# WHITE-LABEL SHOP FOR DIGITAL INTELLIGENT ASSISTANCE AND HUMAN-AI COLLABORATION IN MANUFACTURING

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# DISCLAIMER



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# CONTENT

# LIST OF FIGURES



# LIST OF TABLES

# LIST OF ABBREVIATIONS

| Abbreviation | Description |
|---|---|
| DIA | Digital intelligent assistant |
| SME | small and medium-sized enterprises |
| OVOS | OpenVoiceOS |
| AWM | Assisted Workforce Management |
| PPE | personal protective equipment |
| NLU | Natural language understanding |
| WI | Waste inspector |
| LLM | Large Language Model |

# 1. EXECUTIVE SUMMARY

WASABI aims to develop Digital Intelligent Assistant (DIA) solutions to help humans achieve their goals without marginalizing them - this will contribute to human-centered manufacturing. The DIA solutions are developed for SMEs and mid-caps to help them achieve their sustainable goals and faster onboarding of new workers.

The WASABI project is structured around five use case partners: CROMA (sterilization of surgical equipment), EPISCAN (production of personal protective equipment), REINOVA (testing and validation of e-mobility components), SILK-BIO (solubilisation and casting of silk fibre) and TRIMEK (metrology systems, solutions, and machines). Some of these partners are involved in more than one use case.

Deliverable 2.4, "Joint WASABI Demonstrator – Version 2", demonstrated the project's second phase (M10-M15) results in developing and deploying the WASABI solution across three distinct use cases.

1. Augmented waste management and valorization (Task 2.2)

This use case focuses on managing dismissed items in manufacturing by implementing the Waste Inspector DIA's skills and the rEUse waste management platform. By M15, the rEUse Platform has been extended with new functionalities. Further implementation scenarios for the waste inspector DIA for TRIMEK and CROMA have been deployed and presented in Section 4.

2. Assisted workforce management (Task 2.3)

This use case focuses on implementing the Onboarding DIA, which aims to help new employees and experienced workers understand the technical instructions and manufacturing processes and reduce training times for new workers. By M15, further implementation scenarios for the onboarding DIA's skills for EPISCAN have been deployed and presented in Section 5.

3. Assisted quality assurance for sustainable products (Task 2.4)

This use case focuses on enhancing product quality testing processes by leveraging a DIA that supports workers in executing validation protocols for safer and more sustainable products. By M15, the Analytics components had been extended to new functionalities. Further implementation scenarios for the Assisted Quality Assurance DIA's skills for REINOVA, TRIMEK, CROMA, EPISCAN, and SILKBIO have been deployed and presented in Section 6.

Tasks 2.2., 2.3, and 2.4 will continue until M24. During the project's second phase, our focus was on enhancing the DIAs' capabilities by close collaboration with the end users and incorporating feedback obtained from users during evaluations. Furthermore, we ensure that the DIAs are developed and operated according to the GDPR and EU AI Act. Some examples of relevant aspects are introduced in section 3 of this deliverable. Valuable lessons we learned and challenges from the second implementation phase are presented and will be addressed in the next development phase. Key aspects related to AI explainability and AI robustness for conversational AI and AI algorithms used in data Analytics in WASABI are discussed in the Section 7.

In the third and final phase, we will also integrate findings from the second round of the evaluation and the first round of the open-call experiments. Finally, we will integrate the developed solutions into the end users' infrastructure and finalize the demonstrations. The result of the final phase will be detailed in D2.6 in M24.

# 2. INTRODUCTION

## 2.1 Purpose and scope of the deliverable

The WASABI project centers on advancing Digital Intelligent Assistant (DIA) solutions to facilitate goal achievement for humans without marginalization, aligning with the principles of human-centered manufacturing and sustainability. The vision involves integrating DIAs and conversational AI as standard practices to address sustainability goals in manufacturing. Deliverable 2.4, "Joint WASABI Demonstrator – Version 2", presents outcomes from the second phase of the project (M10-M15) of the project across three distinct use cases.

- Use case 1: Augmented waste management and valorisation for TRIMEK and CROMA (Task 2.2)
- Use case 2: Assisted workforce management for EPISCAN (Task 2.3)
- Use case 3: Assisted quality assurance for sustainable products for REINOVA, TRIMEK, CROMA, EPISCAN, and SILKBIO (Task 2.4)

This deliverable reports a summary of the WASABI approach to data privacy and AI law, the infrastructure changes, and the main activities and results carried out during M10-M15 across Tasks 2.2, 2.3, and 2.4, and addresses the explainability and AI robustness across the AI components. This deliverable is the second of three Joint WASABI Demonstrators, and the final version is set to be released in M24.

## 2.2 Relation to other WPs and tasks

This deliverable receives input from WP1 (T1.1, T1.2, T1.3, T1.4), WP3 (T3.3, T3.4), WP4 (T4.2, T4.4), and WP5 (T5.5). Figure 1 shows how D2.4 relates to other WPs and Tasks. There are minor relations to the data management plan (D7.2 and D7.5) and the periodic progress reports (D7.3 and D7.4) because they contain information about privacy.

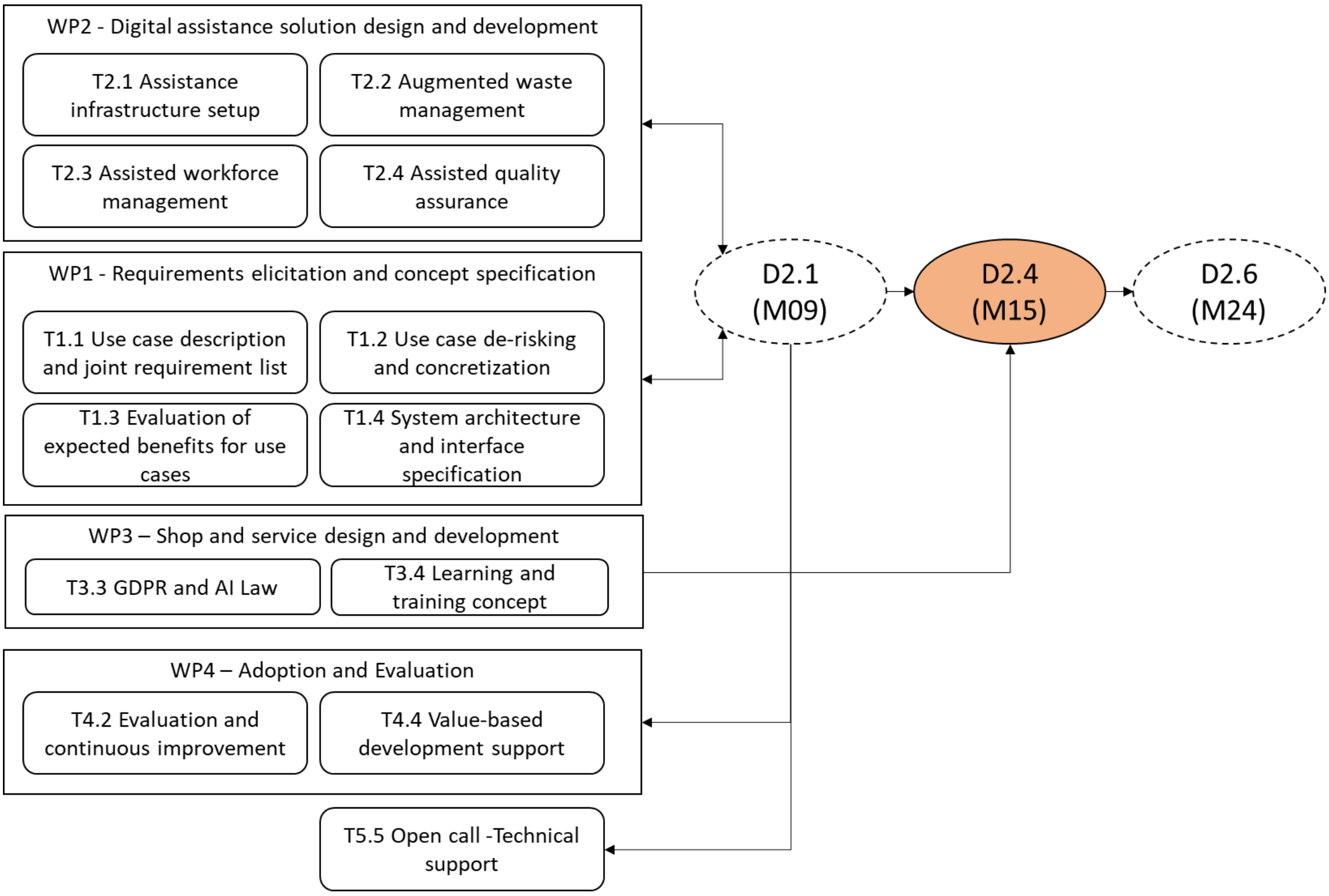



*Figure 1: D2.4 relation to other work packages and tasks*

# 3. Approach and Infrastructure

We introduced the basic functions of WASABI DIAs and key terms in the first version of this deliverable (D2.1).

## 3.1 Data Privacy and AI Law

We develop and operate the following DIAs in line with the **General Data Protection Regulation** (GDPR). The baseline for it are the documents and procedures established during the research project COALA (GA957296) funded by the EU's Horizon 2020 program.[1] Its main assumption is that the DIA collects and processes different kinds of personal information. Since COALA-based DIAs operate in corporate environments with confidential information, the end users must **register each user** in the system with a pseudonym. Some use cases require additional information associated with the pseudonym, such as an experience level or role at work. Users do not have to provide their full name or personal information like an address or location. Furthermore, the transcript of each user utterance receives a **unique conversation identifier** to group all utterances that belong to the same conversation. The same person can have several associated conversations. Each conversation contains the unfiltered transcript of what the user said, which could contain further personal information of the user or any other person (e.g. a colleague or superior). WASABI's training and change management concepts (D3.6 and D4.1) seek to minimize exposing unnecessary personal information during conversations through training and awareness raising. The DIA infrastructure stores records of a conversation to provide essential technical functions, e.g., having a conversation. In addition, we keep records to analyze challenging conversations and to improve the DIAs' behavior. Finally, we keep the IP addresses of the mobile devices to deliver messages and to track system access. WASABI introduces minor changes to account for technology updates and business-case-specific requirements.

Besides, we developed the DIAs by operationalizing the **EU AI Act**[2], which is a comparably new regulation for AI applications. Task 3.3 (Contract and tort law for AI-based digital assistance solutions), Task 4.3 (Assessment of trustworthy AI systems), and Task 6.2 (Exploitation of results) will revisit specific aspects and impacts of AI in the law. The findings will ultimately converge in the final exploitation plan (D6.7).

## 3.2 Infrastructure changes

The main elements and characteristics of the WASABI infrastructure remain as outlined in D2.1. The following paragraphs introduce major changes to address end user requirements and emerging technological challenges.
All WASABI DIAs now use OpenVoiceOS (OVOS) as the basic voice assistant framework.[3] OVOS is the continuation of the privacy-focused open-source assistant Mycroft.[4] Since OVOS' forked Mycroft, its developers introduced architecture changes, many features, and bug fixes substantially increasing its reliability, flexibility, security, maintainability, and usability. The migration also allows WASABI DIAs to handle multiple languages in one OVOS service and maintain a conversation session per user to fix the issue where all users shared the same skill states. Besides the migration, WASABI updated the COALA Android App to align with the OVOS features and to provide a flexible and user friendly interface to interact with WASABI DIAs.

[1] https://doi.org/10.3030/957296
[2] EU website about the AI Act
[3] https://github.com/OpenVoiceOS
[4] Mycroft Inc. discontinued their support for the Open Source project and stopped their online services.

The containerization (with Docker) of DIA skills, introduced with OVOS, motivated splitting the DIA infrastructure in two parts. From now on, a "base-stack" contains the main OVOS services, major infrastructure services (e.g. identify management and reverse proxy) and any service shareable by multiple skills (e.g. file storage). Skill-specific services (e.g. Rasa services, analytics services, and databases) including the skill container itself reside in a "skill stack". By splitting services like this the base-stack becomes a shared infrastructure for many skills. This change substantially simplifies the stack deployment and maintenance – which is a prerequisite for further scaling and exploitation. Third parties can now provide their own OVOS skill and the related services in the skill-specific stack. Figure 2 illustrates the new split-stacks and some of the infrastructure's core components.

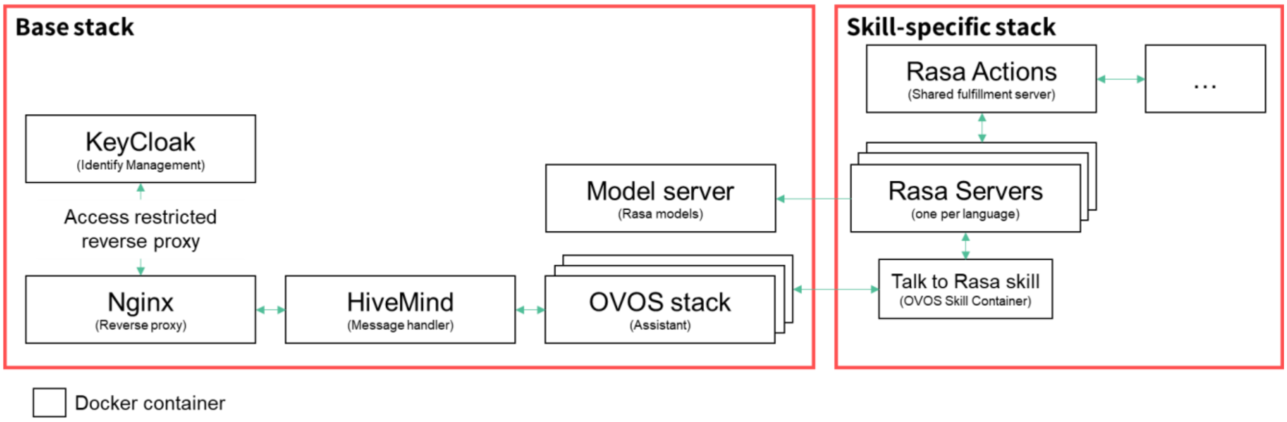



*Figure 2: Infrastructure overview with OVOS and split-stacks*

# 4. AUGMENTED WASTE MANAGEMENT AND VALORIZATION

In accordance with the scope presented in the previous deliverables, this use case focuses on the management of dismissed items in manufacturing with the aim of inventory management and minimization of items found to be suboptimal based on their specific manufacturing or tolerance criteria. If a production process cannot avoid generating some non-conforming items for technical reasons, these items may still be considered to be reusable or refurbishable by first parties or other third-party organizations, provided the characteristics can meet whatever requirements are deemed appropriate. Furthermore, it allows for the traceability of these items through a comprehensive inventory with identifiers, allowing the DIA component to read and write to the rEUse platform to facilitate entry and retrieval.

In the Bremen GA in November 2023, the scope of this task was extended to move away from waste management and instead towards circularity by extension through the concept of a circular entity. This was the result of realizing that the scope of the project and the nature of contributions from the pilots were not a subject of managing waste products but far more applicable to reusing and tracking existing stock. A circular entity in this context is an abstract way to manage green processes, flows, and items; becoming a component of circular economy. This scope proved to be very welcome to the pilots and technical partners of the project and allowed us to move away from the unnecessary complexity of managing waste which not only proved inapplicable to the use case partners, but would inevitably come with a host of legal and practical considerations.

Progress achieved in the context of the augmented waste management and valorization task is a major component of this approach; it provides a simple way for the DIA to interact with rEUse while at the same time providing workers with advanced user interfaces to help describe dismissed items and allowing for third parties to identify if they qualify for reuse purposes. Workers can use the powerful tools provided by the combination of the DIA and the rEUse platform to describe these dismissed items, have them stored in the rEUse environment, and enrich the description with specific descriptive attributes that facilitate the reuse process. rEUse provides REST endpoints to the DIA and potentially other components which might decide to utilize this functionality for the open calls to facilitate automatic response to queries received from the rest of the WASABI ecosystem, which can be used to automate parts of this process.

## 4.1 Components

The main components used to build the waste inspector (WI) DIA include:

- Base stack
- WI Docker stack
- WI OVOS skill
- WI Rasa services
- rEUse platform with REST API
- Apollo server and GraphQL for fetching data from rEUse REST API

In the following sections, we will explain the updates in the reuse platform and the DIA skill. The DIA skill includes the WI OVOS skill and the WI Rasa services.

### 4.1.1 rEUSe Platform

rEUse is a flexible platform that is used to create, manage, and scale circular entities. In the context of circular economy, a circular entity can be conceived as an abstract component, item or process which possesses functionalities applicable to the realization of these circular purposes.

In the context of WASABI, rEUse has a dual purpose; it acts as a bridge between the DIA and the end-user by allowing the retrieval and storage of entity data through API calls, and, at the same time, it provides a comprehensive front-end to the end-user to manually add and retrieve data on specific entities through an easy to use interface that can be tailored to the specific use cases of the respective partner.

In the progress of the project, extensive consultations with the pilots have resulted in a list of the entities that were deemed important for the realization of the scope. In each respective section below, we present screenshots from the actual operational instance of rEUse for the corresponding pilot as well as a list of the entities which were settled on through these consultations.

Future work until M24 will consist of expansion of interaction options, backend changes, and bug fixes as real-world use cases partners begin to feed extensive data to the platform. Furthermore, future work will include supporting the needs of partners in other areas which involve the component, like potential utilization in the open-call experiments and user training material.

Figure 3 and Figure 4 are screenshots from the landing page with the corresponding sections for the pilots on the left side of the sidebar. The second screenshot presents the entity page where new entities can be created and existing ones can be viewed and modified. For the scope of the project, the environment was significantly improved through the addition of instant search filters which work for any and all fields, the ability to backup and restore the underlying entries, the ability to attach accompanying files to specific entries and better visualization.

