Deliverable 6.3
Report on the installations in the plants

Dr. Udo Enste: LEIKON
Involved Partners: INEOS, Covestro, Lenzing, Frinsa, P&G, ASM, ORSoft, TUDO, UVA, CSIC, Sabisu, Divis

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THE CoPro PROJECT

The goal of CoPro is to develop and to demonstrate methods and tools for process monitoring and optimal dynamic planning, scheduling and control of plants, industrial sites and clusters under dynamic market conditions. CoPro pays special attention to the role of operators and managers in plant-wide control solutions and to the deployment of advanced solutions in industrial sites with a heterogeneous IT environment. As the effort required for the development and maintenance of accurate plant models is the bottleneck for the development and long-term operation of advanced control and scheduling solutions, CoPro will develop methods for efficient modelling and for model quality monitoring and model adaption.

The CoPro Consortium

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<tr>
<td>1 (Coordinator)</td>
<td>Technische Universität Dortmund (TUDO)</td>
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<td>HES</td>
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<td>INEOS Manufacturing Deutschland GmbH (INEOS)</td>
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<td>Process Systems Enterprise LTD (PSE)</td>
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<td>Argent &amp; Waugh Ltd. (Sabisu)</td>
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Deliverable 6.3:
Report on the installations in the plants

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**LIST OF AUTHORS - NAME(S) AND ORGANISATION(S)**

Enste, Leikon
Jasch, Lenzing
Beisheim, INEOS
Lemoine, Covestro
Corominas, P&G
Adrian, FrinSA
Wenzel, TUDO
Welch, Sabisu
Müller, ORSoft
Krause, DIVIS
Pitarch, UVA
Lopez, ASM

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**Abstract**

One main goal of CoPro is to demonstrate the results of the project in industrially relevant environments. Different approaches were realized. The evaluation implies the methods developed in CoPro as well as the handling of the tools to integrate the CoPro results into the existing IT-environments of the industrial partners. The handling includes the whole life cycle starting from scratch by offline modelling up to integrating the developed model based applications into the operative use.

This document describes the different approaches realized up to now to integrate the methods developed within COPRO into the heterogeneous IT landscapes of the use case providers.

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# Table of contents

1 Executive summary ........................................................................................................ 6

2 CoPro installations in the plants .................................................................................. 6

   2.1 Installations at INEOS site ..................................................................................... 6
       2.1.1 Optimal production scheduling of interconnected plants ................................. 6
       2.1.2 Anomaly detection in production plants ............................................................. 7
       2.1.3 Solution IT architecture .................................................................................... 8

   2.2 Installations at Covestro site ................................................................................. 9
       2.2.1 CO and H2 production and distribution network ............................................... 9
       2.2.2 Solution IT architecture ................................................................................... 10

   2.3 Installations at Lenzing ......................................................................................... 12
       2.3.1 Evaporator load allocation ............................................................................... 12
       2.3.2 Solution IT architecture ................................................................................... 12

   2.4 Installations at Procter & Gamble ....................................................................... 14
       2.4.1 Daily production planning .............................................................................. 14
       2.4.2 Solution IT architecture ................................................................................... 14

   2.5 Installations at Frinsa ......................................................................................... 16
       2.5.1 Optimization of production weekly schedule ................................................. 16
       2.5.2 Real-time sterilization scheduling ................................................................. 17
       2.5.3 Solution IT architecture ................................................................................... 17

   2.6 Installations at SGL Carbon ................................................................................. 19
       2.6.1 Online Monitoring of grain size distribution ................................................. 19
       2.6.2 Solution IT architecture ................................................................................... 19

3 Conclusion ............................................................................................................... 22
1 Executive summary

One main goal of CoPro is to demonstrate the results of the project in industrially relevant environments. This document describes the different approaches realized to integrate the methods developed within COPRO into the heterogeneous IT landscapes of the use case provider and of one additional feasibility study. The options of integration technologies depend on the various kinds of existing IT systems at the sites and the different requirements to demonstrate and evaluate the developed methods. All in all, a broad range of integration variants can be shown, so that for third parties different reference architectures can be depicted.

