AI·PROFICIENT

Artificial intelligence
for improved production efficiency,
quality and maintenance

Deliverable 4.1

D4.1: Human-machine interaction and feedback mechanisms (Design and specification)

WP4: Human-machine interfaces, explainable AI and shop-floor feedback.

T4.1: Human feedback mechanisms for AI reinforcement learning.

Version: 1.0

Dissemination Level: PU

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 957391.

Table of Contents

List of Figures

List of Tables

Disclaimer

This document contains a description of the AI-PROFICIENT project work and findings.

The authors of this document have taken any available measure for its content to be accurate, consistent and lawful. However, neither the project consortium as a whole nor the individual partners that implicitly or explicitly participated in the creation and publication of this document hold any responsibility for actions that might occur as a result of using its content.

This publication has been produced with the assistance of the European Union. The content of this publication is the sole responsibility of the AI-PROFICIENT consortium and can in no way be taken to reflect the views of the European Union.

The European Union is established in accordance with the Treaty on European Union (Maastricht). There are currently 28 Member States of the Union. It is based on the European Communities and the Member States cooperation in the fields of Common Foreign and Security Policy and Justice and Home Affairs. The five main institutions of the European Union are the European Parliament, the Council of Ministers, the European Commission, the Court of Justice and the Court of Auditors (http://europa.eu/).

AI-PROFICIENT has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 957391.

Title: D4.1: Human-machine interaction and feedback mechanisms (Design and Specification)

Lead Beneficiary:	TEK
Due Date:	30/04/2022.
Submission Date	02/05/2022
Status	Final ~~Preliminary Draft~~
Description	Design and specification of the Human-machine interaction for feedback management enhancing reinforcement learning for each 8 use cases.
Authors	Izaskun Fernandez (TEK), Kerman Lopez de Calle (TEK), Pedro de la Peña (IBE), Laritza Limia Fernande (IBE), Alexander Vasylchenko (TF), Julien Hintenoch (CONTI), Christophe Van Loock (INEOS), Katarina Stanković (IMP), Dea Pujić (IMP), Vasillis Spais (INOS), Marc Anderson (UL-ethics), Alexandre Voisin (UL), George Triantafyllou (ATC)
Type	Report
Review Status	Draft WP Leader accepted ~~PC + TL accepted~~
Action Requested	~~Contribution from partners leading in each UC the feedback collection and management~~ ~~To be revised by partners~~ ~~For approval by the WP leader~~ For approval by the Project Coordinator & Technical Leaders

VERSION	ACTION	OWNER	DATE
0.1	First Draft for partners review	TEK	17/03/2022
0.2	Integration of comments after 1st review from partners	TEK	14/04/2022
0.3	First Draft sent for internal review	TEK	19/04/2022
0.4	First Draft extended and sent for internal review	TEK	28/04/2022
1.0	Integration of comments after final internal review for submission	TEK	02/05/2022

Executive Summary

The Deliverable D4.1 is a public document of AI-PROFICIENT project delivered in the context of WP4 (Human-machine interfaces, explainable AI and shop-floor feedback), and more precisely T4.1: (Human feedback mechanisms for AI reinforcement learning), regarding the specification of the eight use cases related to the different pilot sites. These use cases were initially described and reported in deliverable D1.1 (Report on the pilot characterizations and operation scenarios) and their demonstration scenarios were described and reported in deliverable D1.3 (Pilot-specific demonstration scenarios).

D4.1 incorporates the description of the end user's requirements related to the use cases in terms of the feedback management and the description for each one to manage it for a reinforcement learning approach. These requirements are the expectations of both technical partners, Continental and INEOS, in terms of what the AI-PROFICIENT project must provide as solution dealing with feedback management for reinforcement learning approach.

The specifications and the design for each use case regarding feedback management to feed reinforcement learning are described in the current Deliverable. All the required components for that are identified.

Finally, a summary table is available at the end of the deliverable, including all the components facilitating feedback collection and management for reinforcement learning, allowing to have an overview of all functional components resulting from this work.

Further advances on task 4.1, like development and deployment details will be provided within deliverable D4.5, taking as basis this deliverable D4.1, and updating where necessary.

1 Introduction

The goal of this deliverable is to gather the different mechanisms designed to deal with human feedback management, from the plant operators sitting in the control rooms to the workers on the shop floor, by calling upon the know-how and expertise of the operators and process engineers of the industrial partners, to improve AI services in the context of AI-PROFICIENT. As part of the solutions of the use cases, the deliverable will use methods of human-machine interaction and collaboration, and self-learning.

These mechanisms will provide the necessary functionalities to AI-PROFICIENT to provide the S_HUM service detailed in the deliverable D1.5:

Table 1: S_HUM service description (from D1.5).

Service ID	S_HUM
Service input and dependency on other services:	This service might be present in use cases that contain AI systems making predictions/estimations/suggestions etc. Such as in UCs CONTI2, CONTI3, CONTI5, CONTI10, INEOS1, INEOS2 and INEOS3. As the aim of this service is to improve the AI services that are already installed, this service strongly relies on the existence of said services, hence, a clear definition of inputs/outputs is complex. As an example, that could be the case of Diagnostic and anomaly detection services, which provide diagnostic information and anomaly KPI; and the Predictive Production quality assurance service, that provides quality KPIs and future projections of these KPIs. Additionally, in order to capture human feedback, it will be necessary to provide operators/managers with interfaces, which could be different depending on the UC. AI-PROFICIENT develops ways of human-machine interaction, such as the human-machine interfaces for data visualization services and the extended reality and conversational interface services that will be employed to transfer the feedback information. This service requires channels to ease the integration of the feedback mechanisms in the production line.
Service output:	This service will be in charge of adapting the feedback of the users to data records that can be used to re-train the algorithms/models or the creation of the new algorithms/models that will be carried out in algorithmic service. Hence, the final output of this service is data.
High level service description:	As project contributors reviewing and adapting the AI system predictions, operators and/or maintenance managers will face scenarios were the suggestions/predictions made by the AI are wrong. This service is in charge of detecting the most viable means to receive the feedback of the operators and to use that feedback in the tuning of the AI systems, so that they can improve over the time.

