage on that SL_ID due by multiplying the **achievement percentage** with the **adjustment coefficient**. The **total sum of all the adjusted achievements** will represent the percentage of fulfillment of the site-level requirements.

We can see the tables relative to the production site level in section 6.5 of the annexes.

4 Conclusion

In this document, we have detailed a methodology that aims to measure as objectively as possible the results of the application of AI developments in the industrial process. As mentioned above, it constitutes the final version of Deliverable D6.1, where an initial idea of the procedure to follow to develop the methodology was proposed. During these months, work has been done with the rest of the partners involved in the project, as well as directly with the industrial partners, Continental and INEOS, and the Ethics team to mature the initial ideas proposed and achieve a methodology that allows validating the project requirements.

This methodology has focused on the AI-Proficient project but is trying to obtain a model that serves as a basis for developing new methodologies focused on validating industrial AI projects. In addition, an attempt has been made to quantify the measurement criteria, focusing on fulfilling the key performance indicators and the functional and end-user requirements. In those cases where objectivity is not feasible, it has been decided to perform surveys that will be executed multiple times on different users. Qualitative criteria have been designed for these surveys, which likewise allow objectifying the results.

The annexes to this document detail all the specific information for each section described here for each use case. The goal is that these tables will be used to follow up on the following work package tasks, such as task 6.2.

5 Acknowledgments

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6 Annexes

6.1 Production Level - KPI

6.1.1 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	Changes in the plant	Description of the changes
CONTI-2 UC Specification: Restart Setup												
QT-C-UC2-1	Setup duration.	KPI1_CONTI2	Average reduction of 5-15%	20 minutes and 25 seconds average (from February 2021 to July 2021)	Time when the scrap button is turned off - time when the change is done.							
QT-C-UC2-2	Setup duration after a quick product change.	KPI1_1_CONTI2	Average reduction of 5-15%	11 minutes and 39 seconds (from February 2021 to July 2021)								
QT-C-UC2-3	Setup duration after a medium long product change.	KPI1_2_CONTI2	Average reduction of 5-15%	18 minutes and 41 seconds (from February 2021 to July 2021)								
QT-C-UC2-4	Setup duration after a long product change.	KPI1_3_CONTI2	Average reduction of 5-15%	30 minutes and 57 seconds (from February 2021 to July 2021)								
QT-C-UC2-5	System adaption capability.	KPI2_CONTI2	Average reduction of 5-15%	65,71 m average (from February 2021 to July 2021)	Amount of tread (in meter) that is rejected while the scrap button is on.							
QT-C-UC2-6	Rework quantity after a quick product change.	KPI2_1_CONTI2	Average reduction of 5-15%	48,36 m (from February 2021 to July 2021)								