2 CoPro installations in the plants

2.1 Installations at INEOS site

INEOS in Cologne operates a typical integrated petrochemical complex, processing mainly naphtha and natural gas as major feedstock to produce a large number of important base chemicals. The Cologne site consists of more than twenty plants, more than ten utilities networks and a large number of storage tanks. There is a complex interaction between the different plants and site logistics as well as with other plants owned by other companies in the chemical park. At the INEOS site in Cologne, solutions for two different use cases have been installed.

2.1.1 Optimal production scheduling of interconnected plants

The production planning and scheduling of the integrated site of INEOS in Cologne is a challenging task considering the coupling between its plants through energy and material networks and the existence of technical constraints, like the minimum and maximum production rates of different plants, tank levels or the logistics. Currently, this planning is done in a semi-automatic sequential fashion, which is described in detail in D6.1 and D3.2. INEOS in Cologne has defined a use case in order to investigate the potential advantages of using an optimal scheduling tool based on mathematical optimization compared to its current planning approach.

Due to the complexity of the site in Cologne, the scope of this use case is limited to a section of the site as a proof of concept so that the work is manageable within the framework of CoPro. The ammonia network of the site has been chosen, since it resembles a chemical site that produces a product which can be sold directly to the market, stored or sent to downstream plants for further processing to the derivatives of this product. The plants of this network utilize different energy carriers as well as additional resources to produce these products. Storage limitations are considered by a multitude of product specific storage tanks. The topology of the tank farm is considered in the model together with the limitations of their interface to the loading terminals of different transportation means. The detailed description of this network can be found in D3.5. All these factors result in a highly complicated system of systems, for which a mathematical optimisation framework is developed by TUDO that uses the programming language Julia. The necessary data for the optimisation has to be gathered from different data sources within the IT-infrastructure of INEOS in Cologne. The data integration and orchestration platform of LeiKon was implemented to address this challenge. This platform does not only collect and transfer required data (e.g. measurement data or production goals) from various data sources, but also acts as a central hub, through which different
Deliverable 6.3:  Report on the installations in the plants

Platforms can communicate. An innovative HMI (Human-Machine-Interface) that is under development by the visualisation experts of Sabisu will be used by the planners to add/edit constraints or goals to/in the optimization framework and trigger the optimization on demand. The communication between the HMI and the optimization toolbox is established also via the data orchestration platform. Multiple requirements for this integration where realized:

- On-demand: A user is able to trigger the optimization process.
- Parallelism: The platform is able to run multiple optimization processes at the same time. This is necessary to trigger several what-if-scenarios with time consuming calculations in parallel.
- Parameterizable: A user is able to override model parameters.

The parameterizability enables a user to explore what-if scenarios such as raising the maximum level of a storage tank. Since the optimization process can take a considerable amount of time it is required that such scenarios do not block normal operation, hence the parallelism.

The Sabisu HMI triggers an optimization via the web interface of the integration platform, optionally passing scenario parameters. The platform complements the parameters with default parameters and operational data such as current tank levels, current plant load and customer order data. The operational data is fetched from the planning system currently in use at INEOS. The TUDO model uses that data, producing an optimized delivery schedule as well as optimized plans for tank levels and plant load. Finally, the result is transferred back to the HMI.

### 2.1.2 Anomaly detection in production plants

Another use case defined by INEOS in Cologne is the anomaly detection in one of the production plants. This plant can enter a faulty state that ultimately results in the shut-down of the production for multiple days and incur significant costs. However, the transition from the normal to the faulty state is very fast due to the special reaction kinetics and once started, it cannot be prevented anymore. Consequently, the goal is to find hints in real-time, pointing to anomalies in the production data before the faulty state has started, so that the plant personnel can react and prevent its initiation in the future. Previous attempts to identify a faulty state a priori failed.