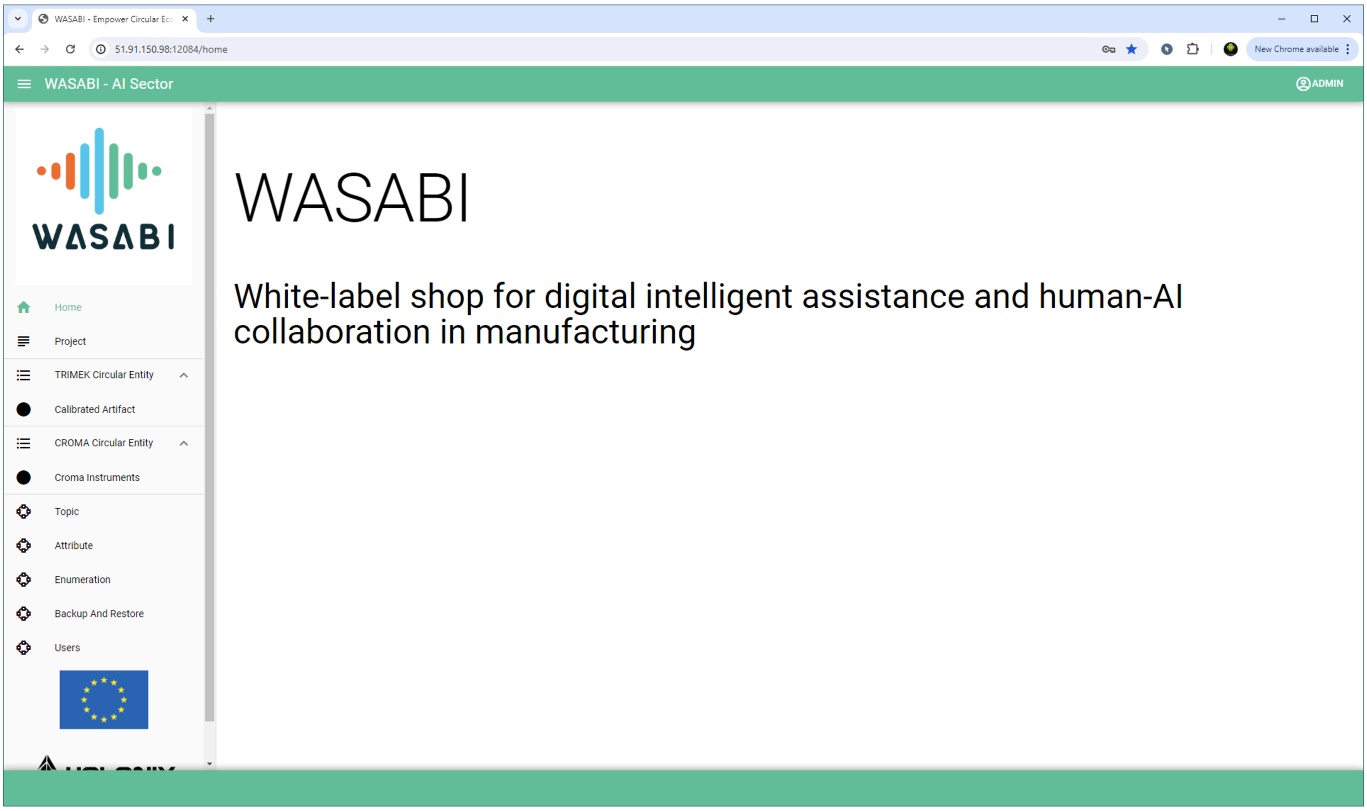



*Figure 3: The initial welcome screen of rEUse, sections for entities for TRIMEK and CROMA visible on the left*

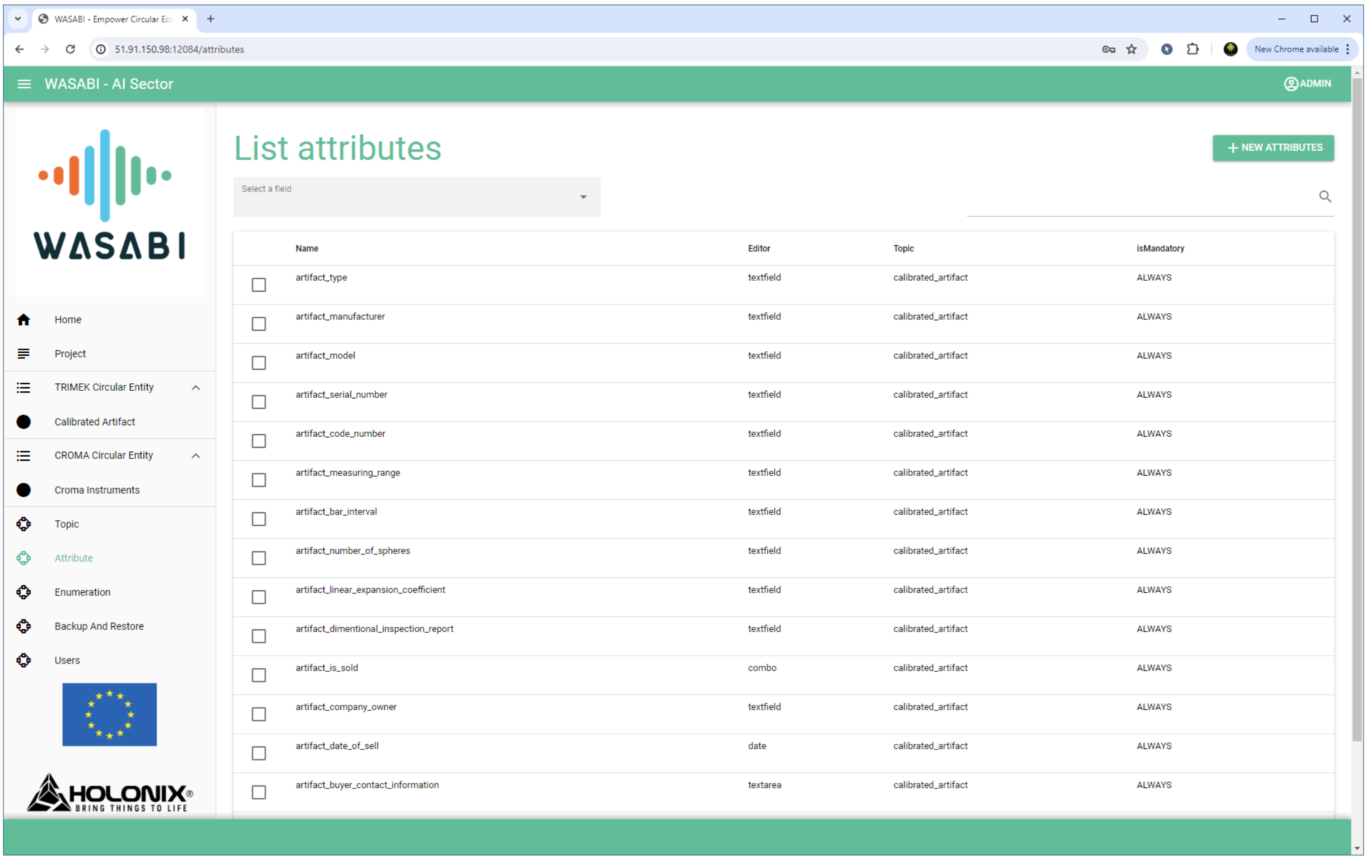



*Figure 4: The circular entities section of the rEUse platform*

### 4.1.2 Assistant Skill

To facilitate user interaction with the rEUse platform via natural conversations, we have developed an OVOS skill called WI which connects to the Rasa chatbot developed for TRIMEK and CROMA. Using the COALA android app, users can talk to the WI Rasa bot by saying "Start waste inspector" or "Start rEUse bot". Once the skill is activated, user messages will be sent to the corresponding rasa endpoint, and similarly, the Rasa responses will be prompted to the user.

The Rasa chatbot uses a configurable NLU (natural language understanding) pipeline, a dialog manager based on rules and probabilistic models, and a fulfillment server performing custom actions via Python code. The action server queries information from the rEUse platform through a REST API via the Apollo server and uses the results to decide how to respond (e.g., using a template with parameters filled out by the query result).

Our implementation of the Rasa chatbot has two groups of features:

- Base Features: including generally applicable intents and conversation patterns such as chitchat, out-of-scope; and GDPR-related intents
- Circular entity traceability features: Tailored to specific use case circular entities, these features are designed to allow users to interact with the rEUse platform by creating new entities and retrieving information about already registered entities. The specifics of these features will be detailed in the following section.

The skill and the Rasa models are developed in Spanish and English language.

## 4.2 Demonstrator scenarios

This section demonstrates the latest features in the WI for TRIMEK and CROMA business cases in the rEUse platform and the WI DIA. For the DIA we demonstrate the interactions from the users' perspective and use screenshots from the chat interface of the new COALA app. The DIA can recognize the same or semantically similar user utterances - i.e., inputs do not have to be the same as indicated in the following screenshots.

## 4.2.1 Waste inspector skill demo for TRIMEK

### *4.2.1.1 Entity model and basic interaction with rEUse*

Below we present some screenshots that present the respective entities for TRIMEK. Figure 5 depicts the new entry section which allows for the registration of a new entity from the web interface of rEUse. Figure 6 presents an existing entry to rEUse from TRIMEK containing actual sample data for the corresponding fields. Figure 7 presents a list of created entities. As mentioned before, all entries are directly searchable from the UI by selecting the corresponding field and entering any search term in the search area.

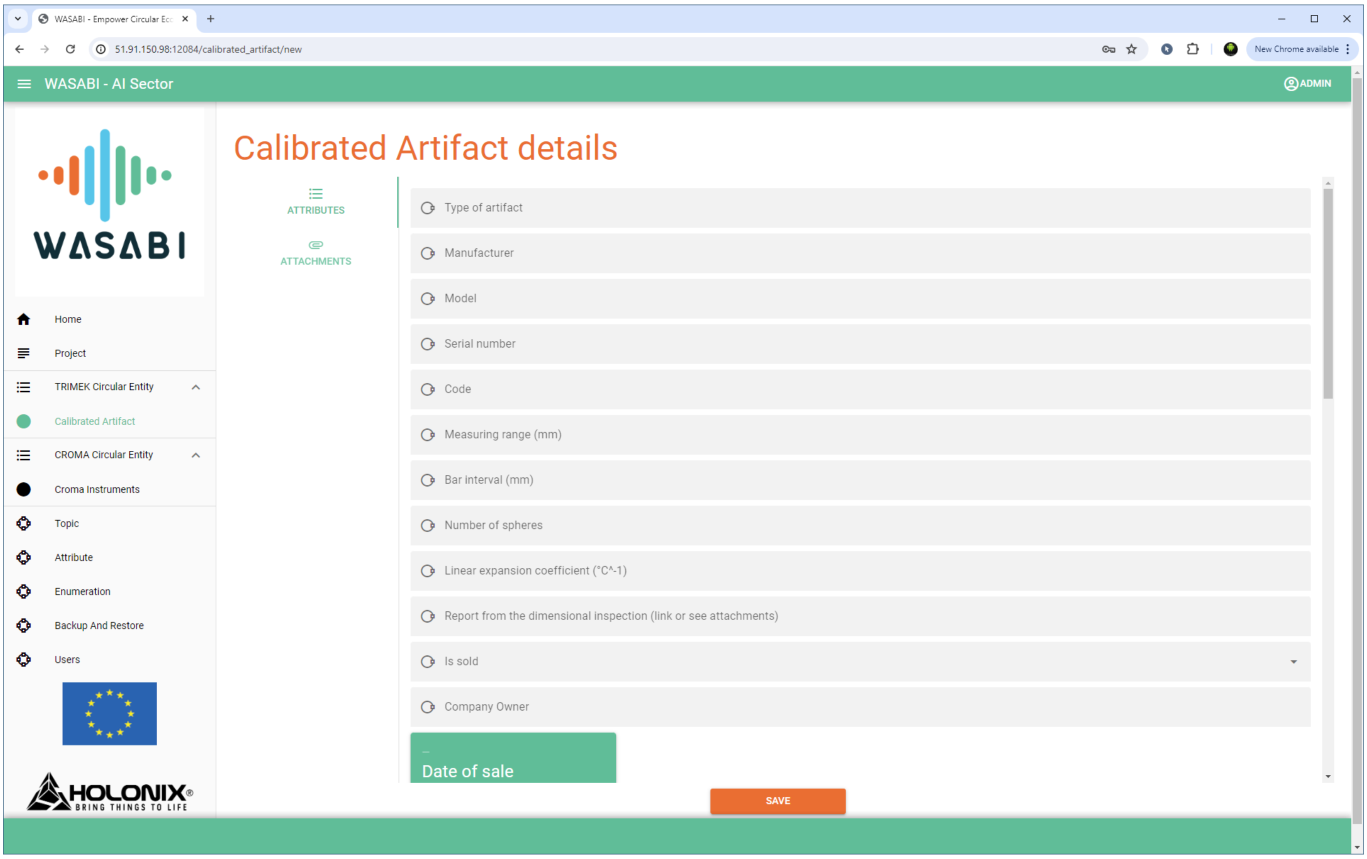



*Figure 5: New entity creation for TRIMEK in the rEUse web interface*

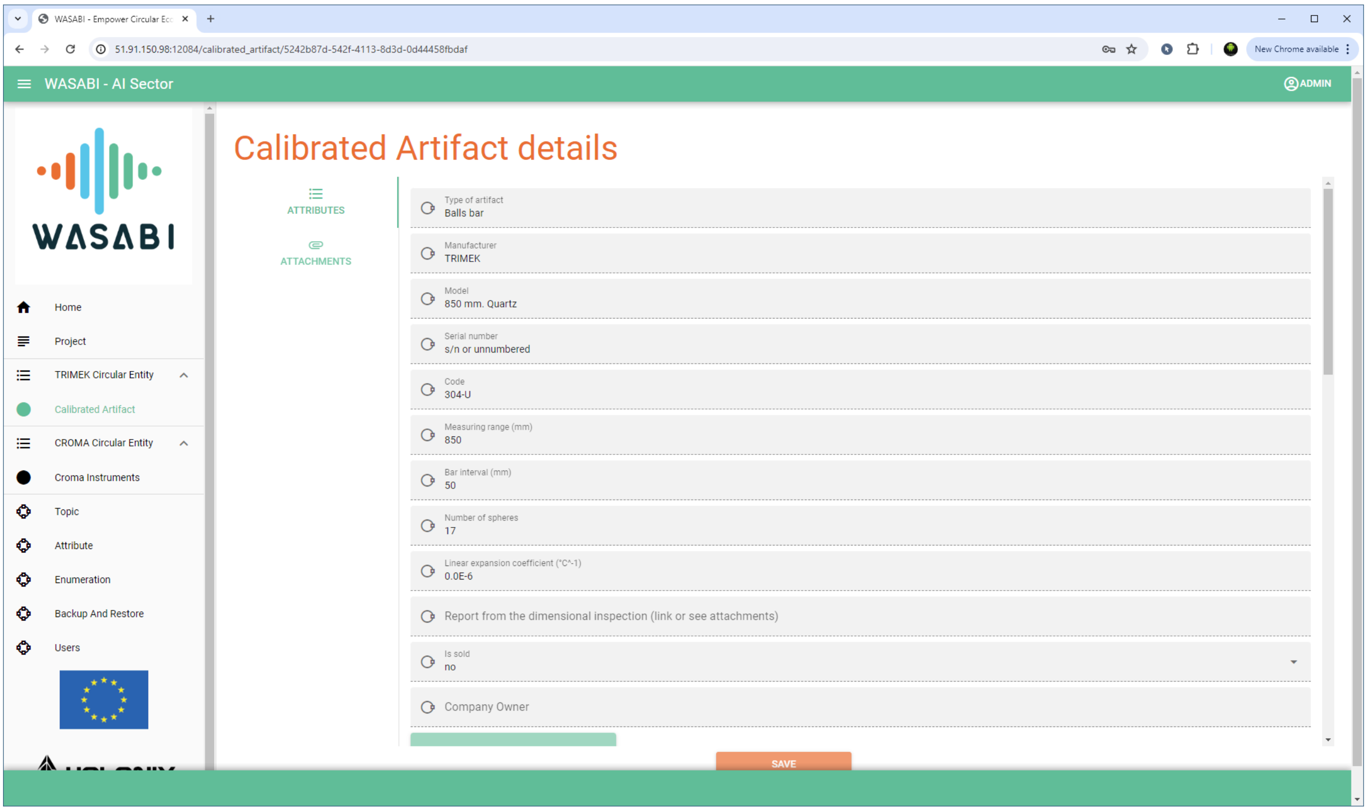



*Figure 6: Actual data entered into the platform by TRIMEK*

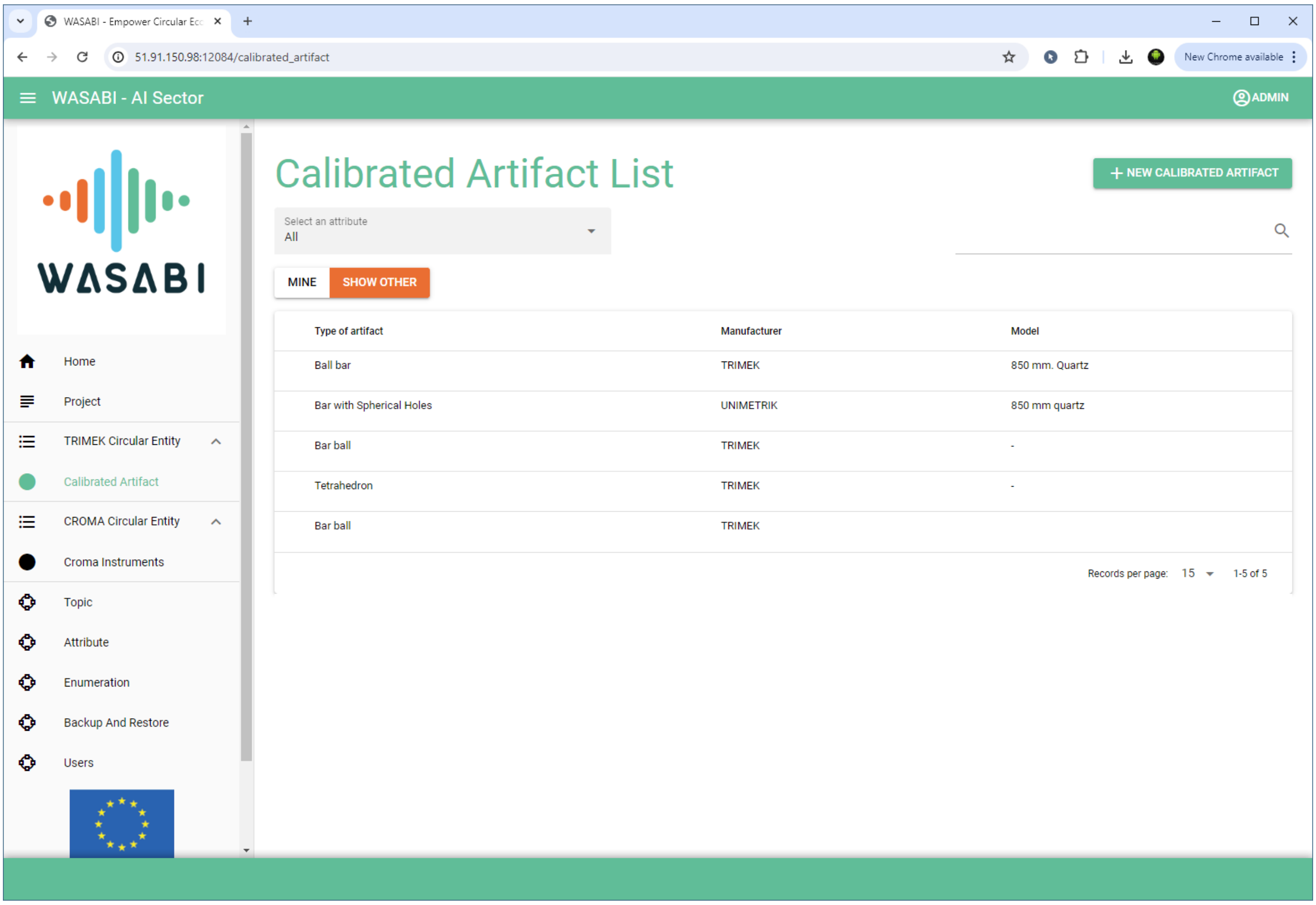



*Figure 7: Registered entity list for TRIMEK, searchable*

The final list of fields for TRIMEK which has been settled upon until M15 are presented in Table 1.