QT-C-UC2-7	Rework quantity after a medium product change.	KPI2_2_CONTI2	Average reduction of 5-15%	57,19 m (from February 2021 to July 2021)								
QT-C-UC2-8	Rework quantity after a long product change.	KPI2_3_CONTI2	Average reduction of 5-15%	91,57 m (from February 2021 to July 2021)								
QT-C-UC2-9	System adaption capability.	KPI2_CONTI2	100%	No baseline because the services related to this UC are not used now	$\frac{Number\ of\ retraining\ requested}{Number\ of\ retraining\ needed}$							
CONTI-3 UC Specification: Released extrusion optimisation												
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)	$\frac{Time\ during\ which\ (V2-V1) respects\ the\ relaxed\ conditions\ in\ the\ hot\ part}{Total\ compliant\ production\ time\ of\ the\ machine}$							
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	$\frac{Amount\ of\ identification\ of\ the\ relevant\ cause\ of\ deviation}{Amount\ of\ identification\ of\ the\ deviation\ of\ the\ product\ relaxation}$							
CONTI-5 UC Specification: Tread blade wear												
QT-C-UC5-1	Reduction in number of interventions of curative mode.	KPI1_CONTI5	Average reduction of 25%	22 blades changes in curative mode (100% of the intervention in currative mode) (from February 2021 to July 2021).	Number of intervention in curative mode to compare to the number of intervention in preventive mode.							
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.							
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							
CONTI-7 UC Specification: Tread alignment												
QT-C-UC7-1	Unplanned unloading station manual intervention rate	KPI1_CONTI7	< 0,2 %	100%	$\frac{Unplanned\ manual\ unloading\ of\ the\ tread}{Total\ amount\ of\ manual\ unloading}$							
QT-C-UC7-2	Planned unloading station manual intervention rate	KPI2_CONTI7	< 1%	No baseline because the services related to this UC are not used now.	$\frac{Planned\ manual\ unloading\ of\ the\ tread}{Total\ amount\ of\ unloaded\ tread}$							
QT-C-UC7-3	Unnecessary planned unloading station manual intervention rate	KPI3_CONTI7	< 0,2 %	No baseline because the services related to this UC are not used now.	$\frac{Unnecessary\ planned\ unloading\ of\ the\ tread}{Total\ amount\ of\ planned\ unloading}$							
QT-C-UC7-4	Unplanned monthly downtime of the tread handling station	KPI4_CONTI7	< 60 minutes per month	No baseline because the services related to this UC are not used now.	Number of minutes lost on the assembly stations due to unplanned tread handling.							
QT-C-UC7-5	Unnecessary alarms	KPI5_CONTI7	< 10 times per month	No baseline because the services related to this UC are not used now	Number of times a tread was reported as incorrectly positioned on the trolley even though the positioning is correct.							
CONTI-10 UC Specification: Quality analysis tool												
QT-C-UC10-1	Reduction of the scrap rate	KPI1_CONTI10	≥ 0,05%.	4,55%	$\frac{Amount\ of\ nOK\ treads\ produced}{Total\ amount\ of\ treads\ produced}$							
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.	$\frac{Number\ of\ deviation}{Total\ amount\ of\ treads\ produced}$							