A wide range of historical and live measurements are recorded in the process and it is assumed that it is possible to identify reasons for the transition to the faulty state by analysing this data using big data analysis methods. In the framework of the CoPro project, the data analysis experts at Divis used the historical process data and trained models with the goal to detect the anomalies before an actual transition to a faulty state. The validation of the model based on historical data showed promising results. In the actual step, the model will be validated using the live measurements on site. The model designed in a platform provided by Divis was integrated into the IT-infrastructure of INEOS in Cologne by using the CoPro Integration Framework developed by LeiKon. The resulting application uses live data from the PIMS to estimate whether a faulty state is imminent and warn the operator.

The data integration platform is configured to fetch current values for approximately 40 measurement points from the OSI PI data historian server. These values are then converted into the suitable format and passed to the Divis model, which is subsequently triggered. The output of the model is read back and stored in a database for future analysis, as well as displayed in a web-based HMI via the web interface of the integration platform. This process will be repeated periodically.
2.1.3 Solution IT architecture

At INEOS in Cologne the CoPro Integration Framework was installed within the PIMS level with connections to the Process Control Network (PCN) as well as to the Common Office Environment (COE). For the use case of optimal production scheduling of interconnected plants an interface (read/write) to the PIMS of OSI PI system as well as an interface to the existing central planning tool (DSP) was developed. For the online integration of the data driven model of DIVIS for the anomaly detection use case, all necessary plant and process data is available in the OSI Pi system. The timespan including reading the data, invoking the model calculation up to presenting the result with a user interface needs approximately 6 seconds, so that the anomaly information is within a suitable timeframe to be able to react in time to a forthcoming faulty state. The models developed by TUDO and DIVIS were embedded into the CoPro Integration Framework and connected to the external systems in real-time. The HMI tool of Sabisu will be connected to the CoPro Integration Framework by web service interfaces.

Using the CoPro Integration Framework, INEOS in Cologne has a suitable IT-Platform to realise rapid prototyping projects as well as stable and fully integrated long term model based applications for different areas (advanced process control, process prediction, advanced production scheduling, etc.).
2.2 Installations at Covestro site

Covestro (COV) is specialised in the manufacture of polymeric materials including polyurethanes, polycarbonates, coatings and specialty raw materials. Carbon monoxide (CO) is a key component for the manufacture of a large amount of the materials produced by COV. At its Dormagen site, the company relies on external providers for the delivery of CO. Some COV factories require hydrogen (H2), which is obtained as a by-product of the chlorine production via electrolysis, as well as co-produced by some of the CO suppliers. The COV factories which need CO and/or H2 are distributed along Dormagen and Leverkusen and connected through pipelines in COV-internal networks.

![Diagram of CO and H2 production and distribution network](image)

**Figure 2: Overall process flow diagram of CO and H2 production and distribution network**

2.2.1 CO and H2 production and distribution network

The costs at which COV purchases CO and H2 are set in the contracts with the suppliers, in which typically complex relationships between the cost of the CO and the amount of the purchased gas are stipulated. It is important for COV to determine the amount of CO which has to be drawn from each supplier to minimize the costs of this raw material while considering technical, contractual and environmental restrictions. The coordination of the amount of CO and H2 to be purchased from each supplier is done by production personnel of COV.

The production schedule of the plants belonging to COV as well as of plants of other companies also present at the Dormagen site, determine the overall CO demand which has to be covered by the suppliers. The CO demand can undergo significant changes not only due to variations in the production schedules, but also due to factors such as e.g. unexpected shutdowns of the plants of the consumers. This makes it necessary to calculate the optimal amounts of CO from the suppliers frequently. Within the scope of CoPro, the TUDO and COV have been developing a tool for this purpose, referred to as the Load Management System (LMS) from this point on, and which is expected to be a significant improvement with respect to the CO purchasing optimization framework currently available at COV. The core of the LMS has been developed based on the modelling language Python.
2.2.2 Solution IT architecture