*Table 1: Entity names, internal names and types of expected inputsEntity names, internal names and types of expected inputs for TRIMEK*

| Entity function | Internal name | Type/Values |
|---|---|---|
| **Type** | artifact_type | Text |
| **Manufacturer** | artifact_manufacturer | Text |
| **Model** | artifact_model | Text |
| **Serial number** | artifact_serial_number | Text |
| **Code number** | artifact_code_number | Text |
| **Measuring range** | artifact_measuring_range | Text |
| **Bar interval** | artifact_bar_interval | Text |
| **Number of spheres** | artifact_number_of_spheres | Text/Number |
| **Linear exp. coefficient** | artifact_linear_expansion_coefficient | Text/Number |
| **Dimensional inspection report (link)** | artifact_dimentional_inspection_report | Text for link if not attached |
| **Sale status** | artifact_is_sold | Combo: Yes/No/Undefined |
| **Owning company** | artifact_company_owner | Text |
| **Date of sale** | artifact_date_of_sell | Date |
| **Buyer information** | artifact_buyer_contact_information | Text |
| **Calibration laboratory** | artifact_calibration_labratory | Text |
| **Applicant for calibration** | artifact_calibration_applicant | Text |
| **Date of test** | artifact_calibration_date_of_test | Date |
| **Technician who performed the calibration** | artifact_calibration_labratory_technician | Text |
| **Name of the measurement equipment used** | artifact_calibration_measurement_equipment_name | Text |
| **Code of the measurement equipment used** | artifact_calibration_measurement_equipment_code | Text |
| **Procedure undertaken** | artifact_calibration_procedure | Text |
| **Calibration temperature** | artifact_calibration_temperature | Text/Number |
| **Calibration humidity** | artifact_calibration_rh | Text/Percentage |
| **Uncertainty factor** | artifact_calibration_uncertainity | Text/Scientific notation |
| **Calibration certificate (link)** | artifact_calibration_certificate_link | Text for link if not attached |

#### *4.2.1.2 Skill interaction scenario*

Two main functions have been implemented based on the latest entity fields for TRIMEK artifacts:

- Registering a new artifact in the rEUse platform:

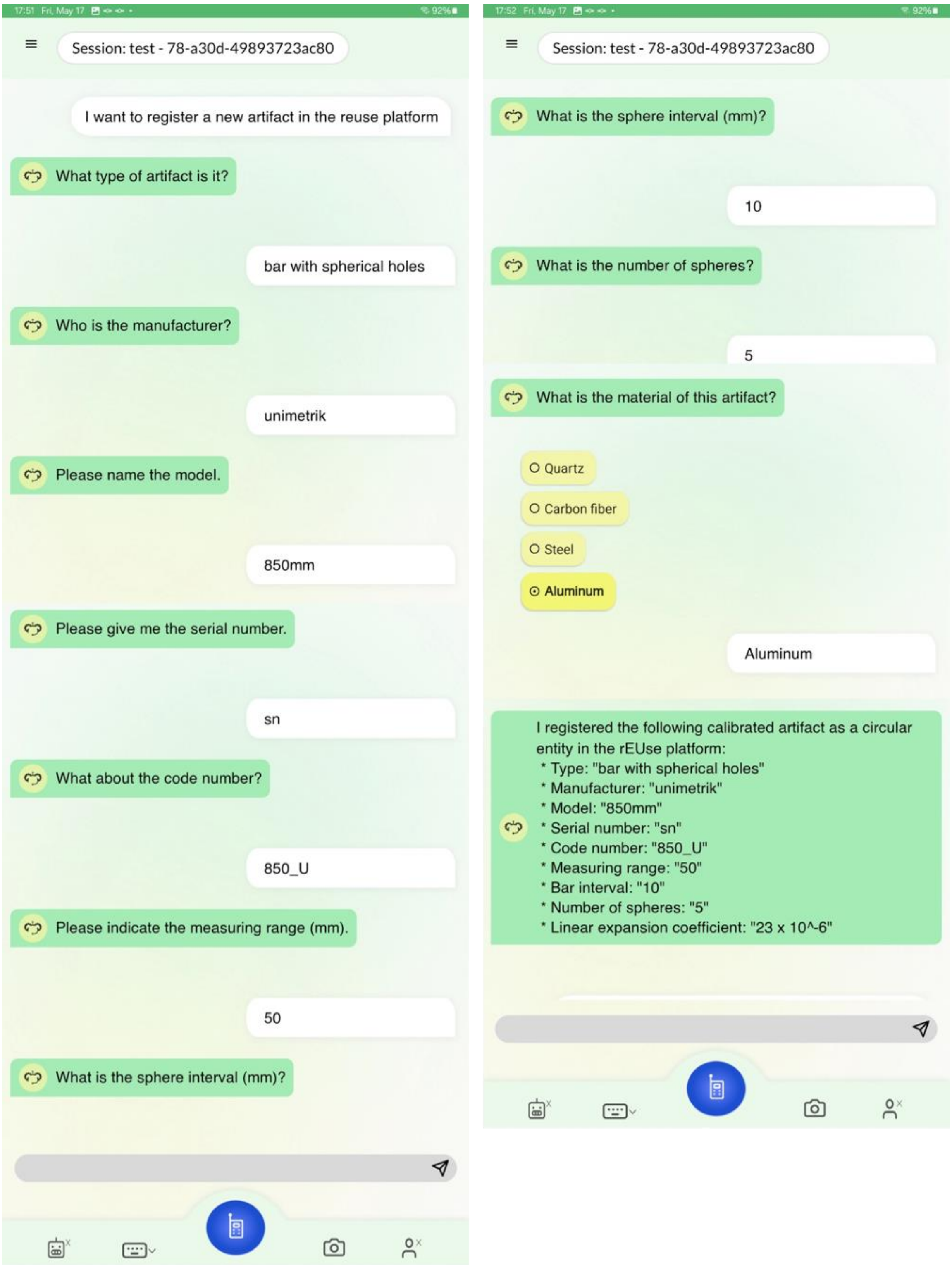
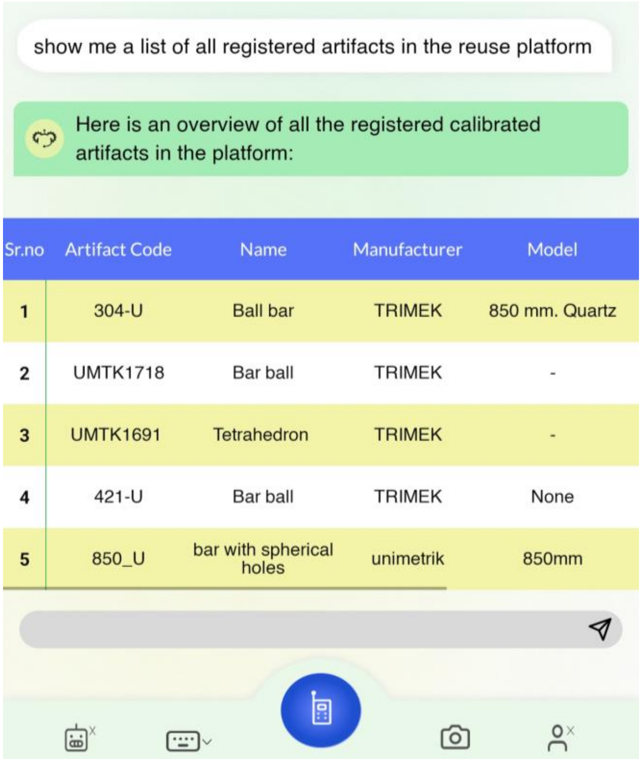



*Figure 8: Registering a new artifact in the rEUse platform*

- Retrieving the list of registered artifacts in the rEUse platform:




| Sr.no | Artifact Code | Name | Manufacturer | Model |
|---|---|---|---|---|
| 1 | 304-U | Ball bar | TRIMEK | 850 mm. Quartz |
| 2 | UMTK1718 | Bar ball | TRIMEK | - |
| 3 | UMTK1691 | Tetrahedron | TRIMEK | - |
| 4 | 421-U | Bar ball | TRIMEK | None |
| 5 | 850_U | bar with spherical holes | unimetrik | 850mm |

*Figure 9: Retrieving the list of registered artifacts from the rEUse platform*

All these scenarios are implemented in both English and Spanish. In the next steps, functions to filter the list of registered entities will be implemented. Additionally, users will be able to update a registered artifact after it has been sold or calibrated.

## 4.2.2 Waste inspector skill demo for CROMA

### *4.2.2.1 Entity model and basic interaction with rEUse*

Like in the case of TRIMEK above, similar tailored fields have been created for CROMA. Figure 10 presents the interface for a new manual entry from the rEUse web interface. Figure 11 depicts the searchable list of already inputted entities.

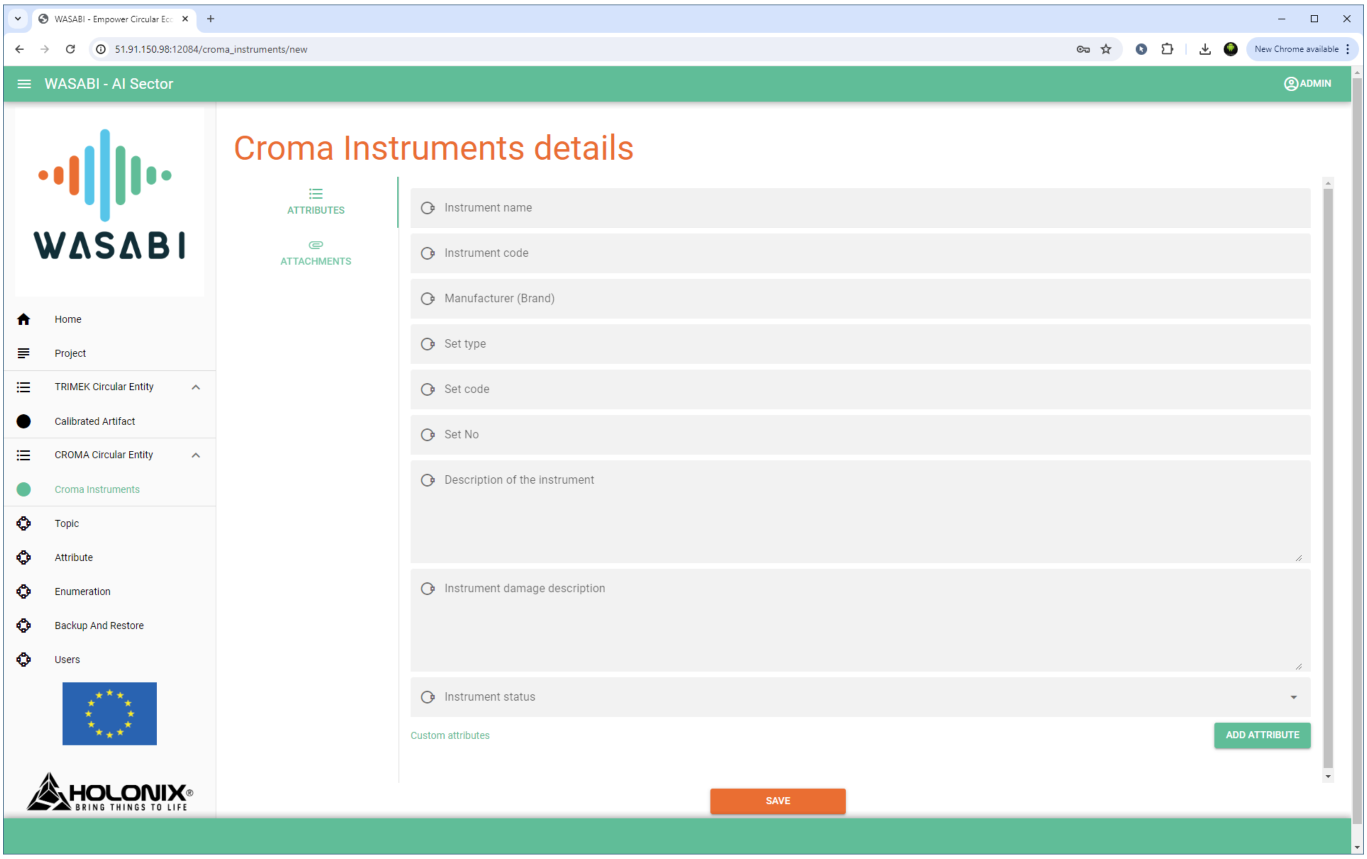



*Figure 10 - New entity creation for CROMA in the rEUse web interface*

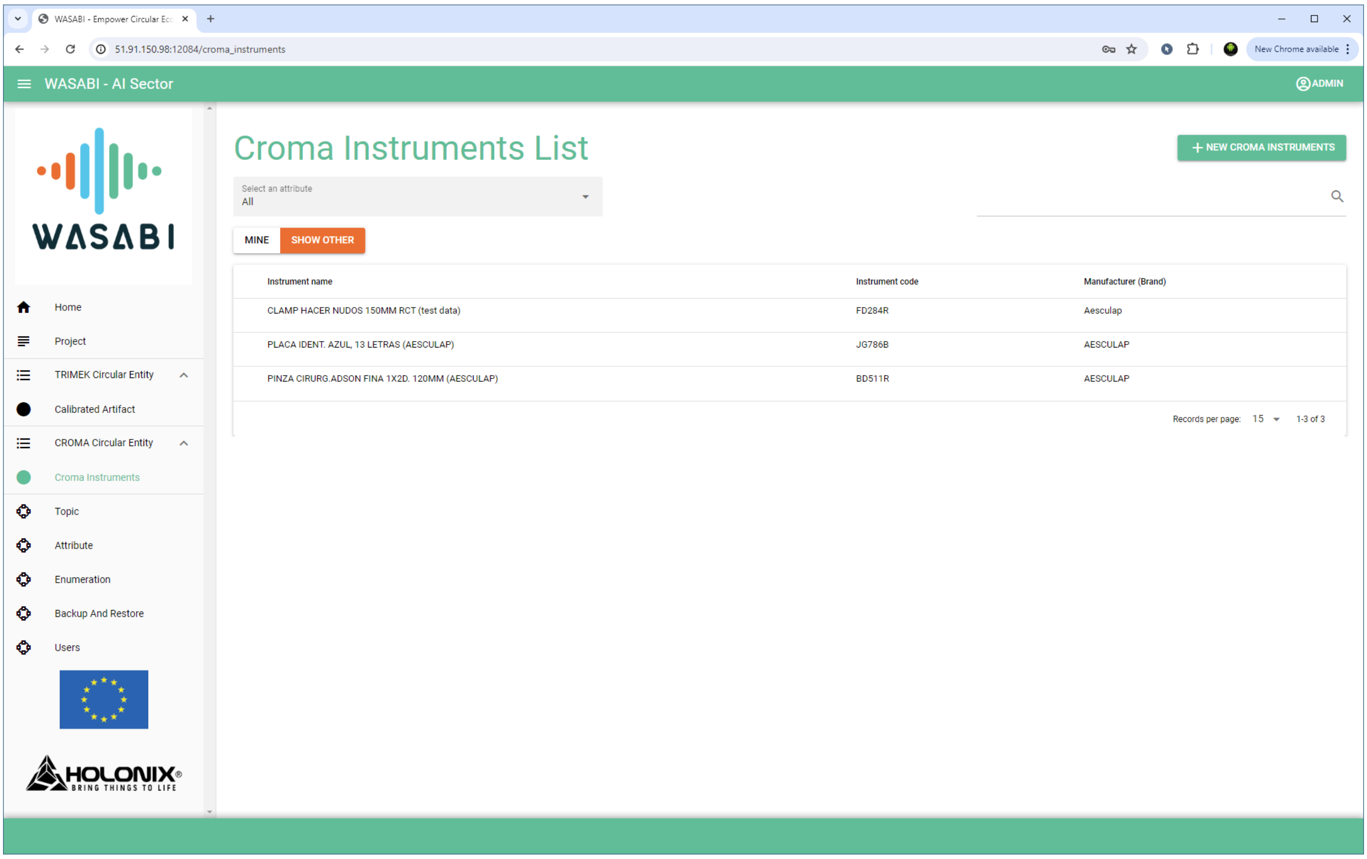



*Figure 11 - Registered entity list for CROMA, searchable*

The corresponding list of fields for the use case of CROMA as of the time of this writing is presented in Table 2.

*Table 2: Entity names, internal names and types of expected inputsEntity names, internal names and types of expected inputs for CROMA*

| Entity function | Internal name | Type/Values |
|---|---|---|
| **Instrument name** | croma_instrument_name | Text |
| **Instrument code** | croma_instrument_code | Text |
| **Manufacturer** | croma_instrument_manufacturer | Text |
| **Description of the instrument** | croma_instrument_description | Text |
| **Description of the damage (if any)** | croma_instrument_damage_description | Text |
| **Status of the instrument** | croma_instrument_status | Combo: Broken/Maintenance |
| **Type of set** | croma_set_type | Text |
| **Code of set** | croma_set_code | Text |
| **Set number** | croma_set_number | Text/Number |

### *4.2.2.2 Skill interaction scenario*

Two main functions have been implemented based on the latest entity fields for CROMA surgical instruments:

- Registering a new surgical instrument in the rEUse platform:

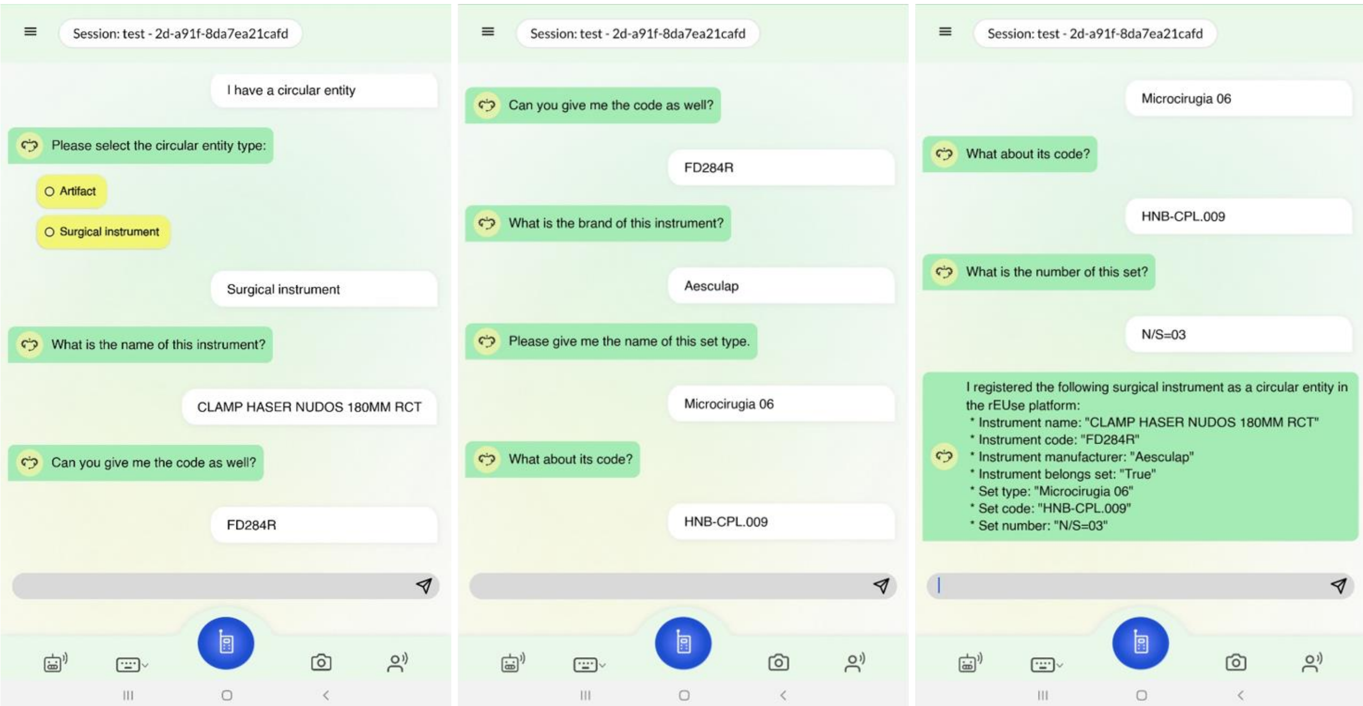


*Figure 12: Registering a new entity in the rEUse platform*

- Retrieving the list of registered surgical instruments in the rEUse platform:

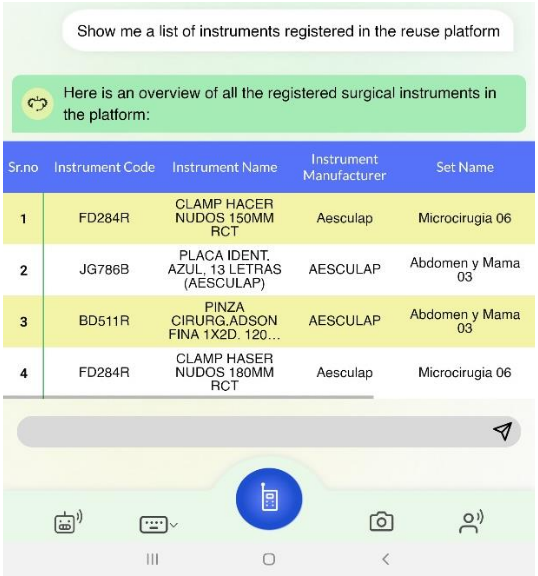



*Figure 13: Retrieving the list of registered surgical instruments from the rEUse platform*

All these scenarios are implemented in both English and Spanish. In the future steps, functions to filter the list of registered entities will be implemented.