6.1.2 INEOS Geel

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	Changes in the plant	Description of the changes
INEOS1 UC Specification: Reactor stability at Geel plant												
QT-IG-UC1-1	Increase the plant reliability	KPI1_INEOS1	97,1	96,6	Annual production of prime product divided by (maximum capacity of plant – planned slowdown).	Monthly						
QT-IG-UC1-2	Drift frequency	KPI2_INEOS1	To be defined once data is validated - assessment made of what is realistic to achieve	Tbc	The drift frequency is definedas the duration in hours during which the reactor is in oscillation versus the average over the 3 years prior to the 'go live' of this project	Annually						
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						
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						
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						
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						

6.1.3 INEOS Cologne

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	Changes in the plant	Description of the changes
INEOS3 UC Specification: Rheology drift at Cologne plant												
QT-IC-UC3-1	Reduce of the offspec product production losses	KPI1_INEOS3	saving ≥ 1M€ per year	Not Applicable	Financial losses are calculated by multiplying offspec production volume with the margin delta.							
QT-IC-UC3-2	Improvement of the two quality parameters	KPI2_INEOS3	≥ 50%	Tbc	Calculated standard deviation.							

6.2 End-User Requirements

6.2.1 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				
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				
UR-C-UC2-3	Prognosticate the readiness of the Combiline	UR1_2_CONTI2	QT-C-UC2-9				
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				
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				
UR-C-UC2-6	Must be retrainable in case of bad proposition	UR3_CONTI2	QT-C-UC2-9				
CONTI-3 UC Specification: Released extrusion optimisation							
UR-C-UC3-1	Ensure the relaxation of the treads.	UR1_CONTI3	QT-C-UC3-1				
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				
UR-C-UC3-3	Identify the cause of the deviation	UR1_2_CONTI3	QT-C-UC3-2				
UR-C-UC3-4	Give the time remaining until the process reach bad quality product or breakdown.	UR1_3_CONTI3	QT-C-UC3-3				
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				
UR-C-UC5-2	Assess wear state of the blade.	UR1_1_CONTI5	QT-C-UC5-1; QT-C-UC5-2				
UR-C-UC5-3	Detect other causes of failure in cutting system.	UR1_2_CONTI5	QT-C-UC5-2				
UR-C-UC5-4	Improve cut quality.	UR2_CONTI5	QT-C-UC5-3				
UR-C-UC5-5	Detect quality deviations in the cuts.	UR2_1_CONTI5	QT-C-UC5-3				
CONTI-7 UC Specification: Tread alignment							
UR-C-UC7-1	Ensure the proper loading of the treads into the tray.	UR1_CONTI7	QT-C-UC7-1; QT-C-UC7-2; QT-C-UC7-3				
UR-C-UC7-2	Alert when a tread is not loaded properly.	UR1_1_CONTI7	QT-C-UC7-5				
UR-C-UC7-3	Detect the small deviations in the motion of the treads.	UR2_CONTI7	QT-C-UC7-4; QT-C-UC7-5				
UR-C-UC7-4	Identify the cause of the deviation.	UR2_1_CONTI7	QT-C-UC7-1; QT-C-UC7-2;QT-C-UC7-4				
UR-C-UC7-5	Give the time remaining before the over drift of the identified malfunctioning element.	UR2_2_CONTI7	QT-C-UC7-1;QT-C-UC7-2				
CONTI-10 UC Specification: Quality analysis tool							
UR-C-UC10-1	Ensure the good quality of the production	UR1_CONTI10	QT-C-UC10-1				
UR-C-UC10-2	Detect deviation for the bad quality treads.	UR1_1_CONTI10	QT-C-UC10-1; QT-C-UC10-2				
UR-C-UC10-3	Identify the cause of the quality deviation	UR1_2_CONTI10	QT-C-UC10-1; QT-C-UC10-2				
UR-C-UC10-4	Optimize the current process parameter settings	UR2_CONTI10	QT-C-UC10-1				

6.2.2 INEOS Geel

UR_ID	End User Requirement	Reference from D1.4	Link with KPI ID	RoI description of the validator	When it is validated	Result	Comments
INEOS1 UC Specification: Reactor stability at Geel plant							
UR-IG-UC1-1	Ensure the stability of the reactor.	UR1_INEOS1	QT-IG-UC1-1				
UR-IG-UC1-2	Identify what causes the oscillations.	UR1_1_INEOS1	QT-IG-UC1-1				
UR-IG-UC1-3	Give advises to the console operator.	UR1_2_INEOS1	QT-IG-UC1-1				
UR-IG-UC1-4	Optimize the temperature control loop.	UR2_INEOS1	QT-IG-UC1-1; QT-IG-UC1-2				
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				
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				
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				

6.2.3 INEOS Cologne

UR_ID	End User Requirement	Reference from D1.4	Link with KPI ID	RoI description of the validator	When it is validated	Result	Comments
INEOS3 UC Specification: Reactor stability at Geel plant							
UR-IC-UC1-1	Ensure the quality of the rheology.	UR1_INEOS3	QT-IC-UC3-1; QT-IC-UC3-2				
UR-IC-UC1-2	Identify what causes the quality drifts.	UR1_1_INEOS3	QT-IC-UC3-1				
UR-IC-UC1-3	Give advises to the console operator.	UR1_2_INEOS3	QT-IG-UC1-1				
UR-IC-UC1-4	Optimize the current process parameter settings.	UR1_3_INEOS3	QT-IC-UC3-1; QT-IC-UC3-2				