In a first implementation step, the improved LMS Tool developed by the TU Dortmund and COV (see the Excel interface developed at COV in Figure 3) has been implemented. A large emphasis has been put in the user-friendliness of the interface. For this purpose, the interface allows a straightforward interaction with the user in order to consider day-to-day as well as situation-dependent decisions which must be considered during the purchase of the gases. The tool has been extended with functionalities for the automatic generation of purchase orders and population of the purchase historian to evaluate its potential for improving the workflow of the operators. It is currently strived to introduce it in production into the existing purchasing optimization workflow. Preliminary evaluations suggest that the developed tool can offer under some scenarios significant improvements regarding the costs of the purchased gases. A thorough evaluation of the cost savings obtained potentially with the tool is in progress.

![Figure 3: Excel Interface of the LMS tool developed at COV](image)

It is intended to substitute the Excel frontend with a web based HMI currently developed by Sabisu to offer an improved framework for the visualization of the results. The Excel interface developed at COV will be used as the basis for the development of the Sabisu HMI. The communication between the LMS tool will be orchestrated within the CoPro Integration Framework developed by LeiKon. The acceptance of the developed HMI prototype among the production personnel will be tested. It is proposed to enable the CoPro Integration Framework to access the relevant individual tags from OSI PI which provide the information about the actual CO and H2 amounts consumed by the customers. For this purpose, the Excel PI Add-In will be used within the Excel frontend as a first option. Another possibility is to use the CoPro Integration Framework instead. The connection of the Sabisu HMI to data from OSI PI will be defined once the HMI has achieved a ripe status.

As referenced above, the implementation of the HMI as a replacement for the Excel facet is essential to provide a user-friendly interface and to automate some of the processes. From a requirements perspective, compatibility and implementation will be reasonably straightforward, and we have two
Deliverable 6.3: Report on the installations in the plants

options to consider. Option one is slightly more conventional and is our preferred method. It consists of Sabisu providing an on-premise installation in Dormagen, which would allow users to connect via a Web App through the intranet. Once the server is prepared, Sabisu will run a site test of test tools to ensure correct connectivity. If successful with the test tools, Sabisu will proceed to install on the server. As the HMI will be set locally and won’t be connecting to any plant data, we’ve negated the need to go through the DCS firewall. Option two explores a SAP container-based solution. Whilst largely considered a more interesting avenue to traverse, far more analysis is needed to define the practicality of this approach before going forward. The decision regarding which of the two options will be used will be made depending on the feedback provided by the COV IT Department.

The HMI will connect to Covestro’s Load Management System and serve as the front-end. It will be layered, providing high level results suitable for all users. If required, more information will be available through drill-downs and other click-through methods to expose more granular levels of information – this includes both narrative and commentary, providing the user with context and amplifying information throughout the optimisation process. Drill-down functionality also ensures that the complexity of the HMI does not inhibit less advanced users from extracting the information they need, while still allowing experienced users to access the more advanced elements of the tool. The outputs of the system must be clear and concise, whilst including everything needed to convey the optimal schedule.

Furthermore, security is restricted by setting certain levels of permissions in order to control the proliferation of data. This can be achieved, for example, by tying down user accounts with Active Directory, or through Sabisu Communities through a ‘role’ based structure. The HMI will also have the capacity to generate and distribute invoices (non-compulsory forecasts), which will be stored on a server, archived and easily accessible for auditing purposes. Deployment is scheduled for early Nov to go through a period of testing and evaluation. This will run in parallel to Covestro’s current tool where results will be compared. Once integrated, iterations and enhanced functionality will continue to be implemented based on user feedback.