It is worthy to mention that these mechanisms have as final purpose to generate new data from the human knowledge and expertise, to feed the models within the service S_LSL, so they will not only deal with the necessary interfaces to get the feedback but also with the conversion of the feedback to data that the AI-based models can take advantage of, and the necessary workflow for that.

Table 2: S_LSL service description (from D1.5).

Service ID	S_LSL
Service input and dependency on other services:	This service heavily relies on the output of other services; hence, a clear definition of inputs/outputs is complex. However, the following are the minimum inputs required that have been identified so far: • Diagnostic and anomaly detection if the service is available • Health state evaluation if the service is available • Predictive Production quality assurance if the service is available • Root-cause identification if the service is available • Early anomaly detection if the service is available • Maintenance decision if the service is available • Generative holistic optimization if the service is available • Feedback/improvements from the users when WP4 services are made available
Service output:	The purpose of the service is to provide a decision-making system that combines the optimization information coming from other AI-PROFICIENT services (developed at WP2 and WP3) with the human feedback mechanisms (developed at WP4).
High level service description:	This service integrates the AI information/data and the maintenance decisions by gathering the outputs of the modelling services developed at WP2 and WP3, then, it enriches that data with the feedback services developed in WP4 to produce a decision that reflects also the operators' feedback on the different AI models. This will enable taking prescriptive actions based on a close collaboration with the end-users. In addition, this service has the capability of being continuously improved over time, based on the feedback of the operators.

These two services are intended to cover the _LSL and _HUM requirements identified and detailed in the deliverable D1.4 as result of T1.4. showed in the following table:

Table 3: Functionalities to be provided by the AI-PROFICIENT project (from D1.4).

AI-PROFICIENT Functionalities	***ID***
Monitoring	_MON
Diagnostic and anomaly detection	_DIA
Health state evaluation	_HEA
Component prognostics	_PRO
Hybrid models of production processes and digital twins	_HYB
Predictive Production quality assurance	_PRE
Root-cause identification	_ROO
Early anomaly detection	_EAR
Opportunistic maintenance decision-making	_OPP
Generative holistic optimization	_GEN
Future scenario based Lifelong self-learning system	_LSL
Human feedback	_HUM
Explainable and transparent decision making	_ETD

Focusing on the Human feedback functionality, it is worthy to mention that most of the AI-PROFICIENT use cases identified the need to include feedback management mechanisms, as it is shown in the synthesis table included in the end of D1.3, providing a quick overview of the expected components to be part of the solution of each use case.

Table 4: Excerpt of expected partners involvement in T4.1 for each use case (from D1.3).

WP/Task	CONTI-2	CONTI-3	CONTI-5	CONTI-7	CONTI-10	INEOS-1	INEOS-2	INEOS-3
WP4- HMI, explainable AI and shop-floor feedback								
4.1 Feedback/reinforc.	TEK/TF*		TEK/IBE/CONTI		IBE/IMP	IMP*	INOS/ATC/INEOS	IMP

Although the interest has not changed from the use cases side, the technical partners have worked on a detailed design of the human feedback approach led by the UC owners and leaders, and some changes have occurred mainly regarding the involvement of the technical partners in different use cases. The new status is demonstrated in the following table.

Table 5: Updated partners involvement in T4.1 for each use case

WP/Task	CONTI-2	CONTI-3	CONTI-5	CONTI-7	CONTI-10	INEOS-1	INEOS-2	INEOS-3
WP4- HMI, explainable AI and shop-floor feedback								
4.1 Feedback/reinforc.	TEK/TF		TEK/CONTI/INOS		IBE/IMP/ATC	IMP*	TEK/TF/ATC	IMP

In the following sections, a detailed description of the main human feedback management components can be found, as well as their use in the different use cases.

2 AI-technologies supporting reinforcement learning based on human feedback

One of the most significant and challenging open problems in Artificial Intelligence (AI) is the challenge of developing systems that can continually learn tasks (from one or more domains) over a lifetime.

Although new approaches are appearing to bridge the gap of continuous learning, during many years the dominant ML paradigms have adopted isolated learning, running a ML algorithm on a given dataset to produce a model, without any attempt to retain the learned knowledge and use it in the future. This isolated ML approach, has been very successful, but it requires many training examples, and is only suitable for well-defined and narrow tasks in closed environments. This ideal situation is not the common scenario in industrial environments. So, AI-PROFICIENT needs to develop reinforcement learning based approaches that start from smaller training data sets of open dynamic environments, develop AI models able to learn over the time, taking advantage not only of a data driven approach but also of a knowledge-based approach. One promising approach to incorporate prior knowledge of the target environment is to manage human feedback.

In AI-PROFICIENT, we can distinguish mainly two types of human feedback to enable a reinforcement-based learning approach: implicit and explicit feedback.

Implicit feedback is tied to a user action that they would perform (or not perform) regardless of their desire to influence the results given by the AI.

Explicit feedback: is when the user performs an action specifically designed to enable them to give feedback to the system.

AI-PROFICIENT will focus on the feedback which trainers give explicit and implicit feedback for correct and incorrect suggestions.

2.1 Implicit feedback

If an AI model registers that a specific suggestion given by it has been adopted or not, it can use that information to strengthen its knowledge based on the outcome of its decision (reward-punish), even when no explicit feedback has been given for that action. In AI-PROFICIENT, mechanisms will be developed to follow up when an AI model suggestion/prediction is adopted/came true or not, and if not, to infer the correct/applied value and convert it into reinforcement information. These mechanisms will enable reinforcement-based learning without any additional explicit human feedback.