6.3 Functional Requirements

6.3.1 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				
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				
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				
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				
FR-C-UC2-5	Predictive production readiness assurance	FR5_CONTI2_PRE	UR-C-UC2-3				
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				
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				
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				
CONTI-3 UC Specification: Released extrusion optimisation							
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				
FR-C-UC3-2	Detect deviation that may induce tension in the tread.	FR2_CONTI3_DIA	UR-C-UC3-2				
FR-C-UC3-3	Diagnosticate the potential component causing the deviation.	FR3_CONTI3_DIA	UR-C-UC3-3				
FR-C-UC3-4	Prognosticate the remaining useful life before tension in the tread reach unacceptab	FR4_CONTI3_PRO	UR-C-UC3-4				
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				
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				
FR-C-UC5-2	Monitor cutting system.	FR2_CONTI5_MON_OPP	UR-C-UC5-1				
FR-C-UC5-3	Estimate cutting blade's health status.	FR3_CONTI5_HEA_OPP	UR-C-UC5-1; UR-C-UC5-2				
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				
FR-C-UC5-5	Prognosticate the wear based on planned cuts.	FR5_CONTI5_PRO_OPP	UR-C-UC5-1				
FR-C-UC5-6	Display information to the relevant user in an understandable way.	FR6_CONTI5_HUM	UR-C-UC5-1				
FR-C-UC5-7	Integrate human feedback on algorithm development.	FR7_CONTI5_HUM	UR-C-UC5-1; UR-C-UC5-4				
CONTI-7 UC Specification: Tread alignment							
FR-C-UC7-1	Monitor the loading of the treads into the trolley.	FR1_CONTI7_MON_OPP	UR-C-UC7-3				
FR-C-UC7-2	Monitor the positioning of the treads in the trolley.	FR2_CONTI7_MON	UR-C-UC7-1				
FR-C-UC7-3	Detect deviations that may induce an improper loading of the tread into the tray.	FR3_CONTI7_DIA	UR-C-UC7-3				
FR-C-UC7-4	Diagnose the component potentially causing the deviation of the treads.	FR4_CONTI7_DIA_OPP	UR-C-UC7-4				
FR-C-UC7-5	Prognosticate the RUL of the component before the malfunctioning component will cause incorrect loading.	FR5_CONTI7_PRO_OPP	UR-C-UC7-5				
FR-C-UC7-6	Display information to the relevant user.	FR6_CONTI7_HUM	UR-C-UC7-2				
FR-C-UC7-7	Keep a time series record of the measurements for training and adapting the deviation detection and prognostics algorithms.	FR7_CONTI7_LSL	UR-C-UC7-1; UR-C-UC7-3				
FR-C-UC7-8	Keep an image log for development and post deployment troubleshooting of the image processing.	FR8_CONTI7_LSL	UR-C-UC7-1; UR-C-UC7-3				
CONTI-10 UC Specification: Quality analysis tool							
FR-C-UC10-1	Process monitoring	FR1_CONTI10_MON	UR-C-UC10-1				
FR-C-UC10-2	Root cause identification	FR2_CONTI10_ROO_GEN_ETD	UR-C-UC10-3				
FR-C-UC10-3	Early anomaly detection	FR3_CONTI10_EAR	UR-C-UC10-2				
FR-C-UC10-4	Quality metrics prediction	FR4_CONTI10_HYB_ETD	UR-C-UC10-3				
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				
FR-C-UC10-6	User interface	FR6_CONTI10_HUM_ETD	UR-C-UC10-1				
FR-C-UC10-7	Human feedback on provided recommendations	FR7_CONTI10_HUM	UR-C-UC10-1				