## 4.3 Lessons learned

In regards to the rEUse environment, there have been significant changes to the component throughout the lifecycle of the project until M15, with more being planned based on the inputs received from partners. rEUse itself was majorly extended with new functionalities like an embedded search function, which is expected to be invaluable as sets of entities get larger, export/import options for easier exporting and backup functions during development, better backend handling of unexpected values from API interactions with the DIA, streamlining of the interface with a decrease in load times and more.

On the DIA's side, extracting the entity fields' names, which include abbreviations, specific names, and alphanumeric strings through speech recognition, presents a set of challenges. Abbreviations can sound like other words, and names often have various pronunciations and spellings, making them hard for the system to recognize. Alphanumeric strings, like serial numbers, need to be transcribed perfectly, as any mistake can lead to the registration of false data in the platform. Issues like poor audio quality, background noise, and different accents make these tasks even harder, requiring extensive training data and advanced validation methods. These challenges have been communicated to the end users, and in the next steps, WASABI will look into feasible mitigation solutions.

## 4.4 Software license

Table 3 summarizes the main exploitable or otherwise critical components for this use case. It refers to a proprietary license that grants a usage permission to WASABI participants. Some components require business-specific training data (e.g., the Rasa chatbots), and the related license does not cover that data because it is confidential. We may change the licenses in the course of the exploitation planning (T6.2).

*Table 3: Software licenses for Waste Inspector use case*

| Component | Developer | License | Note |
|---|---|---|---|
| rEUse platform | SYXIS | Proprietary | Project specific usage license; free to use for project purposes by project participants |
| Waste Inspector skill | BIBA | Proprietary | - |
| Waste Inspector Rasa services | BIBA | Proprietary | Training data excluded |
| Waste Inspector Docker stack | BIBA | Proprietary | - |
| WASABI-Base stack | BIBA | Proprietary | - |

# 5. ASSISTED WORKFORCE MANAGEMENT

In the assisted workforce management (AWM) use case (Task 2.3), the WASABI solution aims to develop an onboarding DIA to introduce technical instructions to new employees and help workers understand the manufacturing process. With the help of the AWM onboarding DIA, the training time for new workers to follow the manufacturing processes can be reduced. EPISCAN, a Canarian-based company that produces personal protective equipment (PPE), is involved in this use case. The main products produced by EPISCAN are two types of masks, surgical and FFP2 without exhalation valves, which are made in two separate production lines at EPISCAN's facilities in the Canary Islands. These masks are produced in very high volumes. In an 8-hour working day, 35,000 surgical masks and 15,000 FFP2 masks can be produced.

By M9 of the WASABI project, the initial prototype of the AWM onboarding DIA had been developed based on the COALA DIA configuration in a Docker environment running on a server in BIBA (detailed in D1.3). Examples of dialogue models for the onboarding process and the knowledge base, both in English and Spanish, have been developed and documented in D2.1. These were developed based on the EPISCAN user scenarios and stories described in D1.2 and the instructions for five training processes provided in the EPISCAN machine manuals.

In the following sections, we outline the skill components used in the AWM DIA and demonstrate how the defined scenarios are further implemented in the EPISCAN by M15.

## 5.1 Components

The main components used to build the AWM DIA include:

- Base stack
- AWM Docker stack
- AWM OVOS skill
- AWM Rasa services with integrated learning nuggets
- Neo4j database
- Apollo server and GraphQL for fetching data from Neo4j database

A knowledge base using the Neo4J graph database was designed for the EPISCAN onboarding process of new employees. The Neo4j database can be queried using the Cypher Query Language, specially designed for querying the Neo4j graph database. We leverage the Apollo Server to integrate with our application layer, which acts as an intermediary between the Neo4j database and our front-end application. Using a schema generated from Neo4j, Apollo Server ensures that our GraphQL layer is tailored to our data model. This integration facilitates real-time data retrieval and updates, enhancing the user experience.

### 5.1.1 Knowledge base

The Neo4J knowledge database is structured to guide and monitor the training process of employees, ensuring they are familiarized with various machine operations. It contains training steps that workers should understand and follow during onboarding. Below are the capabilities of the database:

- **Dynamic Training Paths**: The database offers a structured training pathway, guiding technicians through various machine operations in a logical sequence.
- **User Progress Monitoring**: By tracking the active training stages of users, the database allows for the real-time monitoring of individual progress.
- **Multilingual Support**: Training processes and steps are documented in English and Spanish.
- **Media Integration**: Various training steps are complemented with associated images, videos, or documents to enhance comprehension.

**Nodes and their attributes:** The primary entities are represented as nodes in our graph database. Each node belongs to a specific type, and each type has its own attributes that provide detailed information about that node.

In the current version of the AWM onboarding DIA, the generation of the user nodes is dynamic, based on their login credential on the app. For media, we use images from the EPISCAN machine manual and links from the learning nuggets developed in Task 3.4.

Table 4 summarizes the various node types in our database, the attributes associated with each type, and the total number of nodes of each type.

*Table 4: Nodes and Attributes*

| Node Type | Attributes | Number of Nodes |
|---|---|---|
| **Training Process** | name_en, name_es, description_en, description_es | 6 |
| **Step** | id, description_en, description_es, isMainStep | 30 |
| **User** | id, role, expertise | 4 |
| **Image/Video** | id, description_en, description_es, url | 10 |
| **Document** | id, description_en, description_es, url | 1 |
| **Machine** | name_en, name_es, id | 1 |
| **Screen** | name_en, name_es, description_en, description_es, id | 6 |
| **ScreenZones** | name, description_en, description_es, id | 6 |
| **Icon** | name_en, name_es, description_en, description_es, id | 4 |
| **Message** | name_en, name_es, description_en, description_es, id | 34 |

**Relationships between nodes**: Relationships are the links or connections between nodes, establishing context and meaning to the entities within the database. Each relationship has a direction and a type, which describes how nodes are related. Table 5 provides an overview of the various relationship types in our database, detailing the nodes they connect and any additional attributes or properties associated with these relationships.

*Table 5: Relationships between Nodes*

| Relationship Type | From Node | To Node |
|---|---|---|
| **STARTS** | TrainingProcess | (First) Step |
| **HAS_FOLLOWUP** | TrainingProcess | TrainingProcess |
| **HAS** | TrainingProcess | Step |
| | Screen | Image |
| | Icon | Image |
| | Screen | ScreenZones |
| | ScreenZones | Icon |
| | Machine | Screen |

| | | |
|---|---|---|
| **DISPLAY** | Screen | Message |
| **HAS_MEDIA** | Step | Video/Documents |
| **HAS_MEDIA** | Step | Image |
| **NEXT** | Step | Step |
| **ACTIVE** | User | Step |
| **ANSWERED** | User | Step |

The database structure and the relationships between the defined nodes in our latest Neo4j database are shown below (Figure 14).

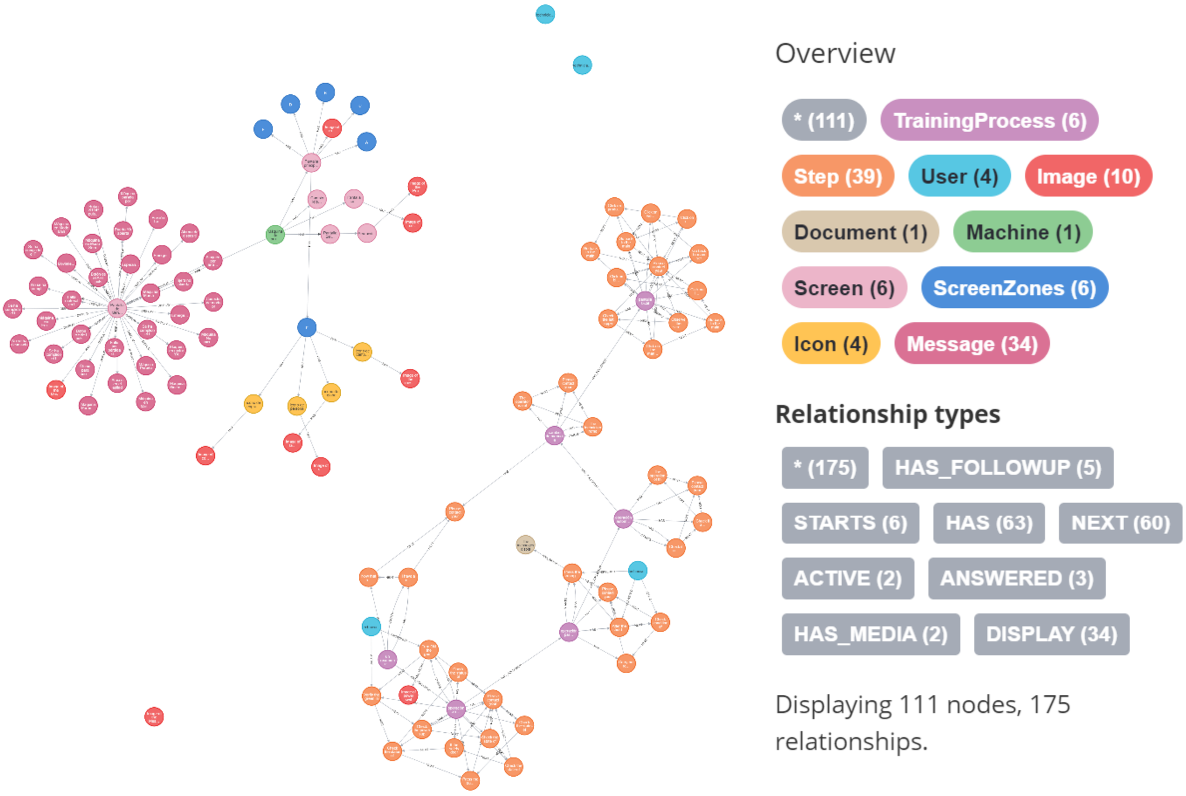



*Figure 14: Neo4j Database structure and relationships*

### 5.1.2 Assistant Skill

We have developed an OVOS skill called AWM, which connects to the Rasa chatbot developed for EPISCAN. Using the COALA android app, users can talk to the AWM Rasa bot by saying "Start training skill" or "Start onboarding assistant". Once the skill is activated, user messages will be sent to the corresponding Rasa endpoint, and similarly, the Rasa responses will be prompted back to the user.

The Rasa chatbot uses a configurable NLU pipeline, a dialog manager based on rules and probabilistic models, and a fulfilment server performing custom actions via Python code. The action server queries information from the Knowledge base via the Apollo server and uses the results to decide how to respond (e.g., using a template with parameters filled by the query result).

Our implementation of the Rasa chatbot has two groups of features:

- Base Features: including generally applicable intents and conversation patterns such as chitchat, out-of-scope; and GDPR-related intents
- Training-specific Features: Tailored to specific use case needs, these features are designed to handle particular queries, manage domain-specific interactions, and execute custom actions. The specifics of these interactions will be detailed in the following section.

The skill and the Rasa models are developed in Spanish and English language.

## 5.2 Demonstration scenarios

The onboarding features of the AWM DIA, which have been implemented until M15, are introduced in this section.

This use case focuses on supporting new employees through the steps of operating the machine and the machine's touch screen. Based on the user stories developed in D1.2, machine manuals, and the interviews conducted during the factory visit, we deploy the training processes for employees for operating one of the mask production machines at EPISCAN factory.

By M9, we had initially deployed two demonstration scenarios, namely starting/continuing and navigating the training process both in English and Spanish, and reported in the D2.1. By M15, new functions related to different machine screens, including its zones, icons, and messages, have been developed and deployed (Figure 15). Moreover, an initial training process was identified during the factory visit. This training process involves the overview of the elements required for starting and operating the machine. For this training process, learning nuggets were created and integrated into the DIA.

Another update in M15 compared to the last version (D1.2) is that user ID is extracted automatically from the app login credentials, and users do not need to provide it additionally when they want to start or continue a training process. Once the employee's identity is confirmed during logging in, the rasa bot retrieves the user connection to the training processes in the Neo4j graph to see if the user has an active training process.

The following sections demonstrate the different functions of the AWM DIA and the interaction from the users' perspective. We use screenshots from the chat interface of the new COALA app. The DIA can recognize the same or semantically similar user utterances - i.e., inputs do not have to be the same as indicated in the following sections.

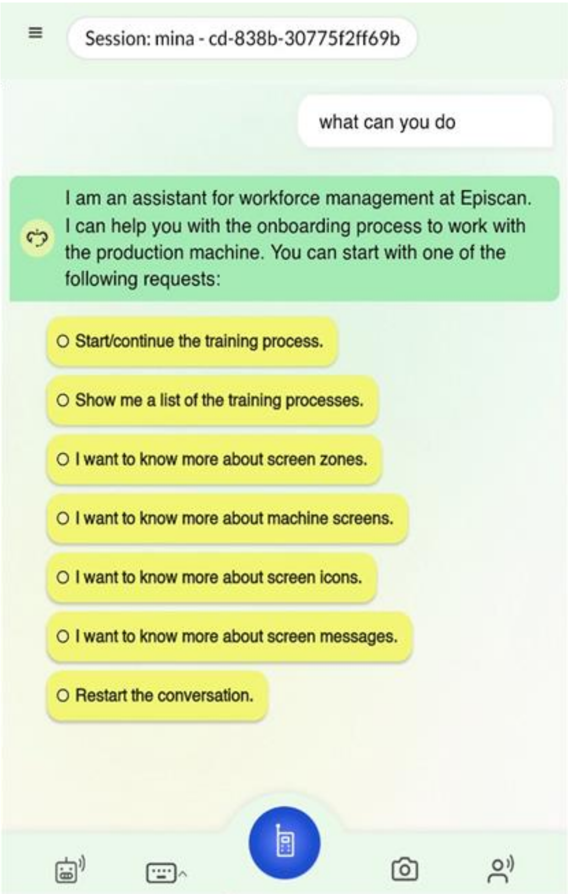



*Figure 15: AWM DIA onboarding functions*

### 5.2.1 List of training processes

In this scenario, users can ask the DIA to give them an overview of the available training processes. Users can select which processes they want to start or continue with (Figure 16).

1. Overview of the elements required for starting and operating a machine: a new training process that was built during the factory visit. It contains two steps with links to the learning nuggets to make the trainees familiar with the machine starting and operation elements, followed up by a test.
2. Starting Operation: contains the steps to start the machine.
3. Emergency Stop-Reset Operation: contains the steps to shut down the machine in case of emergency and to reset operation after the appropriate safety and operating conditions are met.
4. Automatic Operation: contains the definition of the automatic operation and the steps to be carried out when attention is required.
5. Change from Manual to Automatic Operation: contains two possible scenarios when switching from manual to automatic operation.
6. Machine's Touchscreen

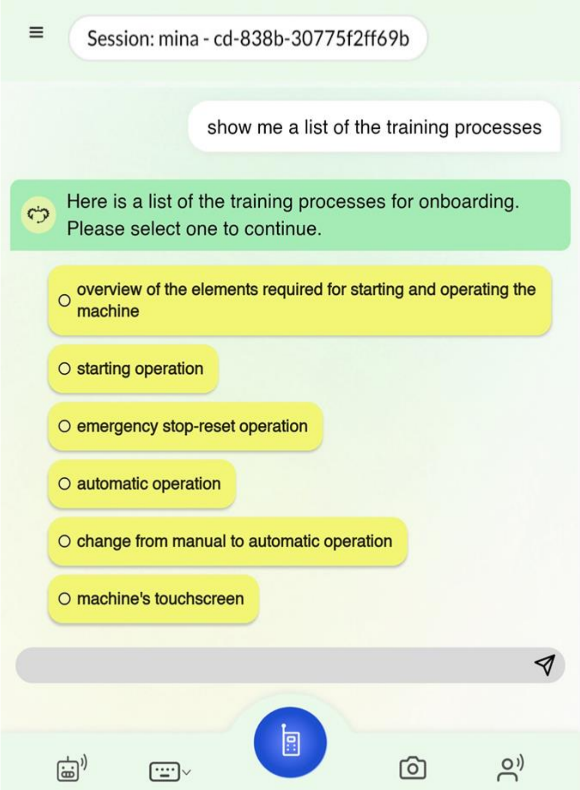



*Figure 16: List of the training processes for onboarding new workers*

### 5.2.2 Start/continue a new training process

In this scenario, the users can select a training process to start. Once selected, the DIA will confirm the choice and guide the user through the steps. If they are in the middle of another training, the DIA will ask them to finish the current process first and then proceed with the selected process.

In addition to the scenarios from EPISCAN machine manuals, an additional training process has been added. This new training process was built during the factory visit in January 2024. It contains two steps with links to the learning nuggets to make the trainees familiar with the machine starting and operation elements, followed by a test (Figure 17, Figure 18).