The HMI will be installed locally in Dormagen. It will connect to Covestro’s Load Management System and serve as the front-end for the tool. The tool will also generate non-compulsory forecasts, which can be distributed to suppliers and archived for reference. The Python code, developed by TUDO will be embedded and invoked by the CoPro Integration Framework.
2.3 Installations at Lenzing
The Lenzing site, located in Lenzing, Austria, is a reference factory around the world for producing man-made cellulose fibers. The production of high quality viscose fibers from pulp is a chemical-technological process that proceeds in multiple steps. In the resource and energy intensive viscose fiber production the recovery of the spinbath is one of the processes with the highest energy demand and is therefore a logical objective when it comes down to improving the overall energy efficiency. Although the spinbath recovery itself is a sequence of many basic procedural operations, the overall energy efficiency is mostly determined by the evaporation and the heat recovery steps. Accordingly Lenzing has focused its entire use case on the development of a semiautomatic control of the evaporator load allocation. In the following, the IT environment and the workflow for the semiautomatic control is described.

2.3.1 Evaporator load allocation
Within CoPro Lenzing developed and installed a Decision Support System (DSS) which allows a semiautomatic control of the evaporator network and at the same time improves the energy efficiency of the network. Figure 5 shows the workflow of the DSS. The Matlab optimization will automatically be triggered if certain conditions in a spinbath cycle change (e.g. a change of the overall evaporation capacity of a spinbath cycle). The results of the optimization are displayed to the operator in the PI ProcessBook interface. The operator then will check if the results are feasible and if so accept them. The new set points for every afflicted evaporator are then written automatically to the distributed control system (DCS).

![Figure 5: Workflow for the evaporator load allocation in combination with the DSS after CoPro.](image)

2.3.2 Solution IT architecture
The installation of the DSS contains an OSIsoft PI HMI, a Matlab optimization and modelling script and a custom built interface between PI and the APROL DCS used to control the evaporator network. The interface enables Lenzing to directly write results in form of load set points from the Matlab optimization to the DCS.

Figure 6 shows the OSIsoft PI HMI for the semiautomatic control of the evaporator network. The operator sets the overall evaporation capacity of a spinbath cycle (2). Due to the change of the overall evaporation capacity the Matlab optimization starts and shows the proposed change in the

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**Deliverable 6.3:**
Report on the installations in the plants
Deliverable 6.3: Report on the installations in the plants

evaporation capacity of single heat exchangers (3). The operator makes a feasibility check of the proposed parameter change and accepts or rejects them assisted by the semiautomatic control (1). Furthermore, the OSIsoft PI HMI shows if an evaporator is available for the semiautomatic control (4). An evaporator is available when the set points of the evaporators in the DCS can be written through an external program, in this case the PI.

Figure 6: OSIsoft PI HMI for the semiautomatic control of the evaporator network.

Figure 7 shows the implementation of the interface between the PI and the APROL DCS, required to write the set points from the PI to the DCS. An evaporator is available for semiautomatic control when a switch is set to external control mode. The evaporators shown in Figure 7 (left) are both in internal control mode. This means the set-points can only be set directly in the APROL DCS. An evaporator can be switched to external mode in the APROL DCS. Then the proposed and operator confirmed set points from the DSS are used as set points in the APROL DCS as indicated in Figure 7 (right).

Figure 7: Interface between PI and APROL DCS

Switch triggered by PI after feasibility check

Setpoint from DSS
2.4 Installations at Procter & Gamble
The P&G use case is about the optimization of the planning and sequence for the production of all products being produced in the plant. The P&G plant manufactures Fabric and Home Care products, serving all European countries. Given the large variety of products and brands being produced in the same plant, the planning of the production becomes very complex.

2.4.1 Daily production planning
Planning of the production has been performed in a semi-automatic way for the daily and weekly production. Figure 7 shows how the planning and production scheduling is happening in the plant before the CoPro project implementation.

Every day in the morning, the customer demands are downloaded from the SAP system into the planning tool (OMP). This planning tool takes into account the demand and the constraints of the plant (availability of equipment, operators, raw materials, packing materials, inventory levels, etc.) and as a result, it provides a daily feasible production plan. Then, the planners (operators) carry out some manual checks and modifications (last minutes orders, last minute changes, etc.) and the production plan for the day is created and uploaded in the system. The end result of these manual operations and the lack of automated iterative procedure lead to a final production plan which is not at an optimum. The objective within CoPro is to design the infrastructure, algorithms and tools capable of providing an optimum production plan and sequence, so it can be used intuitively by the plant operators and production planners.