6.3.2 INEOS Geel

FR_ID	Functional Requirement	Reference from D1.4	Link with UR_ID	RoI description of the validator	When it is validated	Result	Comments
INEOS1 UC Specification: Reactor stability at Geel plant							
FR-IG-UC1-1	Monitor measured temperatures	FR1_INEOS1_MON	UR-IG-UC1-1; UR-IG-UC1-2				
FR-IG-UC1-2	Estimate peak temperatures with the digital twin.	FR2_INEOS1_HYB	UR-IG-UC1-3				
FR-IG-UC1-3	Diagnose the causes of peak temperatures and temperature fluctuations.	FR3_INEOS1_DIA	UR-IG-UC1-2				
FR-IG-UC1-4	Display information to the relevant user in an understandable way.	FR4_INEOS1_HUM	UR-IG-UC1-3				
FR-IG-UC1-5	Advice the operator on actions to avoid oscillations.	FR5_INEOS1_HUM	UR-IG-UC1-3				
FR-IG-UC1-6	Integrate human feedback on algorithm development	FR6_INEOS1_HUM	UR-IG-UC1-2				
FR-IG-UC1-7	Through modelling, analyze effects of process control and control loop on temperatures.	FR7_INEOS1_HYB	UR-IG-UC1-1; UR-IG-UC1-2				
FR-IG-UC1-8	Improve the control loop.	FR8_INEOS1_	UR-IG-UC1-4				
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				
FR-IG-UC2-2	Display information to the relevant user in an understandable way.	FR2_INEOS2_HUM	UR-IG-UC2-3				
FR-IG-UC2-3	Integrate human feedback.	FR3_INEOS2_HUM	UR-IG-UC2-3				
FR-IG-UC2-4	Keep an image log for development and post deployment troubleshooting of the image processing.	FR4_INEOS2_LSL	UR-IG-UC2-1; UR-IG-UC2-4				

6.3.3 INEOS Cologne

FR_ID	Functional Requirement	Reference from D1.4	Link with UR_ID	RoI description of the validator	When it is validated	Result	Comments
INEOS3 UC Specification: Reactor stability at Geel plant							
FR-IC-UC3-1	Monitoring process parameters	FR1_INEOS3_MON	UR-IC-UC1-1				
FR-IC-UC3-2	Process digital twin	FR2_INEOS3_HYB	UR-IC-UC1-1				
FR-IC-UC3-3	Explainable root cause identification	FR3_INEOS3_ROO_ETD	UR-IC-UC1-2				
FR-IC-UC3-4	Optimal process control settings	FR4_INEOS3_GEN	UR-IC-UC1-3; UR-IC-UC1-4				
FR-IC-UC3-5	Operator's feedback	FR5_INEOS3_HUM	UR-IC-UC1-1				
FR-IC-UC3-6	User interface	FR6_INEOS3_HUM	UR-IC-UC1-3				

6.4 Ethical Approach

6.4.1 INEOS Geel

Group	General AI/Operator(s) interaction		
ID	Description	Result (Y/N)	Method Used
ETH-IG-GAI-1	Are the limits of the AI and the operators' actions clear?		
ETH-IG-GAI-2	Is there more than one human role involved? If so, has the chain of responsibility been clearly defined?		
ETH-IG-GAI-3	Is it defined who/when/how receives the information from the AI system?		
ETH-IG-GAI-4	Is it defined what is the degree of flexibility of the operator?		
ETH-IG-GAI-5	If not, is the operator expected to always follow the AI approach?		
ETH-IG-GAI-6	Are there situations where the default control is only human, e.g. alerts?		
ETH-IG-GAI-7	Have the risks of the user giving a default acceptance been assessed?		
ETH-IG-GAI-8	Has it been considered who (e.g. operator, process engineer, maintenance) is best placed to undertake the new AI-related task based on the time and space considerations of the work context?		
ETH-IG-GAI-9	Where used, have the targets of control concepts been specified, e.g. if HITL who is the human?		
ETH-IG-GAI-10	When the AI use is exploratory and engaging processes that are beyond operator/engineer human capacity, are the related limitations to responsibility formally clarified?		
Group	AI Errors handling		
ID	Description	Result (Y/N)	Method Used
ETH-IG-ERRH-1	Is there an AI error-handling protocol?		
ETH-IG-ERRH-2	If so, has it been defined which role should manage each step of the process?		
ETH-IG-ERRH-3	Is it defined which are the guidelines to continue the production process in case of an AI error?		
ETH-IG-ERRH-4	Is it defined what feedback the human should give to the system in case of an error?		
ETH-IG-ERRH-5	Is it defined how to handle incorrect feedback from the operator to the system as the origin of the failure?		