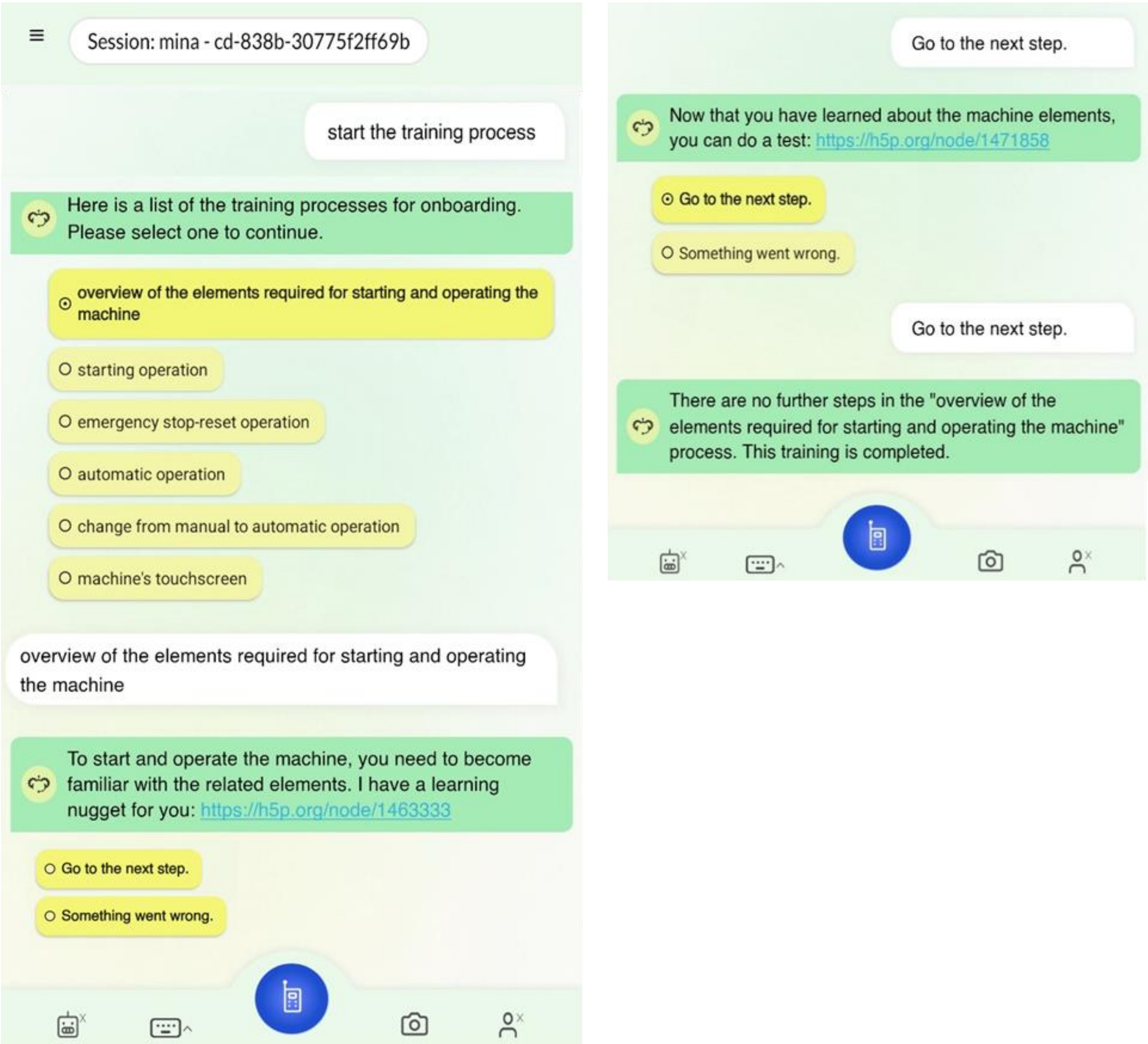



*Figure 17: Example of a training process with a learning nugget*

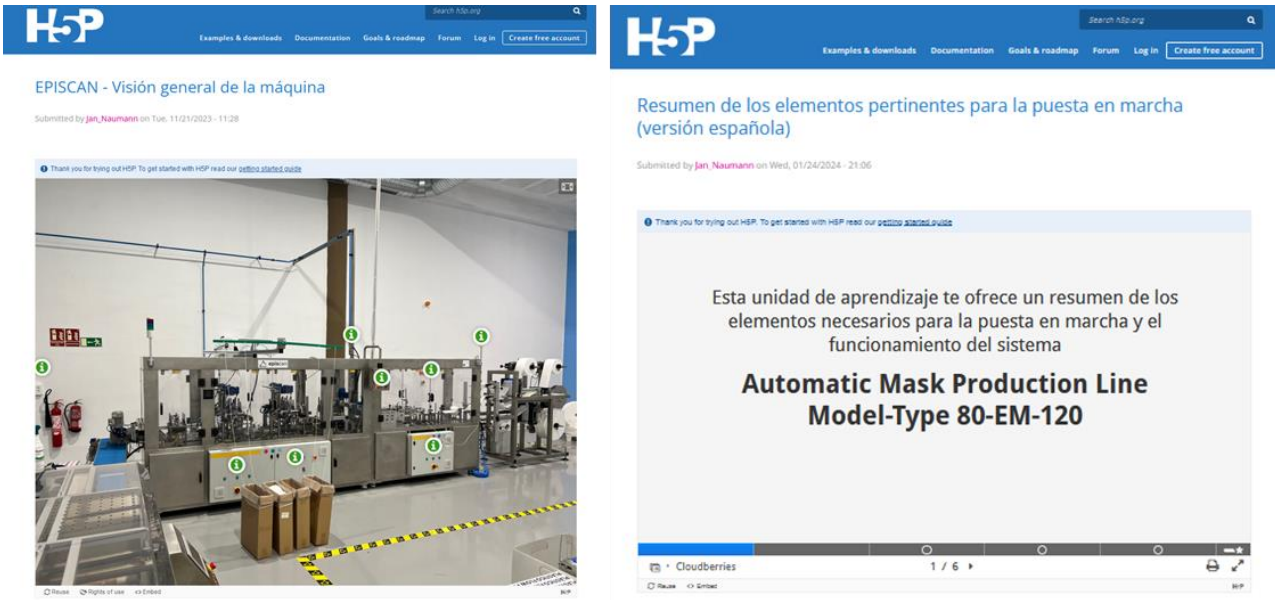



*Figure 18: Training process learning and test nuggets introducing EPISCAN machine's elements in Spanish*

## 5.2.3 Machine screens

In this scenario, users can ask for a list of available machine screens and select a specific screen to get an explanation about it.

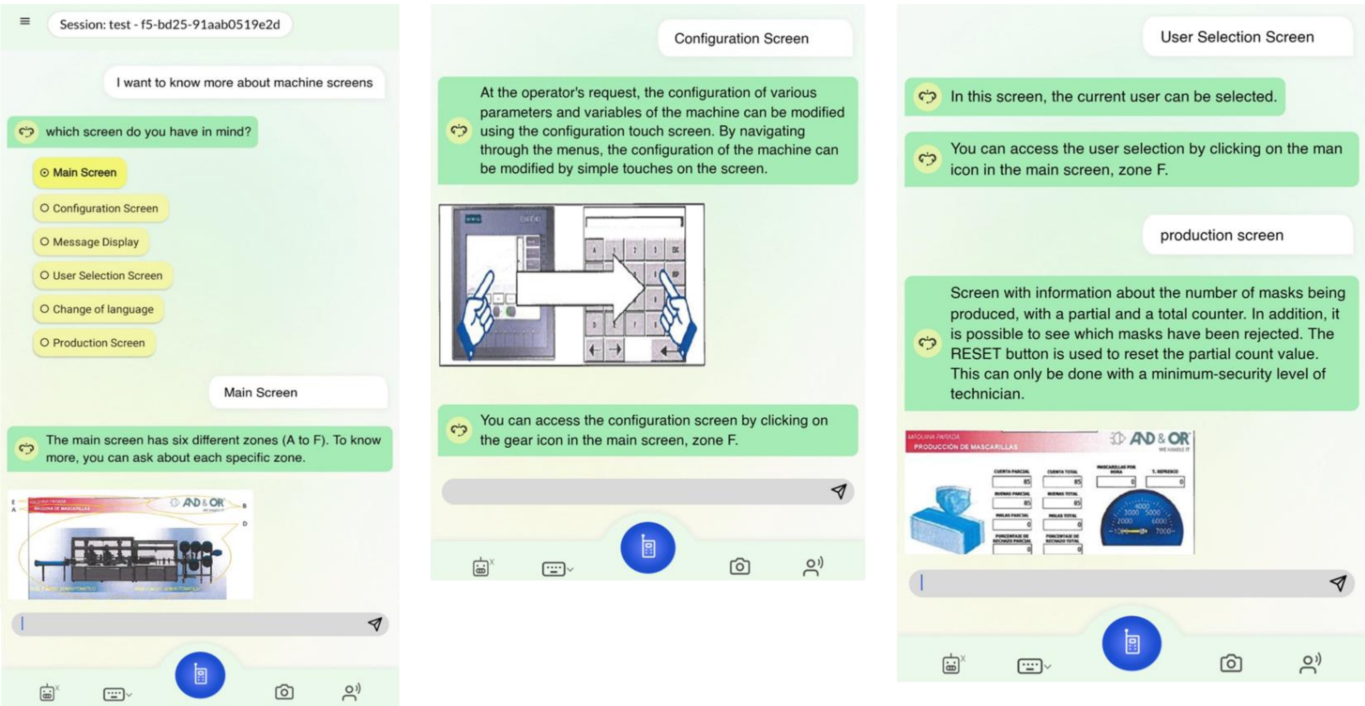



*Figure 19: Examples of retrieving different machine screens' descriptions*

## 5.2.4 Main Screen zones

In this scenario, users can ask for the description of each of the main screen's zones.

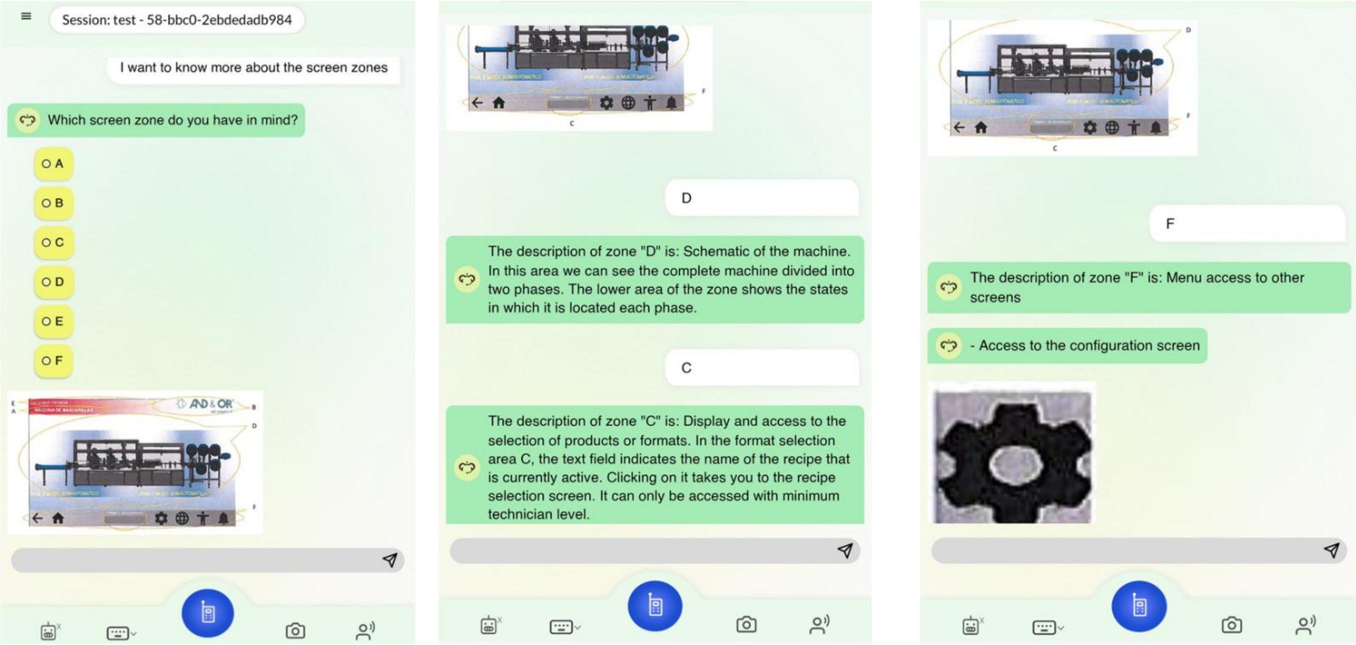



*Figure 20: Explanation of Machine's Main Screen Zones*

## 5.2.5 Screen Icons

In this scenario, users can ask for the description of each of the screen icons.

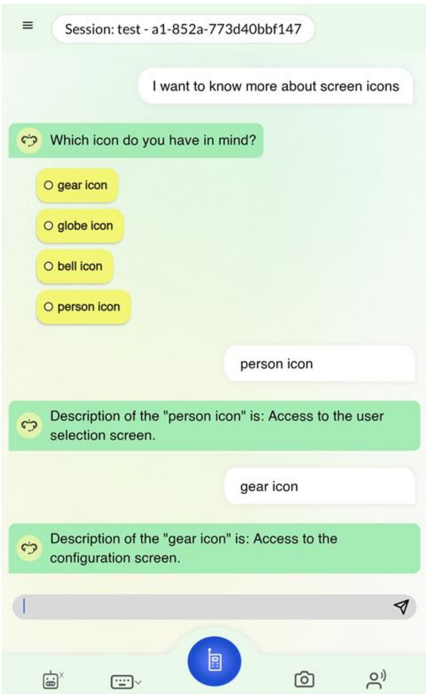



*Figure 21: Example dialogues requesting the description of the machine's screen icons*

### 5.2.6 Screen Messages

In this scenario, users can ask the meaning of the message shown on the screen. The DIA compares the description of the message given by the user with valid screen messages for similarity and suggests the most similar message names to select from. Once a valid screen message name is recognized, the DIA provides the description of this message from the machine manual.

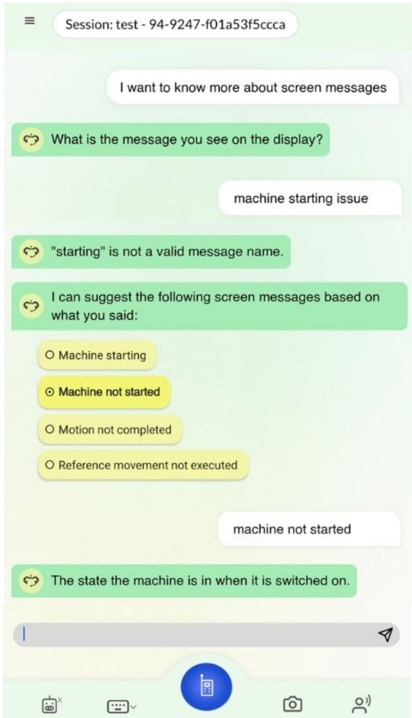



*Figure 22: Machine screen message description*

## 5.3 Lessons learned

*Figure 23: Factory Visit to EPISCAN in January 2024*

In January 2024 (M11), BIBA and ITB visited the EPISCAN factory for four days. BIBA conducted the first round of user evaluation with the production manager and two operators and together with ITB, collected videos, images, and information from two production line workers (one expert and one novice) for the machine screen info and messages. Several tests were conducted with the DIA in Spanish.

Due to data sensitivity, the detailed evaluation results will be reported separately in D4.2, an interim report. The main lessons learned during DIA tests are listed below.

- At this moment there is no WIFI in the factory area
- When the Internet connection is slow, the order of the responses in the app can be wrong
- Noise (up to 80dB) and mask can be a problem for Speech recognition (STT)

- Extension of training data to account for synonyms of some used words needs to be taken into account, as some new workers tend to use more jargon for certain (technical) tasks which differ from the wording used in the machine manual.
- New workers are trained directly by the experienced workers. Positive feedback was received directly from the workers.
  - They perceive the DIA as a beneficial tool, especially for onboarding new employees and for experienced employees when they need to look for specific information, such as "time for rebooting", which currently needs to be searched in the machine manual and with the DIA, they can ask this directly.
  - Video materials would be helpful for the workers, for example, on how to start a machine.
- Some bugs were identified and are systematically being fixed.

During the factory visit, ITB also interviewed the production manager and two operators and collected videos, images, and information from two production line workers (one expert and one novice) for the starting operation, emergency stop-reset operation, and troubleshooting. ITB has built the first learning nugget[5] to give an overview of the machine elements required for starting and operating the machine. BIBA has integrated and tested this learning nugget in the DIA.

Main lessons learned related to the first test of the use of the new learning nugget:

- Introduction sessions are necessary to understand the user's experience level with a voice assistant, associated skills, and the learning nugget.
- It is a good idea to track the users' training progress.
- It is necessary to design a training path, e.g., some processes are prerequisites of others.
- Video materials would be helpful for the workers.

## 5.4 Software license

Table 6 summarizes the main exploitable or otherwise critical components for this use case. It refers to a proprietary license that grants a usage permission to WASABI participants. Some components require business-specific training data (e.g., the Rasa chatbots), and the related license does not cover that data because it is confidential. We may change the licenses in the course of the exploitation planning (T6.2).

*Table 6: Software licenses for AWM use case*

| Component | Developer | License | Note |
|---|---|---|---|
| AWM skill | BIBA | Proprietary | - |
| AWM Rasa services | BIBA | Proprietary | Training data excluded |
| AWM Docker stack | BIBA | Proprietary | - |
| WASABI-Base stack | BIBA | Proprietary | - |

[5] https://h5p.org/node/1471858

# 6. ASSISTED QUALITY ASSURANCE FOR SUSTAINABLE PRODUCTS

This use case aims to enhance product quality testing processes by leveraging a DIA that supports workers in executing validation protocols for safer and more sustainable products. This DIA integrates analytics and predictive modules to optimize testing, reduce energy consumption, and provide real-time guidance, fostering collaboration between the DIA and the operators. WASABI aims to demonstrate this solution across the five business cases, i.e. REINOVA, TRIMEK, EPISCAN, CROMA, and SILK-BIO, spanning automotive battery testing, dimensional metrology, EPI material testing, and prosthetics quality testing, respectively, to improve overall product quality and worker efficiency.

Starting from the existing digital twin for product testing currently in use at REINOVA, in the first phase, task T2.4 deployed and configured the digital twin in a Docker environment hosted in the cloud. Then, it customized and integrated the dialogue component released by T2.1 and added the data synthesizer component that enabled the digital twin to assist the operator in conducting product quality assurance procedures. Starting from this experience, we developed a general DIA architecture for product quality testing.

In the second phase, we revised the general architecture and implemented it to support the other involved business cases, e.g., TRIMEK, COMA, EPISCAN, and SILK-BIO. At the same time, the REINOVA DIA was improved through the integration of additional analytics functionalities.

This section first provides an overview of the architecture and the related components, and then describes the features of the developed DIAs.

## 6.1 Components

Figure 24 shows the general architecture and the related components of the DIA for quality testing procedures leveraging the **COALA technology stack**. The **legacy infrastructure** is meant to grant access to the quality-related data that are available in the data management system of the involved company. A wrapper rest API module is included to this end. Moreover, the architecture supports analytics and machine learning processes using the dedicated **Analytics Module**.

Its design aims to assist workers in the execution of all the quality-related activities that characterize the supported business case settings. Specifically, the functionalities the architecture aims to can be categorized as follows:

- **Data entry functionalities:** these functionalities are devoted to the support of all the updating procedures that are necessary to have quality testing data available and up to date. To this end, dedicated components are integrated into the core assistant infrastructure to assist workers during data insertions and updating by asking for the required feature values, checking for their correctness and completeness, and calling the related insertion and updating procedures through the rest API module;
- **Data access and predictive analytics functionalities:** these functionalities are devoted to the support of the quality testing procedures. To this end, dedicated components are integrated into the core assistant infrastructure to assist workers by providing up-to-date quality information on the procedures and products that are under testing in a user-friendly manner by querying the quality-related data in the legacy infrastructure through the rest API. Moreover, these components optimize testing, reduces energy

consumption, and provides real-time guidance through the integration of information provided by the Analytics module;

- **Process control functionalities**: these functionalities are devoted to guiding the operators in executing human-intensive processes to achieve high levels of process and product quality. To this end, dedicated components are integrated into the core assistant infrastructure to encode the process steps, offer real-time guidance in the execution of the steps, and promptly inform the operators about the process execution conditions. These components are eventually combined with data entry components to enter into the legacy data stores the inputs.

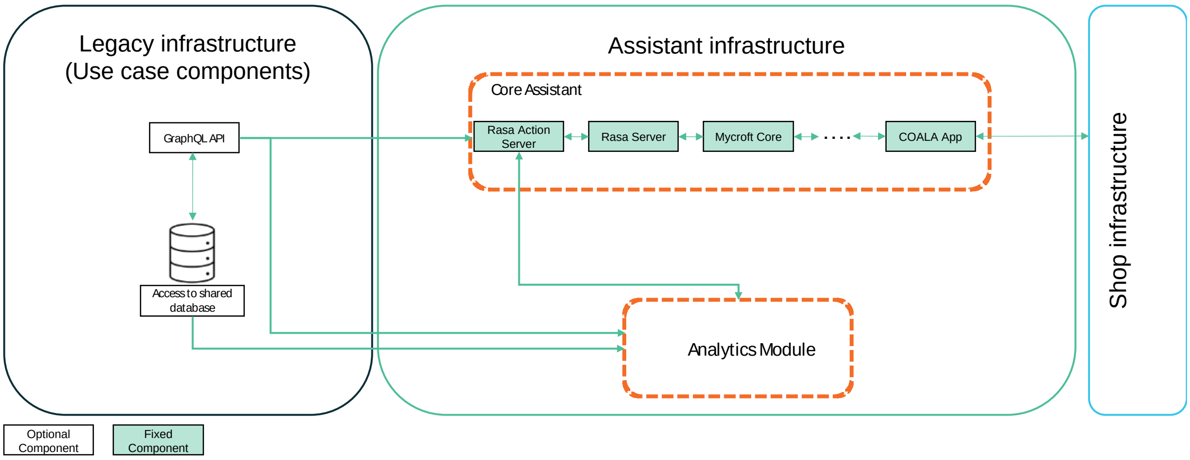



*Figure 24: Architecture of the DIA for quality testing*

It is worth noting that such general architecture can be applied to the diverse quality assurance procedures of the involved business cases through concrete instantiations of the exposed modules and the enablement/disablement of components based on each company's specific requirements. The functionalities' support required by the five business cases are summarized in Table 7.