AI-PROFICIENT implicit human feedback management mechanisms can be grouped in the following groups according to the different typologies of the AI-based models expected in the project mostly associated to parametrization and status of different agents in production plants:

- Predictive AI-based models: the predicted values will be compared automatically with the real value registered by the automatism/agent that affect and create the reinforcement information, indicating if the prediction was correct or not, and if not include the correct value.
- Recommendation (including optimization) AI-based models: the recommended value will be compared with the adopted real value introduced in the automatism/agent. When equal it will produce reinforcement positive information and when different, a negative reinforcement information including the recommended and adopted real value.

This reinforcement information will be used for lifelong learning of the AI-models, without any additional intervention from the human side.

2.2 Explicit feedback

Reinforcement learning without human intervention is not always feasible. For instance, in a vision recognition scenario, when the automatic recognition is not the correct one and specific intervention is required to get the right information.

Since industrial environments are becoming more automatized over time, Human-Machine Interfaces (HMI) have increasingly evolved in the last years with the development of new mobile techniques and new gadgets such as smartphones, tablets, or Augmented Reality (AR) glasses. A big number of solutions have been developed, especially in collaborative robotics, with human-machine interaction capabilities in different degrees, which allow a more intuitive communication with industrial systems, like interaction through gestures or programming by demonstration, and even dialogue systems, which allow workers to interact with industrial systems in a similar way as they would do with their fellows.

In the following section the different strategies to easily collect human explicit feedback through advanced Human-Machine Interfaces in the context of AI-PROFICIENT project are presented.

2.2.1 Natural voice interaction

The possibility of communicating to industrial systems through natural language is highly encouraged since it triggers acceptance from humans, and dialogue systems are a powerful technological solution to deal with that necessity.

Among dialogue systems, task-oriented dialogue systems --as opposed to conversational dialogue systems, which try to emulate regular conversations-- are designed to perform specific actions upon a user request and, for this, are especially relevant in industrial contexts. In this sense, task-oriented dialogue systems are powerful technologies that allow workers to work on multiple tasks at once by delegating secondary assignments through communicating with the target system, usually with voice commands. The use of voice instructions to interact with these systems allows workers to use them from a safe distance if necessary, and in a way that they do not need to interrupt their current tasks, leaving the quality of their work unaffected. Furthermore, enhancing these systems with the capability of interacting with users in natural language releases workers from having to learn specific words of commands to use them.

However, developing systems that facilitate a natural interaction between humans and industrial systems - task-oriented dialogue systems being the most common approach - by using current state-of-the-art technologies, such as Deep Learning (DL) techniques, is a difficult task, and leads to a series of challenges from their design process to commercialization. The main issues to develop task-oriented dialogue systems for industrial environments that allow communication in natural language can be summarized in the following points:

1. available data is usually bound to specific domains and is also scarce especially in industrial scenarios
2. most dialogue solutions designed for industrial settings are highly specific for the application they are intended
3. due to the high specificity of the dialogue systems designed for industrial environments, their capacity to be reused in other scenarios is very limited.

On the one hand, the above challenges are *challenges for the design process*. But on the other hand, they can be characterized as *commercialization challenges*, i.e., they make it more difficult to follow through in extracting commercial value from the systems. But since a value extraction/exploitation paradigm may be unethical and unsustainable, e.g., see Crawford[1], then these challenges provide an

[1] Crawford, Kate. Atlas of AI: Power, Politics, and the Planetary Costs of Artificial Intelligence. Yale. Yale UP. 2021.

ethically beneficent opportunity to design in alternative ways so as to avoid the extraction/exploitation paradigm. In terms of the challenges above this can mean learning to work (more sustainably) with less data, remembering to design dialogue solutions for specific human contexts as much as possible, and questioning more often the appropriateness of easy system reuse. These approaches can help us find a balance between commercializing the systems and keeping them ethical.

In AI-PROFICIENT, a semantic task-oriented dialogue approach will be developed, combining natural language technologies and semantic web technologies, trying to solve the aforementioned issues taking advantage of the capabilities and complementariness of both technologies that: allow to define in detail the domain of application; reduce ambiguity between agents; and to easily model the dialogue process through relationships between individuals and their properties. Furthermore, the use of semantics to develop such a dialogue system framework benefit from one of the main premises of these technologies: reuse, which enables the development of a generic framework that can be reused in different use cases to deal with different requirements for feedback management. The following picture shows the main components of a typical task-oriented dialogue-system that will be considered for the development

.
The main functionalities of each of the components are:

- Automatic Speech Recognition (ASR): To obtain an uttered user request in a text form
- Natural Language Understanding (NLU): To interpret the user's command.
- Dialogue Manager (DM): To manage the dialogue process
- Natural Language Generation (NLG): To generate the responses to be presented to the user
- Text-To-Speech (TTS): To output the generated system response in a voice form