2.4.2 Solution IT architecture
Within CoPro CERTH is developing a MILP-based sequence optimizer to optimize the production sequence using GAMS (together with the CPLEX solver to solve the optimization problems). As a short term goal, P&G has been validating off-line these MILP-based optimizers using real production data from the P&G plant. Before that though, a comprehensive piece of software has had to be developed in order to gather all the data needed for the optimizer. This piece of software, here called “optimization tool” (Figure 9 below), has been developed internally in P&G using the VB.net platform. This tool gathers together important data from different internal systems (SAP, formulation database, production historian database, production machine-events database) and uses this data to generate a file which will be the input to the MILP optimizer. This file contains the information about
Deliverable 6.3:  
Report on the installations in the plants

the production plan to be optimized, all the information about the product changeover, and all the information about the constraints (resources, line availability per product, due times, production rates, ...). This tool then launches GAMS with the script containing the MILP-based sequence optimizer. Once the sequence is optimized, an output file is generated containing the optimized sequence.

![Diagram showing the setup for short term validation of the optimizer from CERTH.](image)

As a next steps and medium term goal, P&G will integrate this optimization tool in the plant IT infrastructure, so that on-line validations can be performed at the right time, once the daily production plan is available. The important action and goal here will be to generate optimized productions sequences that can be sent to production in such a time frame (on-line) that they can already be used for the daily production, as a demonstration within the CoPro project.
2.5 Installations at Frinsa

FRINSA DEL NOROESTE (Ribeira, Spain) is the third largest canning company in Spain. The factory processes more than 500 t/day of 25 different raw materials and produces an average of 3.5 million units per day of more than 3,500 different finished products. So far, daily site production is planned for the year ahead using a central plan in SAP and Excel, then planned monthly, and rescheduled manually on a weekly and daily basis in response to product demand (different products and formats), raw material availability (at competitive prices), unpredicted downtimes, CIP and failures. Typically, more than 40 Process Orders of different products coexist along the plant, even in the same process line.

The production steps of Frinsa are as follows:

1. Unfreezing (batch)
2. Filling and sealing (discrete)
3. Sterilization (batch)
4. Packaging (discrete).

Materials have to pass through batch and discrete processes along their routes. FRINSA’s main challenge to be tackled is to optimally plan and schedule equipment operations and processes, continuous (filling and packing) and batch (cooking and sterilization) in order to minimize waiting times (downtimes, avoiding coupling and queues), reduce lead-time and plant energy consumption. Different products can coexist in different units and changeovers may happen while the previous Process Order is still running. In particular, the coordination of the operation of cookers and sterilizers is required which may include readjustments of temperature/pressure set-points for the different units. The underlying optimal control problems need to be solved on a real-time basis and must take into account quality and safety specifications.

2.5.1 Optimization of production weekly schedule

Frinsa’s overall schedule is performed in several steps:

1. Two weeks in advance, the week’s plan is done. In this step, products are just assigned to days and lines, but with no sequencing neither scheduling. This step is done in order to check workload and feasibility checks.
2. The previous week materials and raw materials are ordered. At this stage many changes can be performed due to demand changes, expected provider delays or production downtimes.
3. On each day previous to the production of a planned day of the week, sequencing and scheduling is done. At this stage the planning done two weeks before has suffered several changes and more changes could be needed, but the production orders need to be created.

The process of planning, sequencing and scheduling involves many constrains related to product attributes. Moreover, there are different changeover times for each combination of products. Some of these changeovers may take from 5 minutes to 1.5 hours, so an optimal sequencing is key for an optimal schedule. This scheduling workflow relies heavily on the expertise of the schedulers, as they have to take into account several constrains and all product attributes to calculate changeover times. In order to optimize this schedule CERTH developed a scheduler algorithm taking into account all the constraints of Frinsa’s production, collected through several data iterations, and all the possible routes that a product can follow. This schedule needs a lot of data from the ERP system, MES production KPIs and a user-friendly interface to reschedule orders. That is why the ORSOFT’s
Manufacturing Workbench was installed. This software connects to the ERP, retrieves all the needed data, executes the algorithm, outputs the results on a Gantt chart, calculates workload KPIs and allows the user to easily reschedule orders.