*Table 7: Overview of the required modules in each business case*

| Business case | Data access and predictive analytics functionalities | Data entry functionalities | Process control functionalities |
|---|---|---|---|
| REINOVA | ✓ | | |
| SILK-BIO | | ✓ | ✓ |
| EPISCAN | ✓ | ✓ | |
| CROMA | ✓ | | ✓ |
| TRIMEK | | ✓ | ✓ |

## 6.2 Demonstration scenarios

### 6.2.1 Assisted quality assurance skill for REINOVA

REINOVA provides testing and validation of e-mobility components such as modules and battery packs; the values of different testing parameters are continuously collected from the sensors located in chambers and batteries under testing.

In this context, the WASABI DIA aims to assist technicians and engineers in a laboratory setting where advanced test machines are running, often long-lasting, tests on various devices (Device Under Tests, DUT). By providing real-time status updates and presenting retrospective data, the DIA can contribute to the safety of the work environment and improve work efficiency in general. To this end, the first DIA prototype implemented the assisted quality assurance skill with status monitoring capabilities.

The Analytics Component (AC) within the assisted quality assurance skill of the WASABI DIA is a pivotal element designed to enhance the quality assurance processes of businesses. Initially developed as part of the "Quality Assurance for sustainable products" WASABI DIA, the AC has undergone significant evolution and expansion since its inception.

The Analytics Module's core objectives remain to provide real-time, accurate insights derived from time-series sensorial and status data. This information is crucial for proactive identification and resolution of potential issues, thereby optimizing product quality processes and minimizing downtime. The AC operates within the Analytics-as-a-Service (AaaS) paradigm, offering a spectrum of analytics functionalities spanning descriptive, predictive, and prescriptive analytics.

**New Functionalities:**

1. Expanded Data Access: Reinova's provision of additional functionality data related to the chambers has enriched the AC's capabilities. This expanded data access enables more comprehensive analysis and improved fault detection algorithms.
2. Automated Data Retrieval: The establishment of a periodic data retrieval connection ensures that the AC remains updated with the latest operational data from the chambers. This automation enhances the AC's responsiveness to real-time changes, contributing to quicker fault detection and resolution.
3. Early Fault Detection Techniques: Implementing early fault detection techniques specific to chamber functionality enhances the AC's predictive capabilities. By identifying potential faults before they escalate, downtime can be minimized, leading to improved operational efficiency.
4. User-Initiated Fault Inquiry: Users can now inquire about the presence of new faults in any chamber part, expanding the AC's usability and responsiveness. This functionality empowers users with timely information, enabling proactive maintenance and reducing the impact of faults on operations.

**Impact on Reinova's Service Quality:**

These new functionalities directly contribute to enhancing Reinova's service quality by minimizing downtime and optimizing operational efficiency. By leveraging the AC's capabilities, Reinova can achieve the following improvements:

- Proactive Maintenance: Early fault detection techniques allow Reinova to address issues before they cause significant disruptions. This proactive approach reduces equipment downtime, ensuring continuous operations and maintaining service reliability.
- Optimized Resource Utilization: With timely insights into chamber functionality, Reinova can allocate resources more efficiently. By prioritizing maintenance based on criticality levels and fault severity, resources are utilized where they are most needed, minimizing downtime and maximizing productivity.
- Enhanced Customer Satisfaction: By minimizing downtime and optimizing operational processes, Reinova delivers a more reliable and consistent service experience to customers. Reduced disruptions and improved product quality contribute to higher customer satisfaction levels.

**New User Queries:**

1. Generic Question:

  - "Are there any faults detected in the chambers?"

  This broad query allows users to quickly assess the overall status of chambers and prioritize actions based on detected faults.

2. Specific Questions:

- "Are there any 'Compressor low pressure' faults in Chamber B3?"
- "Have there been any instances of 'Compressor overpressure' in Chamber A2 recently?"

These specific inquiries enable users to pinpoint faults in particular chambers or specific equipment components, facilitating targeted maintenance efforts and rapid issue resolution.

#### *6.2.1.1 Analytics component*

In D2.1 "Joint WASABI demonstrator - version 1", we presented four analyses, namely: Instrument monitoring, Duration of alarm, Duration of emergency, and Duration of defconlevel. In this Deliverable, we expand on those using the updated Reinova data that consists of 21 new features for the **chambers dataset**. Our target was to create a reliable predictive model that can successfully predict the **defconlevel** of the chambers. We created a new feature to help with the training of the model named, "**live_duration**" that calculates the duration of the defconlevel for each chamber. Basically, we took our "Duration of defconlevel" analysis and added it to the dataset as a feature. After that, we dropped all the unnecessary features for the training and kept only the data that came from the sensors to ensure the correctness of our model. For our model, we used a Machine Learning (ML) algorithm named **XGBoost** which is an evolution of decision trees that uses several intelligent optimizations to achieve a better result. We used the data from the 24th of January until the 18th of February, approximately the 80% of our subset, to train our prediction model and after that we predicted the defconlevel of the chambers from the 18th until the 25th of February, achieving an accuracy of **96%**. It is important to notice that to meet the known requirements of the project, we added several evaluation metrics to ensure the credibility of our predictions. As a next step we will use a Hyperparameter Tuning technique named **GridSearch** to further strength our model.

Below, we present an example query from an indicative analysis in order to demonstrate how the queries and the responses are mapped to the dialogues. This set of analyses aims to provide the user with the requested information related to the predictions of the defconlevel for each respected chamber accompanied with the prediction accuracy.

<table>
<tr><th>Question</th><th>Answer</th></tr>
<tr><td>What is the defconlevel prediction for the 26th of February 2024 at 11:00 hours for the B5 chamber?</td><td>The defconlevel prediction for the 26th of February 2024 at 11:00 hours for the B5 chamber is "Ready"</td></tr>
<tr><th>Query</th><th>Response</th></tr>
<tr><td><pre>
query pred{
    resultRequest(request:{
    request: "PREDICTION_DEF"
    requestFrom: "DA"
    requestFilters: {
         name: "Chamber"
            action: "equals"
            values: "B5"
           }
    ),
     {
         dateFilters: {
         name: "Timestamp"
         action: "equals"
         start: "2024-02-18, 11:00:00"
       }
       {
       results
       reason
     }
   }
</pre></td><td><pre>
{
  "data": {
    "resultRequest": [
      {
        "results": [
          {
            "chambername": "B5",
            "prediction": "Ready",
            "Timestamp": "2024-02-26, 11:00:00"}
</pre></td></tr>
</table>

#### *6.2.1.2 Skill demo*

The skill that REINOVA uses has analytics and status updates by understanding specific queries related to DEFCON levels, chamber statuses, temperatures, and battery levels. It uses the Rasa server to recognize and respond to various user questions, such as daily DEFCON level counts, specific DEFCON occurrences, and date-filtered DEFCON levels. The skill has the natural language understanding, fused with a Rasa action server getting the real-time status updates from the servers of REINOVA. Users can also check the current status, temperature of specific chambers, inquire about battery levels of testers, and request lists of all available chambers and battery testers. This setup ensures efficient and accurate responses, making it easier for users to get the information they need in real time. Examples of conversations are shown in Figure 25 and Figure 26.

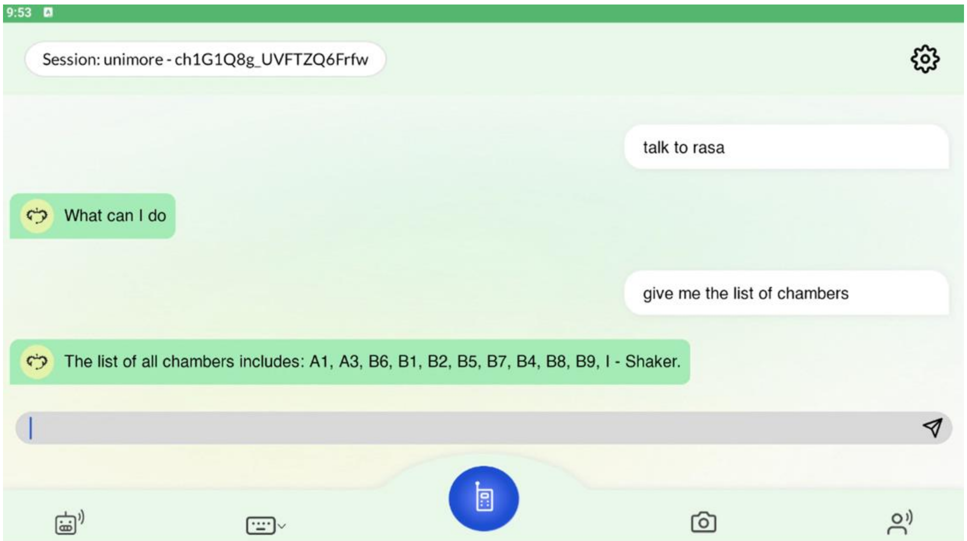



*Figure 25: Inquiring about available chambers in the system*

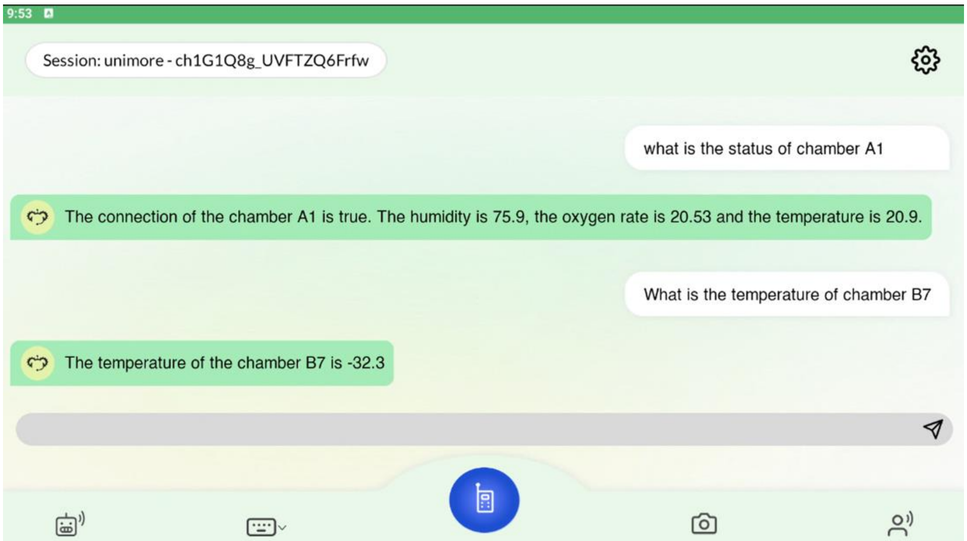



*Figure 26: Inquiring about the statuses of different chambers*

### 6.2.2 Assisted quality assurance skill for TRIMEK

The assisted quality assurance skill for TRIMEK revolves around assisting in measuring processes in the Coordinate Measuring Machine (CMM) with the use of the M3 metrology software. The DIA includes the measurement capabilities to help users with calibrated artifact measurement processes. In the first stage, it recognizes questions about measuring different types of artifacts and the selection of the right template according to the artifact specifications. For this, users can provide details about the type of artifact and their dimensions. In the second stage, the DIA will guide the steps involved in the alignment process and how to execute them. In this case, the user asks for help with aligning calibrated artifacts. The DIA understands these inputs and guides users through the right M3 project template selection and the alignment and measurement processes, making it easier to perform accurate artifacts measurements. As shown in the Figure 27, the user is asking to measure a gear, and then the DIA is asking the follow-up questions for the type of the gear, it then guides the user through the measurement process for accurately meaning the gear. The sample of user questions and responses are shown in Table 8.

*Table 8: User dialogues samples with TRIMEK DIA*

| User Dialogues | Responses |
|---|---|
| I need to measure a gear part | Can you describe the object to me. What type of gear is it? |
| It is a cylindrical gear | You have a cylindrical gear. Is that correct? |
| Yes, that is correct. | What are the dimensions of the ball bar? |
| 1000mm | Then you should select the template No. 2 in the M3 software to start the process. |

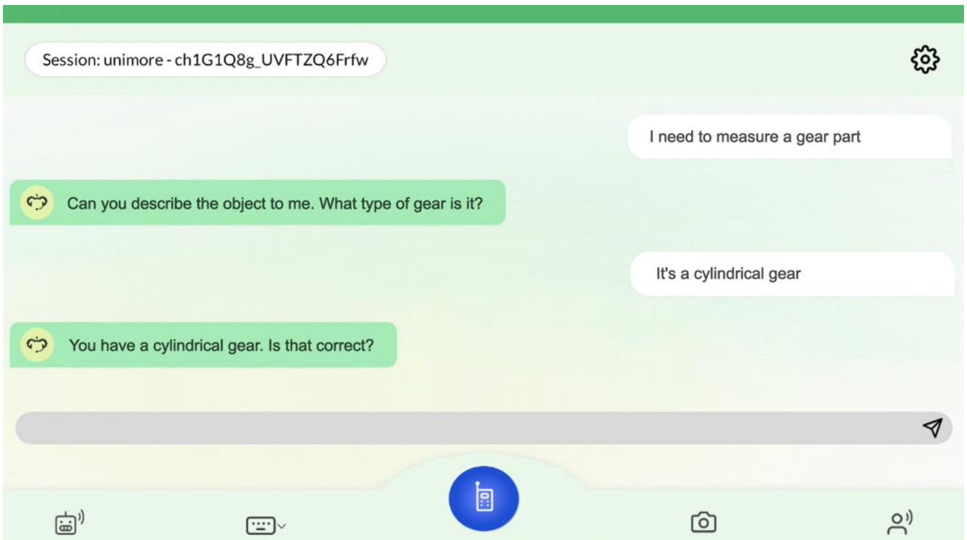



*Figure 27: Interaction with measurement process skill for TRIMEK*

### 6.2.3 Assisted quality assurance skill for CROMA

The assisted quality assurance skill implemented within the WASABI DIA, significantly enhances the sterilization workflow managed by CROMA. This advanced skill leverages a Rasa component trained on comprehensive datasets provided by CROMA, ensuring precise and contextual guidance throughout the sterilization process. By integrating this skill, operators are supported in various quality control tasks, notably during the crucial packaging phase. This assistance streamlines the management of tool lists, mitigates the risk of typing errors, and eliminates the need for direct computer interaction, thereby expediting operations and elevating the overall user experience for the operators.

One of the primary functionalities of the skill is to assist operators in verifying the presence of specific instruments within sets, ensuring no tool is misplaced or omitted. This meticulous verification process is vital in maintaining the high Sterility Assurance Level (SAL) required for medical instruments. Additionally, the skill offers real-time suggestions on instruments that may need to be removed for repair, thus preventing potential disruptions in the sterilization cycle. By facilitating these checks and providing actionable recommendations, the assisted quality assurance skill for CROMA not only enhances efficiency but also upholds the stringent standards necessary to prevent and control hospital-acquired infections.

#### *6.2.3.1 Analytics component*

The dedicated assisted quality assurance skill designed for CROMA within the WASABI DIA represents a pivotal advancement in leveraging cutting-edge technology for streamlined and efficient business operations. By seamlessly integrating a Large Language Model (LLM) with a robust knowledge base derived from CROMA's documents, this skill empowers users to extract critical insights and make informed decisions with unparalleled ease and precision.

The decision to develop a bespoke assisted quality assurance skill for CROMA within the WASABI DIA stemmed from several key considerations. CROMA primarily required a solution that facilitates rapid and systematic knowledge extraction from its extensive document repository, unlike other business cases that rely heavily on real-time streaming data or complex analytical frameworks. Existing generic solutions often lack the specificity and depth required to meet CROMA's unique needs. Moreover, the skill's design ensures it is not only tailored to CROMA but also maintains a level of generality that allows for broader applicability across diverse business contexts. This versatility positions the skill as a valuable asset in the burgeoning skills marketplace.

Central to the functionality of this skill is the utilization of a sophisticated pre-trained Language Model (LLM), which enables the generative production of contextually relevant answers. Unlike rule-based systems, an LLM requires no explicit programming for every possible scenario, making it highly adaptable and capable of handling complex inquiries effectively. The skill's framework includes the integration of CROMA's document knowledge, allowing the LLM to draw upon a rich repository of information without the need for additional training when new documents are added. Furthermore, the LLM's multilingual capabilities ensure seamless support for diverse linguistic contexts, enhancing accessibility and usability for the users.

An integral component of this skill is its integration of a comprehensive knowledge base derived from CROMA's documents. This knowledge base serves as a repository of expertise, augmenting the accuracy and relevance of generated responses. By leveraging the insights encapsulated within CROMA's documentation, the skill enhances user interactions, fosters informed decision-making and streamlines quality assurance processes. This strategic integration ensures that the skill remains dynamic and adaptive, continuously evolving to meet evolving business needs and user requirements.

#### *6.2.3.2 Skill demo*

The CROMA skill helps users with tasks related to scanning, washing, and sterilizing medical equipment. It can handle reports about scanning barcodes, completing manual washing, and requests for the correct sterilization process. Users can also confirm that all items are present and inform the DIA about the condition of the equipment, such as noting if any instruments need repair. By understanding these inputs, the CROMA DIA guides users through these important processes, ensuring everything is done correctly and efficiently. In Figure 28 the user is telling the DIA to start the sterilization process, then the DIA follows with the procedure involving several steps to guide the user to perform the sterilization.

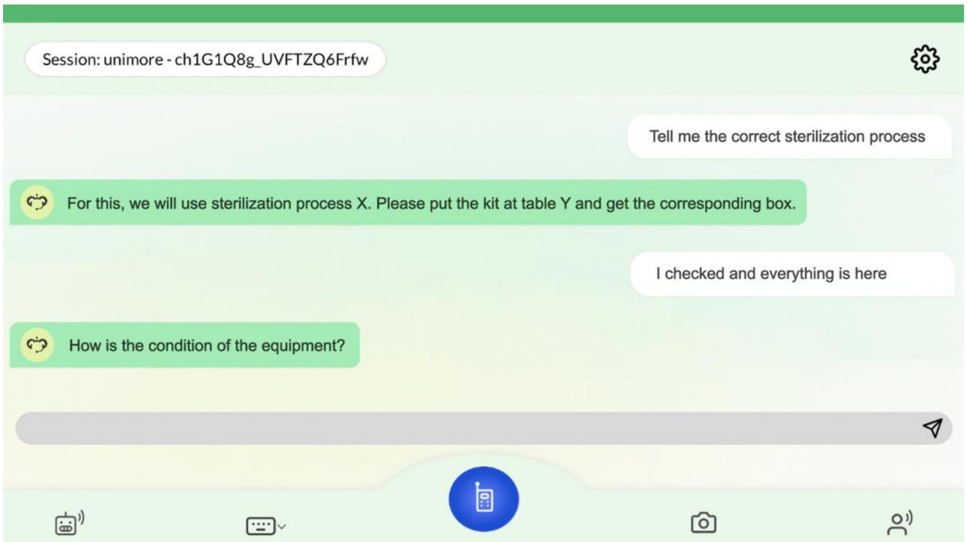



*Figure 28: Interacting with the process control skill of CROMA*

### 6.2.4 Assisted quality assurance skill for EPISCAN

The assisted quality assurance skill for EPISCAN, named as **Production Reporting Skill**, leverages the capabilities of the WASABI DIA to enhance the accuracy and efficiency of quality control processes within the PPE manufacturing environment. This skill is designed to support technicians by providing real-time assistance and guidance during their hourly quality control checks on both the surgical mask and FFP2 mask production lines. By integrating seamlessly with the existing ERP software environments, the DIA can offer contextual and timely information, reducing the likelihood of errors and ensuring that quality standards are consistently met. Through this interaction, technicians receive step-by-step instructions and automated reminders, which streamline the quality assurance workflow and facilitate immediate corrective actions when deviations are detected.