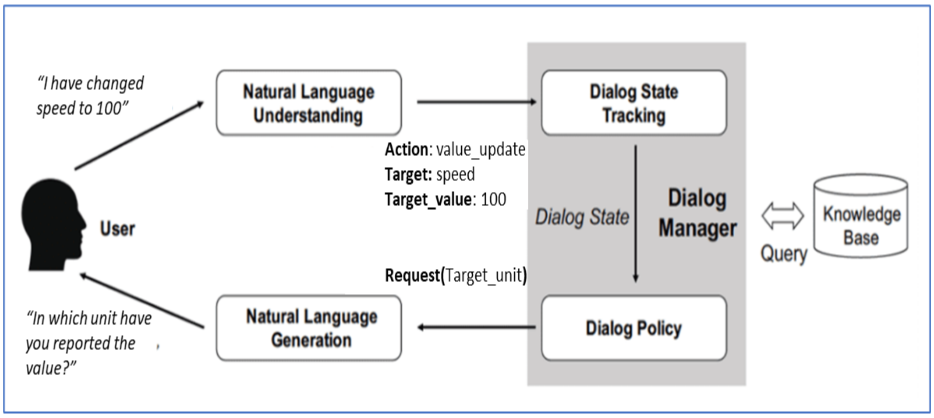

Figure 1: Typical task-oriented dialogue-system architecture

2.2.2 Augmented Reality

Augmented Reality (AR) is a technology field that involves the seamless overlay of computer-generated virtual images on the real world, in such a way that the virtual content is aligned with real world objects and can be viewed and interacted with in real time. AR research and development has made rapid progress in the last few decades, moving from research laboratories to widespread availability on consumer devices.

Augmented Reality through wearable devices such as Google's Augmented Reality glasses can bring numerous advantages for information visualization, such as displaying relevant information to the driver of a forklift through the glasses, they can even be a very useful tool for machinery repair and maintenance mitigating human errors and possible accidents[2] (Martinetti et. al, 2017).

The AI-PROFICIENT Use Cases involving factory floor usage require the use of ATX approved devices. Some of the use cases assume the use of the existing HMI terminals that are already installed on the factory lines. Some use cases would suffice with the use of a dedicated dust-proof tablet, which enables zero-touch functionality. A fully AR-enabled use case would make use of voice-controlled Head Mounted Tablet for hands-free working in potentially explosive zones 1/21 or CSA Class I, II, III (Division 1)[3]. This device enables an intuitive voice control for hands-free working while allowing the micro display to be completely removed from the line-of-site of the operator. But the technology is not limited only to visualization purposes. Indeed, common approaches for AR interaction include tangible user interfaces (UIs) and freehand gesture-based interaction. AI-PROFICIENT will work on augmented reality technologies, not only for advanced information visualization in industrial scenarios, but also to facilitate the user to provide corrections or suggestions on top of it, thus enabling a new channel for the collection of human feedback.

2.2.3 Shop-floor interfaces

New HMIs need to be more sophisticated for enhanced efficiency and remote service operations, especially when workers are interacting with intelligent agents in dusty, humid, or dark industrial environments. Since operators become involved in the manufacturing process for critical decision-making, the HMI system should allow commands that are easily and rapidly entered in order to increase the accuracy, safety and speed of problem-solving. But not all the industrial scenarios are ready to go for a voice or augmented reality driven HMI.

So, in not only the most advanced mechanisms will be considered for feedback management, but extending currently available or newly developed dashboards and interfaces will be also considered to ensure human feedback gathering in scenarios with different level of digitalization in terms of interfaces: excel sheets, web-based dashboards, etc. The feedback methods shall also benefit from the State-of-the-art techniques applied for the use in the industrial environments such as active noise suppression, AI-supported and trained Optical Character Recognition, etc.

---

2 Martinetti, A., Rajabalinejad, M., & Van Dongen, L. (2017). Shaping the future maintenance operations: reflections on the adoptions of augmented reality through problems and opportunities. Procedia CIRP, 59, 14-17.

3 https://www.isafe-mobile.com/en/products/products-zone-1/21/hmt-1z1

3 Feedback management for reinforcement learning based solutions: Detailed description for each use case

3.1 CONTI2: Restart set

In the Restart set UC in Continental the AI-based model is expected to be "registering" the extrusion signals and using the known information about the recipe and compounds that will be used during the next extrusion, it should provide to the user recommendations in terms of readiness state and speed setpoint suggestions for each extruder.

The model will be trained upon the available information, but once it is deployed and in use in production, feedback is considered to be relevant and very valuable to reinforce and improve the model. Both implicit and explicit feedback will be used for such purposes following the approach described above.

3.1.1 Solution

3.1.1.1 Implicit feedback

Two types of recommendations are expected from the AI-models in this use case: readiness state and speed setpoints. The first will be a Boolean while the latter will be numeric values. Both will be provided to the user in a specific moment, he/she will decide if extruder is really ready to start the process and/or the setpoints values are proper. The AI will then configure the process according to the operator's considerations, tuning the speed settings and starting the process. The information about the starting time as well as used speed values are recorded in the system. Taking advantage of this information, and comparing it to the recommended values, information for reinforcement will be generated indicating the success of the recommendation and when not successful, preparing the information indicating the unconsidered values as well as the used ones, considered as the correct ones.

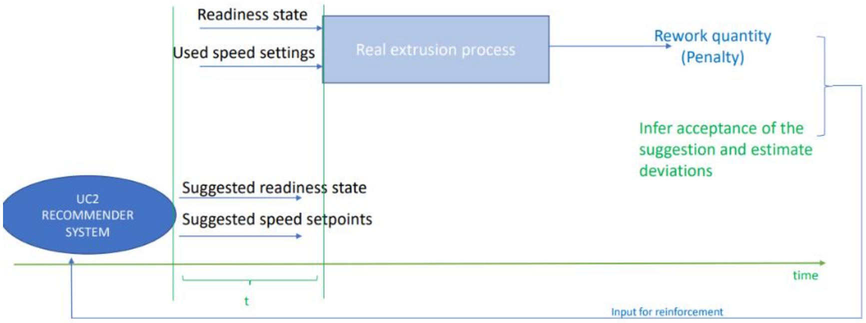

Figure 2: CONTI2 implicit feedback management approach

3.1.1.2 Explicit feedback

Users can provide valuable information explicitly when they do not follow the settings, providing their main reasons for not following the recommendations. For that, an interface showing the following options open to selection will be considered:

- New recipe – The algorithm did not recognize the recipe thus did not provide settings • Not reaching profilometer setpoint – The speed settings provided do not allow to reach profilometer setpoint (the user is forced to increase speed)

- Too sharp ramp – The speed settings are too sharp (according to the user) so they use lower speeds than the ones suggested
- Involuntarily disregarding recommendations
- Others – Allow the user to give free text (writing/speaking)
- No feedback – The slider was not used to provide feedback, and the next restart occurred.