Group	Identification and minimization of (additional) workload:		
ID	Description	Result (Y/N)	Method Used
ETH-IG-WkL-1	Has a maximum reaction time been defined for the testing period / normal working period?		
ETH-IG-WkL-2	Has it been determined which role is the end-user of the tool?		
ETH-IG-WkL-3	Has the additional workload of using the tool been estimated?		
ETH-IG-WkL-4	Has resistance to the use of AI been assessed and measured?		
ETH-IG-WkL-5	Have measures been considered to minimize this resistance?		
ETH-IG-WkL-6	Is the user forced to accept the outcome of the tool?		
ETH-IG-WkL-7	Have the operator's previous workload/task expectations been formally adjusted in view of additional time required for new tasks		
ETH-IG-WkL-8	Has it been clarified who will undertake processing tasks for AI training and feedback: e.g. marking images?		

Group	Facilitate interaction/engagement with AI system:		
ID	Description	Result (Y/N)	Method Used
ETH-IG-IN-1	Has a phased deployment approach been considered?		
ETH-IG-IN-2	Will operator involvement be gradual and phased?		
ETH-IG-IN-3	Will there be a specific training period?		
ETH-IG-IN-4	If the system involves the use of specific hardware, is there an assessment of the ergonomic impact of its use?		
ETH-IG-IN-5	Are the interfaces redundant?		
ETH-IG-IN-6	Has fatigue in the use of automatic decision-making tools been assessed? Have any mitigation measures been considered?		
ETH-IG-IN-7	Have choices of XAI been tailored to the primary user?		

Group	Ethics by Design Developer and Industrial Partner Engagement		
ID	Description	Result (Y/N)	Method Used
ETH-IG-EtbD-1	Have tech developers worked directly with operators from the prototype stages to understand their needs in terms of HMIs and XAI? (Y/N)		
ETH-IG-EtbD-2	Do diagrams and figures in Deliverables specify which people are carrying out which tasks? (Y/N)		
ETH-IG-EtbD-3	Has written content avoided anthropomorphizing the AI?		
ETH-IG-EtbD-4	Has the work team cohesion been monitored after AI integration?		
ETH-IG-EtbD-5	Have operators and process engineers been formally notified about how their roles will change after AI integration?		

6.4.2 INEOS Cologne

Group	General AI/Operator(s) interaction		
ID	Description	Result (Y/N)	Method Used
ETH-IC-GAI-1	Are the limits of the AI and the operators' actions clear?		
ETH-IC-GAI-2	Is there more than one human role involved? If so, has the chain of responsibility been clearly defined?		
ETH-IC-GAI-3	Is it defined who/when/how receives the information from the AI system?		
ETH-IC-GAI-4	Is it defined what is the degree of flexibility of the operator?		
ETH-IC-GAI-5	If not, is the operator expected to always follow the AI approach?		
ETH-IC-GAI-6	Are there situations where the default control is only human, e.g. alerts?		
ETH-IC-GAI-7	Have the risks of the user giving a default acceptance been assessed?		
ETH-IC-GAI-8	Has it been considered who (e.g. operator, process engineer, maintenance) is best placed to undertake the new AI-related task based on the time and space considerations of the work context?		
ETH-IC-GAI-9	Where used, have the targets of control concepts been specified, e.g. if HITL who is the human?		
ETH-IC-GAI-10	When the AI use is exploratory and engaging processes that are beyond operator/engineer human capacity, are the related limitations to responsibility formally clarified?		
Group	AI Errors handling		
ID	Description	Result (Y/N)	Method Used
ETH-IC-ERRH-1	Is there an AI error-handling protocol?		
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ETH-IC-ERRH-3	Is it defined which are the guidelines to continue the production process in case of an AI error?		
ETH-IC-ERRH-4	Is it defined what feedback the human should give to the system in case of an error?		
ETH-IC-ERRH-5	Is it defined how to handle incorrect feedback from the operator to the system as the origin of the failure?		