In addition to real-time support, the Production Reporting Skill also contributes to long-term improvements in product quality and operational efficiency. The skill includes advanced analytics components that provide descriptive and predictive insights into quality metrics and trends. By analyzing historical data collected through the legacy systems, the DIA can identify patterns and suggest proactive measures to mitigate potential quality issues. This data-driven approach not only enhances the overall quality of the masks produced but also optimizes material usage and reduces waste, aligning with EPISCAN's objectives of sustainable manufacturing and cost efficiency. Ultimately, the Production Reporting Skill represents a significant advancement in EPISCAN's quality management practices, fostering a culture of continuous improvement and operational excellence.

#### *6.2.4.1 Analytics component*

The analytics component supports the developed production reporting skill for the EPISCAN use case, by providing the corresponding analytics results that can effectively answer the user's questions with the incorporated generated insight. The implemented analyses focuses on generating inventory insights through descriptive analyses. The next version of the component will extend the current set of analyses to provide descriptive analyses with respect to the manufacturing process, as well as predictive outcomes including inventory, supply and manufacturing duration forecasting.

It is worth noting that the use case data are collected through a widely applied ERP system, facilitating the generalization of the implemented analyses to additional use cases.

Below, we describe the analyses performed in the context of this skill based on the ERP data:

1. Manufacturing Analytics

This set of analyses aims to provide the user with the requested information related to the product manufacturing process, including the Bill Of Material and statistical outcomes related to the raw materials requirements and the manufacturing statistics for a specific product.

a. Bill of Materials Information

The first descriptive analysis of the category retrieves the product requirements in terms of raw materials information from the corresponding ERP datasets and prepares them in the appropriate format for the DIA. The example dialog that this analyses is presented in **Fehler! Ungültiger Eigenverweis auf Textmarke.**, followed by the corresponding analytics query. In this example, the product in discussion is the product with ID 4184, for which the user requests the BOM definition. Similarly to this, the analyses in this category can answer the questions:

- List the products that involve the raw material with Reference X
- List the quantities of the raw materials required for manufacturing Y units of the product with Reference Z

*Table 9: Analytics question samples for the EPISCAN business case*

<table>
<tr><th>Question</th><th>Answer</th></tr>
<tr><td>What is the BOM definition for product with ID 4184 or reference EAQ2C101?</td><td>Manufacturing of this product requires:<br>– 8.12 kg of Melt-Blown No tejido BFE98 25gr/m2 A=175 mm Blanco<br>– 8.13 kg of Spundbond No Tejido (Capa Exterior) Calidad SS, 20gr/m2 A=175mm Blanco<br>– 9.18 kg of Spundbond No Tejido (Capa Interior) Calidad SS, 25 gr/m2 A=195mm Blanco<br>– 3.67 kg of Tira nasal plana de poliester con hilo metálico A=3mm Blanco<br>– 4.66 kg of Cordón Elástico Blanco 3mm<br>– 16.00 kg of Poliprop. Lámina 30 my 250MM</td></tr>
<tr><th>Query</th><th>Response</th></tr>
<tr><td><pre>
 query bom{
     resultRequest(request:{
     request: "PRODUCT_BOM"
     requestFrom: "DA"
     requestFilters: {
          name: "ProductID"
             action: "equals"
             values: "4184"
            }
     ){
           results
}}
</pre></td><td><pre>
{"data": {
    "resultRequest": [
    {
        "results": [
          {
            "ProductID": "4184",
            "BOM": {
                  "Melt-Blown No tejido BFE98 25gr/m2 A=175 mm
Blanco": 8.12
                  "Spundbond No Tejido (Capa Exterior) Calidad
SS, 20gr/m2 A=175mm Blanco": 9.18
                  "Tira nasal plana de poliester con hilo
metálico A=3mm Blanco": 3.67
                  "Cordón Elástico Blanco 3mm": 4.66
                  "Poliprop. Lámina 30 my 250MM": 16.00
            },
          }]}]}}
</pre></td></tr>
</table>

b. Manufacturing Process

This category includes the relevant to the manufacturing process analyses. Using these analyses, the DIA can describe the history of manufacturing specific products through a period of time, as well as provide statistical results over time. The analyses example presented below answers the question of how many units of a specific type have been produced in a specific time period. Similarly to this, the implemented analyses can answer questions similar to:

- What is the average duration of manufacturing X units of product Y
- How many manufacturing orders have been completed including product Y
- How many workorders refer to the manufacturing of product Y
- What is the average number of workorders per day?

*Table 10: Analytics question samples for the EPISCAN business case*

<table>
<tr><th>Question</th><th>Answer</th></tr>
<tr><td>How many units of the product with Reference EAQ2C101 have been manufactured this month?</td><td>In May, 2024, 4230 units of the product [EAQ2C101] Mascarilla Quirúrgica EPISCAN Tipo IIR Blanca con envase unitario, have been manufactured.</td></tr>
<tr><th>Query</th><th>Response</th></tr>
<tr><td><pre>query manu_ref{
      resultRequest(request:{
        request: "GROUP_BY_REFERENCE"
        requestFrom: "DA"
        requestFilters: [{
                    name: "ProductRef"
                    action: "equals"
                    values: "EAQ2C101"}]
        dateFilters:{
          name: "Date"
          action: "between"
          start: "2024-05-01"
          end: "2024-05-31"
          unit: "MONTH"
        }
      }){
        results
      }
    }</pre></td><td><pre>{"data": {
    "resultRequest": [
    {
        "results": [
          {
            "Year": "2024",
            "Month": "5"
            "ProductRef": "EAQ2C101",
            "count": 4230
          },
          }]}]}}</pre></td></tr>
</table>

2. Inventory Analytics

Similarly to the aforementioned analyses, the filtering mechanism that is included in the analytics component, enables the advanced customization of the generated results for the analyses of this category. In that sense, the analyses mentioned below can be configured in order to provide the global view of the stock levels of the case or drill down to the stock levels for specific warehouses, products or time intervals.

a. Stock level of raw materials

The example below presents the query that returns the current stock level for a specific raw material with Reference, in a specific warehouse. Additionally, the analyses of this category can answer questions referring to the current stock of raw materials but also the history of the stock levels. Some example questions that can be successfully addressed are:

- What is the current level of stock for the raw material with Reference X
- List the warehouses with active stock for raw material with Reference X
- What is the average stock level for the raw material with Reference X per month?

*Table 11: Analytics question samples for the EPISCAN business case*

| Question | Answer |
|---|---|
| What is the current stock level of raw material Cordón Elástico Blanco 5mm (FFP2) in warehouse with Reference AETF/Stock | Currently, in the warehouse AETF/Stock there are 8851.28 kg |
| **Query** | **Response** |
| query stock{<br>resultRequest(request:{<br>request: "STOCK_LEVEL"<br>requestFrom: "DA"<br>requestFilters: [{<br>name: "ProductRef"<br>action: "equals"<br>values: "Cordón Elástico Blanco 5mm (FFP2)"}]<br>sumFilters:{<br>name: "Date"<br>action: "max"<br>}<br>}){<br>results<br>}<br>} | {"data": {<br>"resultRequest": [<br>{<br>"results": [<br>{<br>"ProductRef": "Cordón Elástico Blanco 5mm (FFP2)",<br>"Date": "2024-05-13"<br>"count": "8851.28"<br>"metric": "kg"<br>},<br>}]}]}} |

b. Raw Materials Statistics

This category of analyses aims at providing statistical information related to the raw materials used for a selected time interval of the manufacturing process. The filtering mechanism that is embedded in the analytics component facilitates the generation of several statistical outcomes for different products, raw materials and time periods. In the example presented below in Table 12, the analyses can answer the user's question regarding the list of raw materials used for the production of a specific product from 2023-11-16 to 2024-07-16. Other examples of the analyses implemented can answer questions similar to:

- List the top 5 vendors
- List the raw materials with manufacturing requirements priority with respect to the quantities used
- What is the most used material across all the products?
- What is the status of the transfer with Reference APTF|e|00017?
- How many transfers have been completed from 2023-11-16 to 2024-07-16?
- How many transfers are pending right now?
- What is the cancellation rate for a specific vendor?
- What is the average transfers' number per vendor per month?

*Table 12: Other analytics query samples*

| Question | Answer |
|---|---|
| List the raw materials amount that were used for the production of the product with Reference EAQ2C101 for the period 2020-01-01 to 2020-01-31. | During this period, manufacturing of this product has consumed:<br>– 750 kg of Melt-Blown No tejido BFE98 25gr/m2 A=175 mm Blanco<br>– 722 kg of Spundbond No Tejido (Capa Exterior) Calidad SS, 20gr/m2 A=175mm Blanco<br>– 831 kg of Spundbond No Tejido (Capa Interior) Calidad SS, 25 gr/m2 A=195mm Blanco<br>– 320 kg of Tira nasal plana de poliester con hilo metálico A=3mm Blanco<br>– 351 kg of Cordón Elástico Blanco 3mm |

| | – 1500 kg of Poliprop. Lámina 30 my 250MM |
|---|---|
| **Query** | **Response** |
| query bom{<br>resultRequest(request:{<br>request: "RAW_MATERIALS_PER_PRODUCT"<br>requestFrom: "DA"<br>requestFilters: {<br>name: "ProductID"<br>action: "equals"<br>values: "4184"<br>}<br>dateFilters:{<br>name: "Date"<br>action: "between"<br>start: "2023-11-16"<br>end: "2024-07-16"<br>unit: "ALL"<br><br>){<br>results<br>}} | {"data": {<br>"resultRequest": [<br>{<br>"results": [<br>{<br>"ProductID": "4184",<br>"RAW_MAT": "Melt-Blown No tejido BFE98 25gr/m2 A=175 mm Blanco",<br>"count": "750"<br>"metric": kg},{<br>"ProductID": "4184",<br>"RAW_MAT": "Spundbond No Tejido (Capa Exterior) Calidad SS, 20gr/m2 A=175mm Blanco",<br>"count": "722"<br>"metric": kg},{<br>"ProductID": "4184",<br>"RAW_MAT": "Spundbond No Tejido (Capa Interior) Calidad SS, 25 gr/m2 A=195mm Blanco",<br>"count": "831"<br>"metric": kg},{<br>"ProductID": "4184",<br>"RAW_MAT": "Tira nasal plana de poliester con hilo metálico A=3mm Blanco",<br>"count": "320"<br>"metric": kg}, {<br>"ProductID": "4184",<br>"RAW_MAT": "Cordón Elástico Blanco 3mm",<br>"count": "351"<br>"metric": kg},{<br>"ProductID": "4184",<br>"RAW_MAT": "Poliprop. Lámina 30 my 250MM",<br>"count": "1500"<br>"metric": kg},<br>}]}]}} |

These categories with be extended with additional analyses in D2.6 –"Joint WASABI demonstrator – final".

#### *6.2.4.2 Skill demo*

This skill helps users of the DIA with production reporting and material management. It can answer questions about how many products, like surgical masks, were produced on a specific date or in a particular month. Users can ask about the quantity of materials in different locations, such as a manufacturing plant or warehouse. The DIA for EPISCAN also allows users to report the number of materials they have taken or replaced. By understanding these inquiries, the DIA provides accurate information to help manage production and inventory efficiently. In Figure 29 the user is asking questions of different nature, this demonstrates that the user can ask questions related to the number of products produced of certain type, or on a specific day.

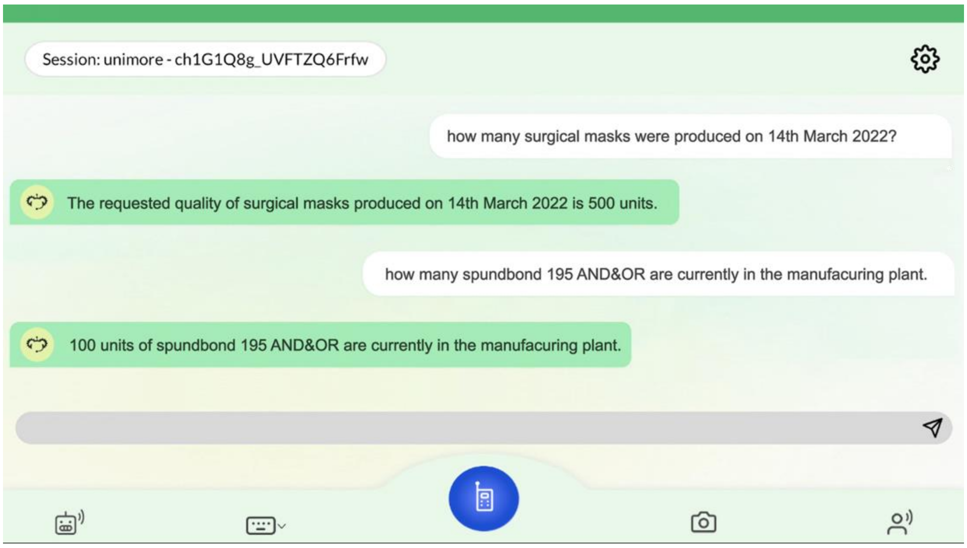



*Figure 29: Interacting with the production reporting skill of EPISCAN*

### 6.2.5 Assisted quality assurance skill for SILKBIO

The assisted quality assurance skill for SILKBIO, integrated within the WASABI DIA, represents a significant advancement in assisted quality assurance for SILKBIO. Specifically designed for process control scenarios, this skill leverages the capabilities of a Rasa server and an action server to provide real-time, step-by-step guidance to operators. This ensures that each stage of the process is executed with precision and adherence to established protocols. The DIA actively engages with the operator, requesting specific data inputs, verifying conditions against predefined thresholds, and confirming the successful completion of each step. This interactive approach not only enhances the accuracy of the procedure but also reduces the cognitive load on the operator, allowing them to focus more on the manual aspects of the process.

The assisted quality assurance skill for SILKBIO offers numerous benefits, including improved cycle time, enhanced traceability, reduced manual documentation, and increased safety. By capturing user input, the skill streamlines the documentation process, minimizing errors associated with manual record-keeping. Real-time tracking and monitoring capabilities ensure thorough traceability, facilitating retrospective analyses and process optimization. Furthermore, the DIA's ability to provide timely instructions and safety checks helps preempt potential issues, thereby ensuring a safer working environment. Overall, this skill enhances the efficiency and reliability of the solubilization process, contributing to the high standards of quality assurance in SILKBIO's innovative applications in regenerative medicine. As shown in the Figure 30, the user asks to start the solubilization process. In the next steps, the DIA asks the follow-up questions as shown in the Figure 31.

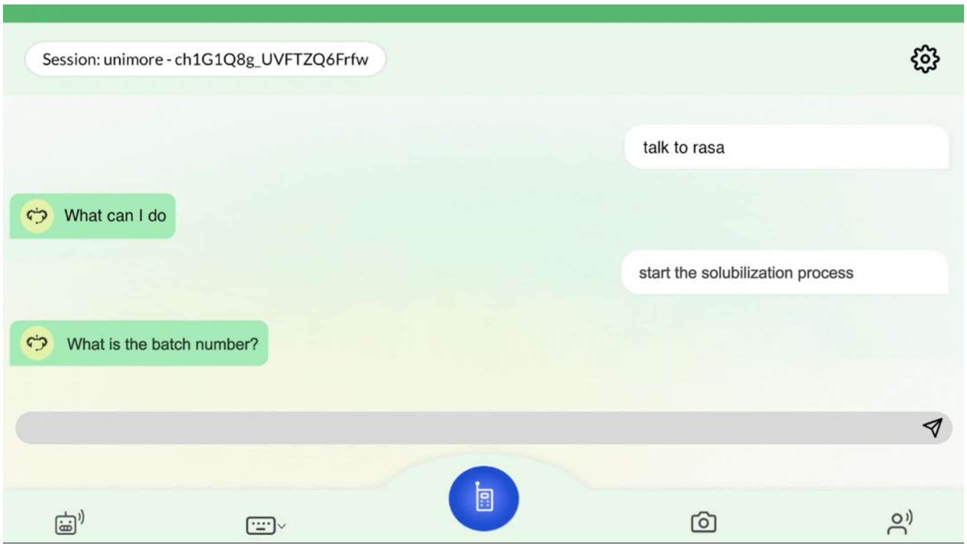



*Figure 30: Starting the solubilization process skill*

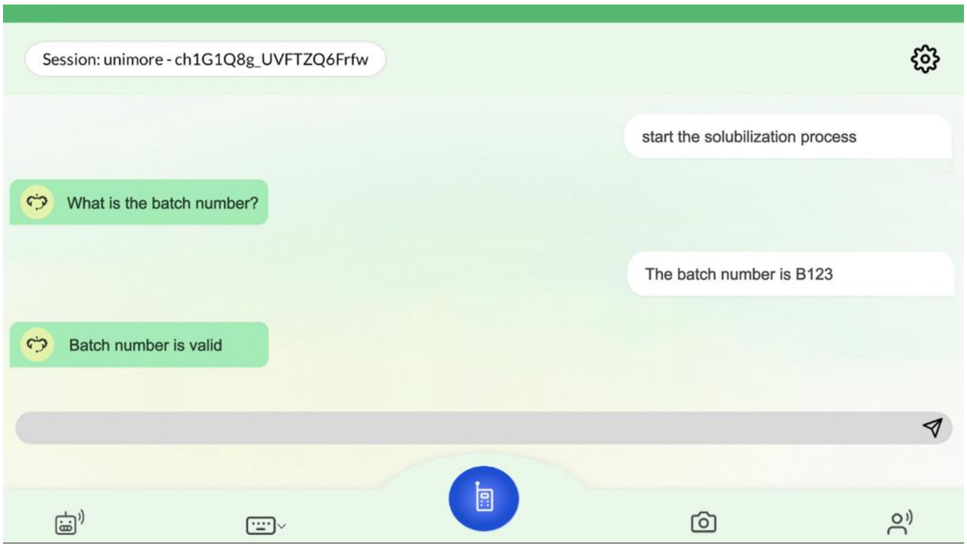



*Figure 31: Starting with the follow-up interactions within solubilization skill*

## 6.3 Lessons learned

Throughout the development and implementation of the WASABI project, several key lessons have emerged, highlighting both successes and areas for improvement. These lessons have been instrumental in refining our approach to optimize the project's outcomes.

Firstly, the integration of DIAs across diverse use cases partners demonstrated the importance of tailoring AI solutions to specific industrial contexts. Customization of DIAs to meet the unique requirements of each business case proved crucial in enhancing operational efficiency and user satisfaction. For instance, the flexibility of the REINOVA DIA to adapt to various testing protocols and environments showcased the need for versatile and modular AI architectures.

The main technical challenges that emerged as outcomes of the first tests UNIMORE conducted on the developed DIAs are summarized as follows:

**Lengthy responses due to data size:**

**Challenge:** The system often generated lengthy responses due to the large size of the data, making it difficult to display the entire response on the DIA app.

**Solution:** Implementing data summarization techniques or breaking down the responses into more manageable chucks can improve readability and user experience.

**Countdown timer and device sleep mode:**

**Challenge:** Some processes required a countdown timer, which could exceed the normal screen time of Android devices, causing the system to enter sleep mode.

**Solution:** Ensuring the countdown timer functionality is integrated in a way that prevents the device from sleeping during critical operations. This could involve adjusting device settings or implementing a wake lock mechanism to keep the screen active during these processes.

**Similar intents and model confusion:**

**Challenge:** The model encountered confusion between similar intents, as identified through the story testing mechanism of Rasa, including confusion matrices.

**Solution:** Enhancing the training data by introducing more diverse and specific utterances for each intent. This helps in clearly distinguishing between similar intents, thus improving the accuracy and reliability of the DIA.