The interface could use a web-based approach or even an augmented reality display. The final implementation decision is under discussion. But in any case, the different options will be matched to a known classification for the AI-model, and combined with the implicit feedback, it will be sent to the AI-model for reinforcement purposes.

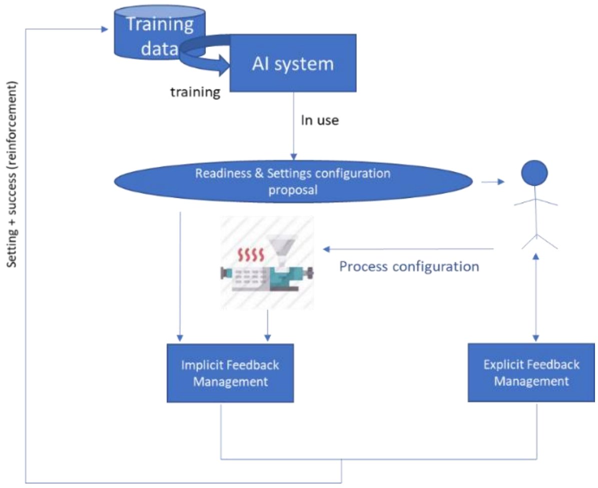

Figure 3: CONTI2 reinforcement-based flow

3.1.2 Ethical aspects – Ethics Team

Ethical issues related to CONTI2 for Human-Machine feedback management and the measures that are planned to address them are shown in the following table.

Table 6: Ethical issues for Human Feedback Management in CONTI2 use case

ETHICS CODE	CODE ORIGIN[4]	Description	Measure	Responsible
ETHICS 4.1-7	CO report	Recommend that, as a best practice, the combined data results from explicit and implicit feedback be tagged, to indicate that active operator choices (explicit feedback) make up part of it	An additional parameter will be included representing the origin of the data (explicit/implicit)	TEK/TF

3.1.3 Implementation and Deployment in AI-PROFICIENT platform

The implementation and the deployment in the AI-PROFICIENT platform of the reinforcement mechanism based on the human-feedback is under discussion and will be detailed in the next version of the deliverable.

[4] As ethic by design involve new requirement as the development are going on, the requirement table shows the deliverable or report and the requirement numbering following the ethic numbering rules (see D1.3).

3.2 CONTI5: Tread blade wear

In CONTI5, AI-models aim to predict the optimal moment for changing the tread blade. However, due to the imperfection of the AI-models, the prediction will not always provide the best moment, and in order to correct these deviations, a human-feedback management will be applied.

Both, implicit and explicit feedback will be used for this purpose following the approach described above.

3.2.1 Solution

3.2.1.1 Implicit feedback

As mentioned above, the aim of the AI models here is to predict the optimal moment to change the blade considering currently available information, such as material types and compositions, performed cuts, current signals information, and even the appearance of the blade. This diverse information will be processed by different AI approaches that are expected to be combined to make the most robust possible AI-based prediction solution, leading to a decision support system (DSS). But all of them give the same information, the optimal moment to change the blade. The suggestion is provided to the maintenance manager, and they decide when the moment arrives to change the blade or not, by the maintenance craftsmen. Whenever the maintenance craftsmen change the blade, it is registered in the system.

Taking advantage of this information and aligning the change moment with all the information registered within the system (current signal values, image of the blade) and comparing it to the prediction, information for reinforcement will be generated indicating the success of the recommendation. When the recommendation is not used, explicit feedback will be activated to try to get the reason why.

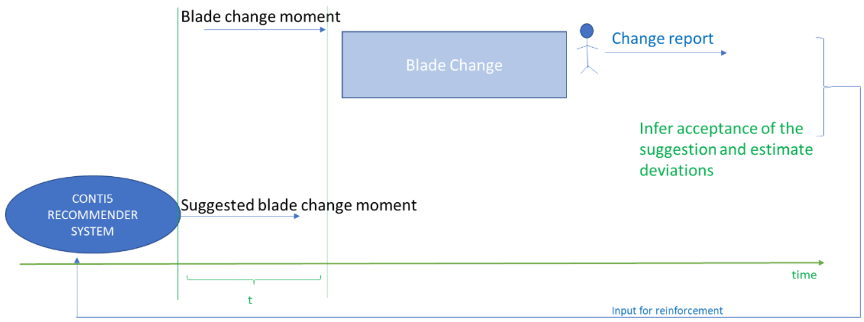

Figure 4: CONTI5 implicit feedback management approach

3.2.1.2 Explicit feedback

As mentioned before, in this use case, the user feedback is very useful for reinforcement purposes since the blade change does not necessarily happen in its optimal end of life moment. The change could be performed due to planned maintenance, when the blade use could be extended for a longer time, or on the contrary it should be changed earlier. So, whenever the change process take place, it could be very useful the reporting of the status of the blade at that specific moment. And, it is also useful to record the main reason why the operator declines to follow a suggestion provided by the AI system.

Since, currently in all the plants, the operators register the blade change and some additional aspects, but none of them reports the real status of it, the approach will be to extend the existing interface to include a set of options related to the blade aspect and then translate it to a proper classification, in terms of status to be interpretable by the AI-model and be used as reinforcement information.

On the other side, in order to gather the reasons when a change suggestion is discarded by the operator, the decision support system's HMI is considered to be extended to collect the reason, again, displaying a set of options to the user to register the reason and then translate it to a classification interpretable by the AI-model, and be used as reinforcement information.