2.5.2 Real-time sterilization scheduling

Even though the schedule estimates the production speeds based on production KPIs, the execution may deviate from the scheduled lead times. As these changes are unpredictable and may have a big impact on overall expected finish times, a corrective approach is needed. With sterilization being the current bottleneck of the process, UVA developed an algorithm that is fed with real-time data (orders being executed on each Filling and Sealing line, expected cart time of arrival, sterilizers state and products attributes) and it optimally distributes the incoming product carts on the available sterilizers. This algorithm connects to a web services to retrieve the needed data and, after the algorithm runs successfully, it sends the results to the web service again in order to store it and display them to the sterilization manager in a web-based dashboard.

2.5.3 Solution IT architecture

Mainly, two solutions have to be integrated into the IT structure:

- CERTH’s algorithm: Fed with ERP data and production KPIs.
- UVA’s algorithm: Fed with real-time data.

ORSOFT’s manufacturing workbench connects directly to the ERP database and is able to execute and retrieve the results from the CERTH’s algorithm. In addition, ORSOFT’s software connects to the MES to retrieve the production KPIs. CERTH’s IT solution architecture is as follows:

As shown in Figure 10, ORSOFT’s software acts in this use case as a centre of data transfer. It gathers data from both data bases, formats and transforms it as needed and sends the data to the GAMS solver. This solver executes CERTH’s algorithm and lets the ORSOFT’s software retrieve the results. Lastly, it shows the results to the user, who can take action that connects to the ERP.

Regarding the UVA’s solution integration, the scheme will be as follows:
Julia, the open source solver that runs UVA’s algorithm, connects to two different web service methods: One that downloads production execution data and formats it to meet UVA’s requirements and another one that uploads the results of the algorithm to store them in the MES database. From this point the results are accessible to the web-based dashboard that the sterilization manager will check. Taking these two integration approaches into account, the overall IT installation is shown in Figure 12.
2.6 Installations at SGL Carbon

In addition to the installations at the industrial use case provider of the CoPro project, LeiKon did a feasibility study to evaluate the CoPro Integration Framework at an additional site and use case. The installation of the CoPro Integration Framework was done at the site of SGL Carbon in Bonn. SGL Carbon is a global market leader in graphite and carbon composite materials. At the site Bonn SGL Carbon operates beside others ovens for graphitization as well as mills to grind the graphitized materials.

The installation of the CoPro integration framework was done within a feasibility study at the graphite mill. The solution realized is an online monitoring application for the prediction of the product quality of the milled material.

![Schematic diagram of a graphite mill.](image)

2.6.1 Online Monitoring of grain size distribution

The grain size distribution of the milled material is an important quality characteristic of the intermediate goods. Up to now the quality of a mill charge will be checked offline by taking samples. Off-spec or inauspicious grain size distributions are detected with a significant time delay, never before the end of a charge. The duration of a charge production is typically in a timeframe of appr. 30 – 40 min. The goal of the feasibility study was to implement an online monitoring solution to predict the grain size distribution in real-time.

The aspired benefits for use case provider SGL Carbon are:

- reduction of Off-Spec
- increase of Product Quality (more high-class product batches)
- reduction of effort for quality control
- reduction of intermediate samples

The approach was to develop a neural network application, trained with historical data. This was done by the associated partner aixprocess, a SME located in Aachen, Germany who is a modelling specialist for applications in process industry.

2.6.2 Solution IT architecture

Based on the CoPro Integration Framework the trained neural network application was connected online to the existing IT systems. In addition an intuitive web based visualization was designed and implemented.
Deliverable 6.3:
Report on the installations in the plants

implemented. This is now used inside the control room to monitor the grain size distribution online. The operator can react directly to poor quality predictions by changing setpoints e.g. of the speed of the grinder or of the amount of material flow coming into the mill.