Group	Identification and minimization of (additional) workload:		
ID	Description	Result (Y/N)	Method Used
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ETH-IC-WkL-3	Has the additional workload of using the tool been estimated?		
ETH-IC-WkL-4	Has resistance to the use of AI been assessed and measured?		
ETH-IC-WkL-5	Have measures been considered to minimize this resistance?		
ETH-IC-WkL-6	Is the user forced to accept the outcome of the tool?		
ETH-IC-WkL-7	Have the operator's previous workload/task expectations been formally adjusted in view of additional time required for new tasks		
ETH-IC-WkL-8	Has it been clarified who will undertake processing tasks for AI training and feedback: e.g. marking images?		

Group	Facilitate interaction/engagement with AI system:		
ID	Description	Result (Y/N)	Method Used
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ETH-IC-IN-2	Will operator involvement be gradual and phased?		
ETH-IC-IN-3	Will there be a specific training period?		
ETH-IC-IN-4	If the system involves the use of specific hardware, is there an assessment of the ergonomic impact of its use?		
ETH-IC-IN-5	Are the interfaces redundant?		
ETH-IC-IN-6	Has fatigue in the use of automatic decision-making tools been assessed? Have any mitigation measures been considered?		
ETH-IC-IN-7	Have choices of XAI been tailored to the primary user?		

Group	Ethics by Design Developer and Industrial Partner Engagement		
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ETH-IC-EtbD-1	Have tech developers worked directly with operators from the prototype stages to understand their needs in terms of HMIs and XAI? (Y/N)		
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ETH-IC-EtbD-3	Has written content avoided anthropomorphizing the AI?		
ETH-IC-EtbD-4	Has the work team cohesion been monitored after AI integration?		
ETH-IC-EtbD-5	Have operators and process engineers been formally notified about how their roles will change after AI integration?		

6.5 Production Site Level

6.5.1 Continental

ID	Description	Target	The baseline value of the KPI /Unit	How is it measured	Final measurement	% of achievement	Coefficient of adjustment	Achievement Adjusted
SL-C-1	System breakage: reduction by 50%	50% of reduction	2%	$\frac{Time\ during\ which\ the\ machine\ was\ stopped\ because\ of\ a\ breakage}{Total\ running\ time\ of\ the\ machine}$				
SL-C-2	Reduction in production of scrap:	0.05% of reduction	4,55%	$\frac{Amount\ of\ nOK\ treads\ produced}{Total\ amount\ of\ treads\ produced}$				
SL-C-3	Reduction of Low-quality products:	50% of reduction	0,60%	Number of treads shared with a defect				
SL-C-4	Improve the Extrusion line speed	improvement by 2%	31,8 m/s	The average of the speed recorded with the speed sensor of the Line				
SL-C-5	Reduction ofr Number of trial loops before release	improvement by 12,5%	4 month	Total time spent for the production line tunning & process parameters definition (Assembly, tuning, modifications, run at rate, aproximetively 1 months for each).				

6.5.2 INEOS Geel

ID	Description	Target	The baseline value of the KPI /Unit	How is it measured	Final measurement	% of achievement	Coefficient of adjustment	Achievement Adjusted
SL-IG-1	Plant availability: improvement by at least 0,5%	0.05% of reduction	96,60%	monthly manual calculation				
SL-IG-2	Reduction of human errors: reduction by at least 50%	50% of reduction	1 occurence per annum	manual lab analysis				

6.5.3 INEOS Cologne

ID	Description	Target	The baseline value of the KPI /Unit	How is it measured	Final measurement	% of achievement	Coefficient of adjustment	Achievement Adjusted
SL-IC-1	Reduce Offspec product production losses.	1M€ per year.	Not Applicable	Financial losses are calculated by multiplying offspec production volume with the margin delta.				
SL-IC-2	Improvement of the two quality parameters.	Improved standard deviation by 50%	Tbc	Calculated standard deviation.				