The explicit feedback reinforcement information will be combined with the implicit feedback and sent to the model with reinforcement purposes.

-

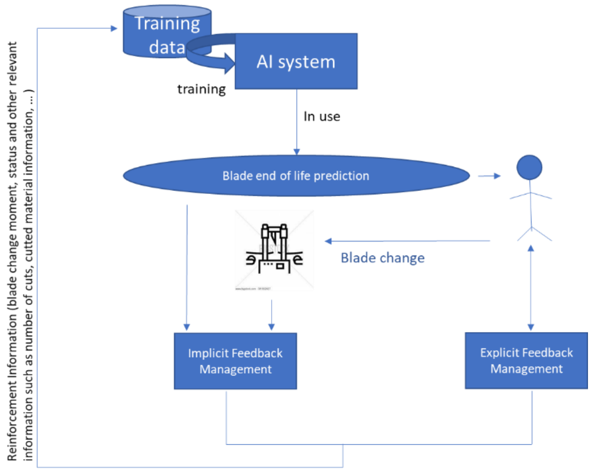

Figure 5: CONTI5 reinforcement-based flow

3.2.2 Ethical aspects Ethics Team

Ethical issues related to CONTI5 for Human-Machine feedback management and the measures that are planned to address them are shown in the following table.

Table 7: Ethical issues for Human Feedback Management in CONTI5 use case

ETHICS CODE	CODE ORIGIN[5]	Description	Measure	Responsible
ETHICS 4.1-7	CO report	Recommend that, as a best practice, the combined data results from explicit and implicit feedback be tagged, to indicate that active operator choices (explicit feedback) make up part of it	An additional parameter will be included representing the origin of the data (explicit/implicit)	TEK CONTI INOS

3.2.3 Implementation and Deployment in AI-PROFICIENT platform

The implementation and the deployment in the AI-PROFICIENT platform of the reinforcement mechanism based on the human-feedback is under discussion and will be detailed in next version of the deliverable.

[5] As ethic by design involve new requirement as the development are going on, the requirement table shows the deliverable or report and the requirement numbering following the ethic numbering rules (see D1.3).

3.3 CONTI10: Quality analysis tool

3.3.1 Solution

Quality analysis tool aims to monitor relevant process signals and to alert the user when the deviation in certain product characteristics is predicted, with the decision support provided in order to prevent further deterioration. That shop floor assistance will comprise the information about the potential cause of the deviation and (sub)optimal sets of recommended readjustments that could be taken by the user. However, the quality of described direction of the user-tool communication can be highly improved through proper integration of the users' feedback regarding the tool's outcomes. The current approach in its collection envisions both explicit and implicit feedback, among which the implicit ones can be used in any phase of tool deployment (both testing and later active use in production).

3.3.1.1 Implicit feedback

Under implicit feedback are assumed the control actions (changes of some reference values) made by the operator after the event of interest (some disturbance in the process occurred that has been considered as a potential cause, or the deviation, in product characteristics, is already present). The feedback is valuable, either being in compliance with the latest tool outcomes or not.

3.3.1.2 Explicit feedback

Concerning provided suggestions of relevant process variables set-points values, the explicit feedback can be extracted from users' actions made through the human machine interface (HMI), while the following scenarios are possible:

- user selected one of the suboptimal set of parameters as an indicator of his/her agreement
- user selected the "none of the above" option, as the indicator of opposite opinion that there is no appropriate suggestion, derived from expert knowledge,
- user stayed abstained from making a choice.

Aside from the HMI, natural voice interaction will be utilized to gather explicit feedback. For the interaction to occur naturally, the system must understand the user's communicative intention from the STS that has been recognized and convert it into semantic actions. To develop this task, we have started working with the cognitive services offered by Microsoft Azure. Azure Cognitive Services provide an API so you can add the ability to speak, see, listen, search, understand, and accelerate decision-making to your applications.

We are developing an ASP.NET application using the Cognitive Services API to recognize the user's voice commands, interpret them and execute actions. We are using the voice services offered by the Cognitive Services API, specifically the Speech to Text service. Also, we will use Language Services for language interpretation, specifically the Language Comprehension Service (LUIS).

LUIS is a cloud-based conversational artificial intelligence service that applies personalized machine learning intelligence to a user's natural language text or conversation to predict meaning and extract relevant and insightful information. LUIS provides a portal for setting intents, but you can also use the Visual Studio Developer Tool API. In the first phase of development, we will use the portal to configure the intents, and later we will be integrated into the ASP .NET application.

The collected status of users' actions (both operators' and quality managers') will be recorded in the database in a compliant manner (as suitable datatype) and further available to the services within the tool, where the optimization service is the one that primarily will benefit from them.

Regarding the root cause identification and feedback of the user in that term, an explicit approach is considered, in the testing phase, using the HMI. Similarly, to the previous scenario distinction, there are the following options:

- "Recommendation does not correct; the cause is an improper setting of (a drop-down menu will appear with listed potential causes)"
- "Recommendation does not correct; but the cause still unknown to the operator and/or to the quality manager"
- "Recommendation correct".

It should be emphasized that concrete wording is given for the sake of illustration and that it is prone to modifications.

For the sake of instantiation on the use case level, some of the relevant process variables considered here for readjustment are the extruders screw speed set-points, the temperature of barrel zones set-points, the downstream shrinkage roller and conveyor speeds, etc.