The system architecture of the implemented solution is shown in Figure 14. The neural network model was developed offline by using TensorFlow (open-source software library developed by Google). The online implementation is an On Premise Solution using the CoPro Integration Framework developed by LeiKon. The Model was embedded into a control module of the Integration Framework. Two connections were realized:

- The neural network application was connected to the Process Data Historian PHD of Honeywell. Process Data needed for the prediction of the grain size distribution will be read within a cyclic task and the model calculation will be invoked with real time data, accepting a time delay needed for the existing transfer of data from DCS to the Historian. The CoPro Integration Framework includes a webserver with services to read imported and calculated data. So the results of the prediction will be visualized in real-time for the operators in the control room by a web based HMI (see Figure 15). Up to now, the application delivers suitable results beginning appr. 10 min after starting a charge.

- The neural network application was connected to the LIMS in order to fit the model continuously. Sample results of the laboratory will be stored using a LIMS (part of the MES of GFOS). Within a second task, the CoPro Integration Framework reads the results of the LIMS and transfers the data to the neural network application. Within the neural network application a model fitting function will be used to retrain the model.
Deliverable 6.3: 
Report on the installations in the plants

The implementation within the feasibility study done by LeiKon at the SGL Carbon site of Bonn showed, that the engineering and configuration efforts to bring a model driven application into industrial use was very time efficient and the installation itself including all data communications robust in use. IT security requirements were fulfilled. The use case provider got a benefit by avoiding Off-Spec and accelerating throughput of charges.
3 Conclusion

All new approaches developed in CoPro were installed in the plants of the use case provider and in addition at one plant of an external partner within a feasibility study.

At INEOS two model based applications developed by TUDO and DIVIS were installed already for real-time use of the planner and operators. Different model development tools were involved, interfaces for different data sources were needed and additionally, a new HMI tool of Sabisu with unique HMI approaches was used. A smooth integration of this combination of heterogeneous IT systems was needed. Therefore, the CoPro integration framework developed in WP5 was implemented and successfully evaluated.

The main goal for the installations at Covestro and P&G was to evaluate the new optimization methods developed by TUDO and CERTH which has been realized in the first step. The optimization results had to be validated in order to convince the planners. Therefore a pragmatic installation using archived data and customized file transfer solutions were sufficient. To get a long term solution with more real-time requirements, a more holistic installation is needed. The usage of the CoPro integration framework is still an aspiration for the project. However, agreements with the IT departments to implement a new software framework are still needed.

At Lenzing, Matlab solutions developed by UVA and TUDO could be implemented by using a customized interface and built in features of the already installed PIMS of OSI PI to invoke Matlab functions. The PIMS was also used to build a HMI; because of this well-arranged IT system environment, all demonstrations and evaluations of the Lenzing use cases could be realized without any additional software platforms.

At the Frinsa site, a comprehensive MES provided by ASM, a long-term solution partner of Frinsa and CoPro consortium member, was employed to implement optimized scheduling solutions of UVA and CISC. In addition, a solution of partner ORSOFT was implemented for data transfer and to integrate the GAMS models of CERTH. ORSOFT provides solutions based on SAP ERP systems. Such a system is already in use for planning activities at Frinsa. The Manufacturing Workbench of ORSOFT with an available Gantt chart visualisation can be used to compare original SAP plans with optimized production plans. The platform was also chosen with the additional expectation that in future more scheduling features of ORSOFT could be used on-site.

The feasibility study at SQL carbon showed as in the INEOS use case that the CoPro integration platform is mature for productive industrial applications. The easy way to include code from a variety of model development tools and modelling languages in combination with a modular and reusable interface concept provided a smooth online integration of the model-based algorithms into the heterogeneous production oriented IT systems. In addition modern HMI concepts could be integrated by open service oriented interfaces.