Lastly, UNIMORE visited REINOVA in February 2024 (M12) to test the DIA on premise together with the REINOVA staff who was involved in the development of the DIA. The meeting was mainly devoted to the installation of the app on different Android smartphones and different tests were conducted to assess the stability of the connection to the server in the laboratory. The outcomes of this first visit represents a valuable input to the introduction of the framework for the iterative evaluation and feedback process which will be conducted in task T2.4. This process will play a pivotal role in refining the AI assistants. Conducting pilot tests and gathering user feedback will allow us for continuous improvement and the identification of potential challenges early in the development cycle. This approach will ensure that the DIAs remained aligned with user needs and operational realities, ultimately leading to more effective and reliable solutions.

These lessons will guide future phases of the WASABI project, ensuring ongoing innovation and enhanced collaboration. By leveraging these insights, the project can continue to advance the capabilities of DIAs, fostering greater efficiency and sustainability in manufacturing processes.

## 6.4 Software license

Table 13 summarizes the main exploitable or otherwise critical components for this use case. It refers to a proprietary license that grants a usage permission to WASABI participants or an open-source license. Some components require business-specific training data (e.g., the Rasa chatbots), and the related license does not cover that data because it is confidential. We may change the licenses in the course of the exploitation planning (T6.2).

*Table 13: Software licenses for assisted quality assurance components*

| Component | Developer | License | Note |
|---|---|---|---|
| Analytics component (PREVENTION) | ICCS | GPLv3 | - |

| | | | |
|---|---|---|---|
| Analytics component (WISE) | ATLANTIS | Proprietary | Any access for exploitation purposes, will require prior negotiation with Atlantis Engineering SA for forming a License and/or Business Agreement. |
| Analytics component (DocuBot) | | | |
| Assisted Quality Assurance skill | UNIMORE | Proprietary | Changes and modifications must be consulted beforehand |
| Assisted Quality Assurance Rasa services | | | |
| Assisted Quality Assurance Docker Stack | BIBA | Proprietary | BIBA provides the basic stack and UNIMORE modifies it |

# 7. EXPLAINABILITY AND AI ROBUSTNESS

In WASABI, AI algorithms belong to one of two main categories: (i) Conversational AI or (ii) Data Analytics. Conversational AI refers to the services that use algorithms for natural language processing and dialog management (e.g., in the case of Rasa chatbots). Tasks 2.2, 2.3, and 2.4 use these algorithms. Data Analytics refers to the work taking place in Task 2.4: "Assisted quality assurance for sustainable products". This section discusses aspects related to AI explainability (Section 7.1) and AI robustness (Section 7.2) for the aforementioned categories of AI algorithms in WASABI.

## 7.1 Explainability

Explainability in AI refers to the methods and techniques for enabling humans to retain intellectual oversight and comprehend and trust the results of AI and ML algorithms (Longo et al., 2024). The main focus is usually on the reasoning behind the decisions or predictions to make them more understandable and transparent (Vilone, and Longo, 2021). Explainability aims at countering the so-called "black box" tendency of ML, where, in some cases (e.g., in deep learning architectures and models), even the AI developers cannot explain why a specific outcome (e.g., a prediction or a decision) has been generated (Adadi, and Berrada, 2018).
Explainability for conversational AI should not be confused with an assistant's capability to explain causal relations relevant to specific use cases. For instance, asking an assistant to explain why a defect occurred differs from asking why it predicted the occurrence of a defect. The former aims for a causal explanation usable in a root-cause analysis. In contrast, the latter aims to tell the user about the assistant's internal decision-making, i.e., what drove it to predict this defect.

### 7.1.1 Conversational AI

Usually, Rasa-based conversational digital assistants classify each user utterance's intent and extract meaningful information (named entities). The classification calculates confidence scores and uses the top-ranked class for further processing. A mix of rules and example dialogs determine how the assistant responds to the classified intent and the extracted named entities. Typically, it selects a manually designed response template and fills placeholder variables with information acquired during the conversation or retrieved from databases. A user cannot understand directly why the assistant selected a specific response. Developers can investigate logs, API results, and trained models to understand response selection.

### 7.1.2 Analytics Component

Explainability within the Analytics Component (AC) refers to the capacity to clarify and justify the conclusions and actions derived from the analytical processes. The AC prioritizes transparency and interpretability as fundamental aspects, acknowledging that deep learning techniques, while powerful in certain domains, may not always align with the need for explainability in the context of the business case. The data analytics functionalities of WASABI do not embed deep learning models in which deep neural networks create features that humans cannot understand. Instead, in order to satisfy the business requirements, typical supervised and/ or unsupervised ML algorithms are sufficient. The challenge is exposing the user analytics results via voice, where detailed graphical views are unavailable.

Within the AC framework, several strategies are employed to enhance explainability effectively:

1. **Algorithm Selection and Interpretation**: The AC prioritizes algorithms with inherent interpretability and transparency. This includes rule-based heuristics, statistical models, and other techniques with clear

decision-making processes. By using such algorithms, the AC ensures that analytical outcomes can be readily understood and explained.

2. **Customizable Dashboards**: The AC features customizable dashboards that allow users to intuitively visualize raw data, algorithmic outcomes, and analysis details. These dashboards are tailored to each pilot's needs, providing a structured view of the analytical process and facilitating user understanding.
3. **Role-Based Interpretation**: To accommodate varying user backgrounds and information needs, the AC implements a role hierarchy that governs the level of detail and interpretability provided in analytical outputs. Users with different roles receive information at varying levels of granularity, ensuring that explanations are contextualized and relevant to each user's expertise and responsibilities.
4. **Transparent Reporting**: The AC incorporates transparent reporting mechanisms that document the steps taken in the analytical process, from data preprocessing to model selection and validation. This documentation enhances transparency and accountability, allowing users to trace the rationale behind analytical decisions and outcomes.
5. **Human-in-the-loop Approach**: While automated analytics play a crucial role, the AC adopts a human-in-the-loop approach to decision-making. Human experts interpret and validate analytical results, providing additional layers of context and explanation where automated algorithms may fall short.

By embracing these strategies, the AC balances sophisticated analytical capabilities and explainability, ensuring that analytical outcomes are accurate, actionable, comprehensible, and transparent to users. This approach is precious in domains such as quality assurance, where clear explanations of analytical insights are essential for informed decision-making and continuous improvement.

### 7.1.3 DocuBot (CROMA Business case)

The CROMA use case skill prioritizes explainability, ensuring users have clear insights into the reasoning behind the answers generated to build trust and confidence. As DocuBot is based on pre-trained LLMs, it inherits the uncertainties an LLM includes during its text generation process, including hallucination problems (Lei et al., 2023) and lack of proper citation. DocuBot acknowledges and accommodates these challenges based on three main pillars, as shown in Figure 32.

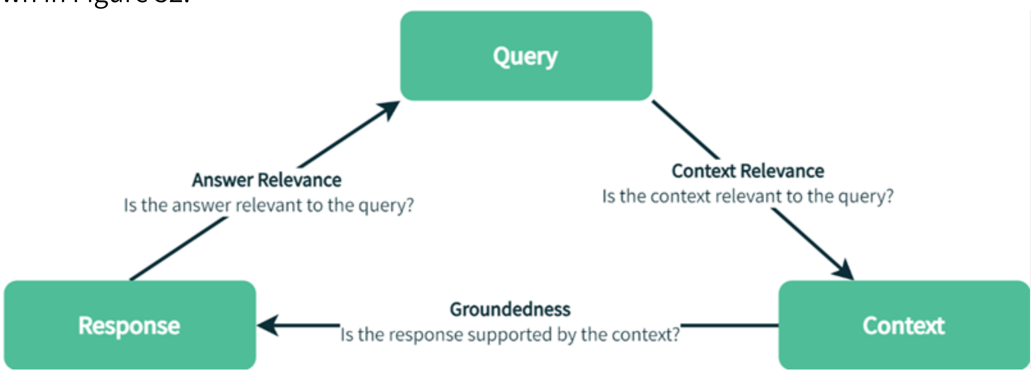



*Figure 32: DocuBot Explainability Pillars*

- **Context Relevance:** In the CROMA use case, ensuring the quality of information retrieval is paramount. Each context retrieved must directly relate to the user's input query. This precision is critical because the context is the foundation for the LLM's answer-generation process. Any irrelevant information within the context could lead to inaccuracies or "hallucinations" in the generated response.
- **Groundedness:** Following context retrieval, the LLM formulates an answer. However, LLMs tend to exaggerate, distort, or fabricate facts that may seem plausible but lack factual grounding. To address this concern, DocuBot involves breaking down the response into distinct claims and independently verifying each claim against evidence found within the retrieved context. Groundedness measures the degree to

which the LLM's claims align with verifiable information from the source text, enhancing the credibility and accuracy of the generated response.

- **Answer Relevance:** Ultimately, the generated response must remain relevant and useful in addressing the user's original question. We evaluate this by assessing the relevance of the final response to the user's input, ensuring that the information provided is accurate and directly addresses the user's query in a helpful manner within the CROMA context.

One of the key features to achieve the above points within the CROMA business case skill is incorporating a **citation mechanism** for answer verification. This mechanism allows users to delve deeper into the sources of information used by the skill to generate a particular answer. Users can independently verify the accuracy and relevance of the provided answer by referencing specific sections or documents within CROMA's repository. This instills confidence in the skill's capabilities and empowers users with greater control and understanding of the information presented.
In addition to providing transparent explanations and citation mechanisms, the CROMA use case skill leverages advanced techniques such as **vector similarity properties** to enhance the relevance and contextuality of generated responses. This innovative approach ensures that users receive accurate answers and a deeper understanding of the underlying concepts and relationships within CROMA's domain.

## 7.2 AI Robustness

Ensuring AI robustness has been a fundamental priority in developing the WASABI project's DIAs. AI robustness refers to the system's ability to consistently perform under various conditions, including handling noisy data, adapting to changes in the operating environment, and resisting adversarial attacks. This robustness is crucial for maintaining the reliability and trustworthiness of AI systems deployed in industrial settings.

One key aspect of AI robustness in the WASABI project is the implementation of comprehensive testing and validation processes. For instance, the analytics components undergo rigorous testing to evaluate their performance across different scenarios. Techniques such as cross-validation, story testing, and scenario-based simulations ensure that the models can generalize well and provide accurate predictions even when faced with unexpected inputs. Additionally, continuous monitoring and real-time feedback mechanisms are in place to detect and promptly address deviations from expected behavior. This proactive approach helps maintain the stability and reliability of the AI systems throughout their deployment.

Furthermore, the emphasis is on the data quality and preprocessing to enhance AI robustness. Data collected from various sources undergoes cleaning and preprocessing to eliminate inconsistencies and ensure compatibility with the analytical algorithms. Robust data governance frameworks and automated quality checks ensure that only high-quality, relevant data is used for model training and analysis. By maintaining stringent data quality standards, the risk of errors and biases is minimized, thereby enhancing the overall robustness of the AI systems. This focus on robustness improves the performance and reliability of the DIAs and fosters greater user confidence and trust in the AI solutions implemented across the various business cases.

### 7.2.1 Conversational AI

Robustness in conversational AI involves ensuring that the AI systems are dependable, resilient, and capable of operating reliably under various conditions. For the Rasa-based digital assistants implemented in business cases like REINOVA, TRIMEK, EPISCAN, CROMA, and SILKBIO, robustness is achieved through continuous monitoring and

validation of the performance. We follow conversation-driven design with regular updates to the training data to ensure it remains current and representative of the environment in which the DIA is deployed.[6]
Additionally, the Rasa models can be tested for accuracy and reliability, with mechanisms in place to gracefully handle unexpected inputs or failures. Robustness also encompasses security measures to protect the DIA from potential cyber-attacks and ensure that the Rasa server can withstand adversarial conditions without compromising performance. These measures are essential to prevent unintentional harm and ensure that the DIA operates as intended, even in the face of changes in the operating environment or malicious interactions.

### 7.2.2 Analytics Component (REINOVA Business Case)

ML robustness refers to the ability of a model to maintain its performance when faced with uncertainties or adversarial conditions. This includes handling noisy data, distribution shifts, and adversarial attacks, among other challenges. A robust model should be able to generalize well and provide reliable predictions even when dealing with unforeseen inputs or circumstances. ML algorithms are incorporated in data analytics pipelines, including data cleaning, imputation, and preprocessing, before the model building. This process is repeated every time the analytics pipelines receive new data. Then, the model is subject to training and evaluation. In this context, extensive validation procedures have preceded the deployment of ML algorithms (including, among others, sensitivity analysis, comparative analysis, etc.) in order to ensure ML models' stability and scalability. This ML testing procedure includes evaluation metrics, such as accuracy, sensitivity and specificity, and adversarial testing.

The AC relies on diverse training data. The training data is structured, cleaned, and preprocessed to ensure compatibility with the analytical algorithms utilized within the AC.

**Relevant Quality Characteristics:** Several key quality characteristics are essential for ensuring the reliability and effectiveness of the AC's analytical processes:

1. Accuracy: Data accuracy is paramount, ensuring that analytical insights and predictions align closely with real-world scenarios.
2. Completeness: Complete data sets are necessary to avoid biases and ensure comprehensive analysis.
3. Consistency: Consistent data formatting and standards across different data sources enhance the reliability of analytical outcomes.
4. Relevance: Relevant data that directly contributes to the analytical objectives of quality assurance and fault detection is prioritized.
5. Timeliness: Timely data updates and retrieval processes enable real-time analytics and proactive decision-making.

**Manual and Automated Quality Processes**: The AC employs a combination of manual and automated processes to measure and ensure high data quality:

1. Data Cleaning and Preprocessing: Automated algorithms are utilized to clean and preprocess raw data, addressing missing values, outliers, and inconsistencies. Manual validation processes complement these algorithms, ensuring data accuracy and relevance.
2. Quality Checks and Validation: Automated quality checks are integrated into data pipelines to identify data anomalies and discrepancies. These checks include data integrity validation, consistency checks, and outlier detection algorithms.

[6] Rasa Training data types: https://rasa.com/docs/rasa/training-data-format

3. Data Governance Framework: A robust data governance framework is implemented to enforce data quality standards, metadata management, and data lineage tracking. This framework ensures accountability and traceability in data handling processes.
4. Continuous Monitoring: Real-time monitoring tools are employed to track data quality metrics, alerting stakeholders to deviations from established quality standards. Automated alerts trigger corrective actions and data revalidation processes as needed.

**Testing Model Robustness:** Ensuring the resulting analytical models deliver robust and reliable results involves rigorous testing methodologies:

1. Cross-Validation Techniques: Cross-validation techniques such as k-fold cross-validation are employed to assess model performance across different data subsets. This mitigates overfitting and validates model generalization capabilities.
2. Model Evaluation Metrics: Relevant evaluation metrics such as accuracy, precision, recall, and F1 score are used to quantitatively assess model robustness and predictive performance.
3. Scenario-Based Testing: The AC conducts scenario-based testing to simulate diverse operational conditions and validate model responses. This includes stress testing, outlier detection testing, and edge case simulations to evaluate model resilience.
4. Feedback Loop Integration: A feedback loop mechanism is integrated into model testing processes, allowing for continuous model refinement based on real-world performance feedback and user input.
5. Deployment Monitoring: Post-deployment monitoring tools track real-time model performance, detecting drifts in data patterns and model behavior. This enables proactive adjustments and ensures sustained model robustness over time.

In conclusion, the AC's data quality and robustness management strategies encompass a comprehensive approach that integrates automated processes, manual validation, continuous monitoring, and rigorous testing methodologies. By prioritizing data accuracy, completeness, consistency, relevance, and timeliness, coupled with robust model testing and validation, the AC delivers reliable and actionable insights to support Reinova's quality assurance and operational efficiency goals.

### 7.2.3 DocuBot (CROMA Business case)

The AI robustness of DocuBot is a critical factor in ensuring the skill's reliability, scalability, and performance in diverse operational environments.

| Factor | DocuBot Approach |
|---|---|
| **Adaptive Learning and Continuous Improvement** | DocuBot's AI robustness is characterized by its adaptive learning capabilities, allowing it to analyze and interpret complex information from CROMA's documents with high accuracy and agility. Through continuous learning mechanisms, DocuBot refines its understanding of domain-specific concepts and updates its knowledge base dynamically, ensuring that it remains up-to-date with the latest information and industry best practices. |
| **Resilience to Variability and Uncertainty** | Moreover, DocuBot demonstrates robustness in its ability to handle variability and uncertainty within the CROMA use case context. Whether faced with nuanced queries, ambiguous terminology, or evolving operational scenarios, DocuBot employs advanced algorithms and contextual analysis techniques to navigate complexity and deliver reliable answers. This resilience to |

| | |
|---|---|
| | variability enhances the skill's adaptability and utility across a wide range of user interactions and business scenarios. |
| **Scalability and Performance Optimization** | The AI robustness of DocuBot extends to its scalability and performance optimization capabilities, enabling it to efficiently process large volumes of data and user queries without compromising speed or accuracy. By leveraging parallel processing and optimization algorithms, DocuBot maintains optimal performance levels even as workload demands fluctuate, ensuring seamless user experiences and minimal downtime. |
| **Error Handling and Feedback Integration** | Furthermore, DocuBot's AI robustness is reflected in its robust error-handling mechanisms and integration of user feedback. When uncertainties or inaccuracies arise, DocuBot employs error detection and correction strategies to mitigate potential issues and maintain the integrity of generated responses. Additionally, the skill's feedback loop allows for continuous refinement based on user input, enhancing its overall reliability and performance over time. |
| **Error Handling and Feedback Integration** | Another aspect of DocuBot's AI robustness lies in its cross-domain adaptability, enabling it to transfer knowledge and insights across different business cases within the WASABI DIA. This versatility ensures that the skill remains relevant and effective in addressing diverse user needs and organizational requirements, showcasing its robustness in handling complex and multifaceted AI tasks. |
| **Cross-Domain Adaptability** | Another aspect of DocuBot's AI robustness lies in its cross-domain adaptability, enabling it to transfer knowledge and insights across different business cases within the WASABI DIA. This versatility ensures that the skill remains relevant and effective in addressing diverse user needs and organizational requirements, showcasing its robustness in handling complex and multifaceted AI tasks. |

In essence, the AI robustness of DocuBot within the CROMA use case skill represents a sophisticated blend of adaptive learning, resilience to variability, scalability, error handling, and cross-domain adaptability. These attributes collectively contribute to the skill's reliability, performance, and utility in supporting quality assurance processes and enhancing operational efficiency within the CROMA context.

# 8. CONCLUSION AND OUTLOOK

Deliverable 2.4, "Joint WASABI Demonstrator – Version 2", demonstrated the project's second phase (M10-M15) results in developing and deploying the WASABI solution within three use cases:

- Augmented waste management and valorisation for TRIMEK and CROMA (Task 2.2)
- Assisted workforce management for EPISCAN (Task 2.3)
- Assisted quality assurance for sustainable products for REINOVA, TRIMEK, CROMA, EPISCAN, and SILKBIO (Task 2.4)

In the first phase of the project (M1-M9), we created early prototype versions of the DIA skills and their involved components based on the scenarios, user stories, and requirements collected from the partners in D1.1 and D1.2. In the second phase of the project (M10-M15), we continuously collected feedback from use case partners through workshops and two pilot tests, updated the infrastructure, and further developed and deployed the DIAs across the use cases. Throughout the implementation of the DIAs, several key lessons have emerged, highlighting successes and areas for improvement. These lessons have been instrumental in refining our approach to optimize the project's outcomes.

This deliverable reports a summary of the WASABI approach to data privacy and AI law, the infrastructure changes, and the main activities and results carried out during M10-M15 across Tasks 2.2, 2.3, and 2.4, and addresses the explainability and AI robustness across the AI components. This deliverable is the second of three Joint WASABI Demonstrators, and the final version is set to be released in M24.

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