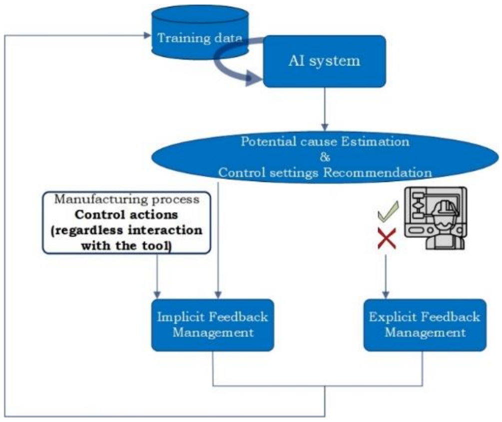

Figure 6: CONTI10 reinforcement-based flow

3.3.2 Ethical aspects

Ethical issues related to CONTI10 for Human-Machine feedback management and the measures that are planned to address them are shown in the following table.

Table 8: Ethical issues for Human Feedback Management in CONTI10 use case

ETHICS CODE	CODE ORIGIN[6]	Description	Measure	Responsible
ETHICS 4.1-7	CO Report	Recommend that, as a best practice, the combined data results from explicit and implicit feedback be tagged, to indicate that active operator choices (explicit feedback) make up part of it	An additional parameter will be included representing the origin of the data (explicit/implicit)	IBE IMP ATC

3.3.3 Implementation and Deployment in AI-PROFICIENT platform

The implementation and the deployment in the AI-PROFICIENT platform of the reinforcement mechanism based on the human-feedback is under discussion and will be detailed in the next version of the deliverable.

[6] As ethic by design involve new requirement as the development are going on, the requirement table shows the deliverable or report and the requirement numbering following the ethic numbering rules (see D1.3).

3.4 INEOS1: Reactor stability at Geel plant

3.4.1 Solution

INEOS1 use case will result in a set of advanced analytical tools which will help in solving problem of temperature variations in the chemical reactor, as explained in deliverable D1.3. One of the key components of this system will be generative optimization, as the recommendation system, which provides a set of (sub)optimal control parameters set points which should prevent temperature variations or would reduce them and will include operator's feedback in order to improve corresponding recommendations.

3.4.1.1 Implicit and explicit feedback

Hence, this system is like the one described as a part of section related to CONTI10 use case, with details in *Figure 6* including both explicit and implicit feedback. The explicit one will be present through the HMI developed as a part of tasks 4.2 and 4.3 where operators will be able to accept, reject and not respond to the suggested action. On the other hand, by analyzing the actions taken by the operator after the recommendation, additional feedback regarding the recommendation quality could be extracted.

3.4.2 Ethical aspects Ethics Team

Ethical issues related to INEOS1 for Human-Machine feedback management and the measures that are planned to address them are shown in the following table.

Table 9: Ethical issues for Human Feedback Management in INEOS1 use case

ETHICS CODE	CODE ORIGIN[7]	Description	Measure	Responsible
ETHICS 4.1-7	CO Report	Recommend that, as a best practice, the combined data results from explicit and implicit feedback be tagged, to indicate that active operator choices (explicit feedback) make up part of it	An additional parameter will be included representing the origin of the data (explicit/implicit)	IBE IMP

3.4.3 Implementation and Deployment in AI-PROFICIENT platform

The implementation and the deployment in the AI-PROFICIENT platform of the reinforcement mechanism based on the human-feedback is under discussion and will be detailed in the next version of the deliverable.

[7] As ethic by design involve new requirement as the development are going on, the requirement table shows the deliverable or report and the requirement numbering following the ethic numbering rules (see D1.3).

3.5 INEOS2: Image recognition at Geel plant

This use case takes advantage of computer vision, Optical Character Recognition (OCR), and a trained AI module for data checking and matching to automatically scan labels on the additives packaging in the INEOS Geel plant. Label scanning implies visually recognizing the label alphanumeric data, finding the appropriate data fields for the production process, and verifying the selected data fields against the AI module trained to match the correct data combination based on historical inputs. As in other use cases, the AI model trained using historical logs of the label data together with a set of images could make mistakes and provide an erroneous label read in this specific use case. Identifying this error and providing the correct value to the model enables a reinforcement approach, for which human operator intervention is crucial. The designed process keeps the human in control, allowing the plant operator to make the final verification and, in required, impose the data alterations manually. To facilitate and enhance the feedback contribution from the operators, voice and hand typing (depending on the mobile terminal used) mechanisms will be combined with augmented reality technologies fostering natural feedback management.

3.5.1 Solution

3.5.1.1 Explicit feedback

Two reinforcement feedback mechanisms are used in the INEOS2 use case. The first one is based on the weekly analysis of the approved plant process start datasets. The second one is a direct intervention of the operator during the label scanning procedure. Even though the automatic label scanning could fail in less than 1% of the cases, immediate user feedback is beneficial for reinforcement purposes. The operator is the only actor that could provide the correct information right at the moment of the additive loading during the INNEOS2 Use Case process. Developing advanced mechanisms supporting the reinforcement approach's input channel could also be beneficial for the production plant since the correct information corresponding to the additive label is essential for the process itself.

Considering the potential of the interaction, a natural voice-based component will be developed and combined with the in-place augmented reality solution to collect the correct tag information when an erroneous/incomplete automatic reading occurs. Additionally, a dedicated User Experience flow will be designed to minimize voice iteration on the factory floor. Even though a dedicated industry-grade terminal is used to support applications in noisy industrial environments, the human-machine interaction will be minimized to simplify the process flow while making it more robust to the external factors.

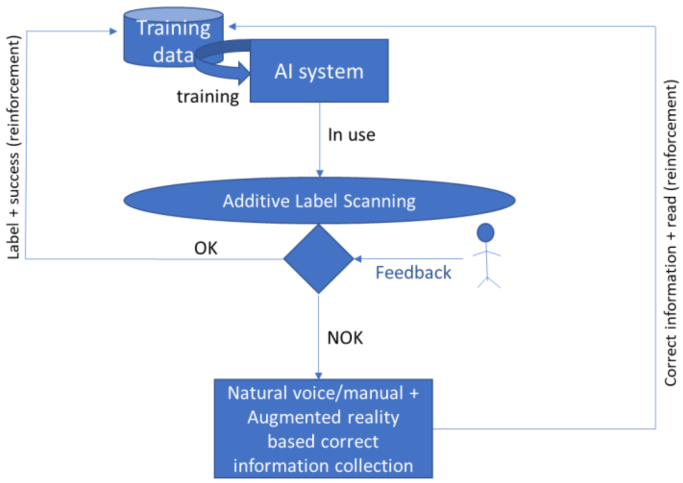

Figure 7: INEOS2 reinforcement-based flow

3.5.2 Ethical aspects Ethics Team

Ethical issues related to INEOS2 for Human-Machine feedback management and the measures that are planned to address them are shown in the following table.

Table 10: Ethical issues for Human Feedback Management in INEOS2 use case

ETHICS CODE	CODE ORIGIN[8]	Description	Measure	Responsible
ETHICS 2	D1.3	AI Errors handling	The responsible partners will develop a protocol to address the 1% of cases where the AI itself will make an error, or where the operator (or Control room Quality manager) will make an error relative to the AI suggestion, i.e. a clear set of instructions about what to do in this or this case	INEOS
ETHICS 4.1-2	CO Report	Definition of tasks after an AI suggestions arrives	The responsible partners will create processes to clarify to the Control room Quality manager exactly what he is supposed to do once AI suggestions start coming for the DCS.	INEOS
ETHICS 4.1-3	CO Report	AI errors propagation handling	The responsible partners will undertake a conceptual analysis of the hypothetical situation in which an AI error may occur and, try to identify the propagation points at which it could be caught before causing a product problem, leading to strengthen and thus, contributing to minimize even eliminate the AI error.	TF TEK ATC INEOS
ETHICS 4.1-7	CO Report	Recommend that, as a best practice, the combined data results from explicit and implicit feedback be tagged, to indicate that active operator choices (explicit feedback) make up part of it	An additional parameter will be included representing the origin of the data (explicit/implicit)	TF TEK ATC INEOS

3.5.3 Implementation and Deployment in AI-PROFICIENT platform

The implementation and the deployment in the AI-PROFICIENT platform of the reinforcement mechanism based on the human-feedback is under discussion and will be detailed in the next version of the deliverable

[8] As ethic by design involve new requirement as the development are going on, the requirement table shows the deliverable or report and the requirement numbering following the ethic numbering rules (see D1.3).

3.6 INEOS3: Rheology drift at Cologne plant

3.6.1 Solution

As explained within deliverable D1.3, the goal of INEOS3 use case is to provide a set of analytical tools which would detect the causes of rheological parameters deviation and would provide a recommendation for control parameter set up which will prevent from potential degradation, or which would result in improving rheological parameters. With the aim of constantly improving the corresponding recommendation system, it is foreseen to include expert feedback.

3.6.1.1 Implicit and explicit feedback

The main tool that will utilize the feedback will be generative optimization, similarly to what was described as a part of section related to CONTI10 and that was presented in Figure 6. Namely, both implicit and explicit feedback will be present. The implicit feedback will be given through the actions by the operators which are influenced by the recommendation system, e.g., adapting the set point value of extruder's speed, since it was recognized as the influential factor for the deviation. On the other hand, explicit feedback will be present through the HMI, where the operator will be able to accept, reject or not to respond to the recommendation. As it can be concluded, the feedback system will be similar to the one in CONTI10, since both of those will serve to a generative optimization service. The specificity will be in the parameters that will be considered, depending on the particular use case. Within this use case the main focus will be temperatures, extruders' speeds and pressures, since these values have been the most relevant for maintaining rheological parameters in the predefine intervals.

3.6.2 Ethical aspects

Ethical issues related to INEOS3 for Human-Machine feedback management and the measures that are planned to address them are shown in the following table.

Table 11: Ethical issues for Human Feedback Management in INEOS3 use case

ETHICS CODE	CODE ORGIN[9]	Description	Measure	Responsible
ETHICS 4.1-7	CO Report	Recommend that, as a best practice, the combined data results from explicit and implicit feedback be tagged, to indicate that active operator choices (explicit feedback) make up part of it	An additional parameter will be included representing the origin of the data (explicit/implicit)	IMP IBE

3.6.3 Implementation and Deployment in AI-PROFICIENT platform

The implementation and the deployment in the AI-PROFICIENT platform of the reinforcement mechanism based on the human-feedback is under discussion and will be detailed in the next version of the deliverable.

[9] As ethic by design involve new requirement as the development are going on, the requirement table shows the deliverable or report and the requirement numbering following the ethic numbering rules (see D1.3).

4 Conclusions

The document presents different mechanisms that could be used for human-feedback management and details how they will be used in the context of AI-PROFICIENT for AI models reinforcement purposes, detailing the concrete design for the different use cases. The following table presents a summary of the different feedback management approaches planned in the different use cases.

Table 12: Human-Feedback management components summary.

UC	Human Feedback Component	Responsible
CONTI2	Implicit & Web-based even augmented reality based explicit feedback management	TEK, TF
CONTI5	Implicit & Shopfloor interface based explicit feedback management	TEK, INOS, CONTI
CONTI10	Implicit & Natural voice based explicit feedback management	IBE, IMP, ATC
INEOS1	Implicit & Natural voice based explicit feedback management	IMP, IBE
INEOS2	Natural voice and Augmented Reality explicit feedback management	TF, TEK, ATC
INEOS3	Implicit & Natural voice based explicit feedback management	IMP, IBE

Acknowledgements

This project has received funding from the European Union’s Horizon 2020 research and innovation program under grant agreement No 957391.