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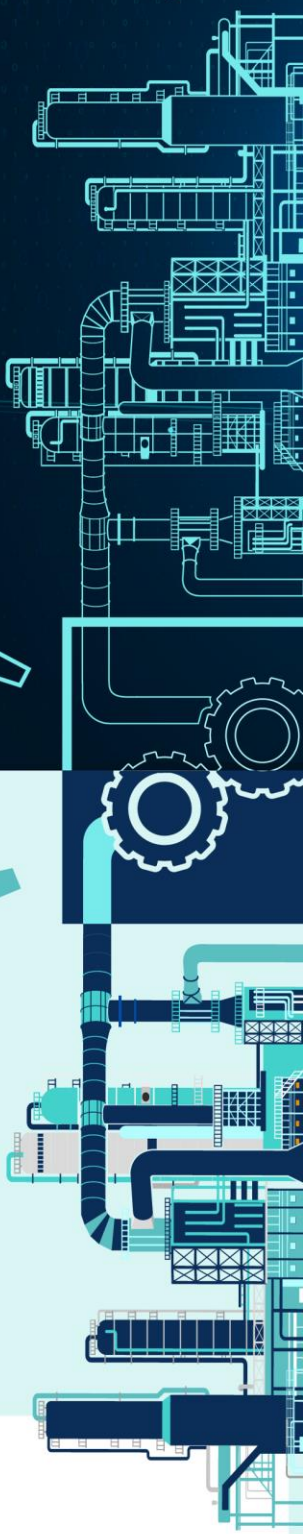
ENERGY-AWARE FACTORY ANALYTICS FOR PROCESS INDUSTRIES

Deliverable D7.5

Validation and Impact Assessment V1



Version 1.2	**Lead Partner** JEMS
Date 25/10/2023	**Project Name** FACTLOG – Energy-aware Factory Analytics for Process Industries

FACTLOG has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement Nº 869951

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Dissemination Level

	PU	Public
X	**CO**	Confidential, restricted under conditions set out in the Grant Agreement
	CI	Classified, information as referred in the Commission Decision 2001/844/EC

Disclaimer

Executive Summary

This is the first version of the FACTLOG validation and impact assessment delivery. The main plan is to use findings from D7.3 where upon identified Key Success Factors (KSFs) and proposed Key Performance Factors (KPIs) functionalities of the AI Solution are in the development stage. These AI functionalities combined into an integral product will provide improvement of the production /business process that will have positive effect on current industry challenges. As a result, process optimization should mirror better process efficiency and productivity with direct and indirect financial impact on the overall success of the company. The aim is to present a KPIs system in a way to validate the planned financial impact on AI solution users (FACTLOG pilots)[1] overall success by using results of the KPIs set as measurable values to show the effectiveness of a company's business objectives.

The document includes business framework that prescribes the procedure for determining KPI system, which are then combined with the cost- and sales price of the developed AI solution and the required rate of return on investment that customer(s) would experience if they would buy this AI solution on the market (done in combination of D8.8).

Some of the information needed for the final plan are not yet available and will be added to the next version(s) of this deliverable. Special focus will be given over the extent of the business impact to which the FACTLOG solution contributed towards more effective process re-configuration, better use of resource or reduction of waste, as well as stimulating the firms' sustainability activities in general.

This document will be regularly updated with new information, details, new potential business collaboration initiatives and with the individual exploitation plans. Content to be adapted is marked yellow.

[1] JEMS pilot did not meet its objectives, especially with regards to the integration of the FACTLOG system to its plant since there is not yet an operative plant in Slovenia.

Revision History

Revision	Date	Description	Organisation
0.1	20/09/2021	TOC prepared	JEMS
0.2	20/10/2021	First draft presented for review	JEMS
0.3	25/10/2021	Internal review comments	JSI, MAG
0.4	29/10/2021	Internal review comments addressed	JEMS
0.5	30/10/2021	Version prepared for review	JEMS
0.6	23/11/2021	Inclusion of Appendixes following the organisation of the workshops	DOMINA; All pilots
1.0	24/11/2021	Final version ready for submission	JEMS
1.2	25/10/2023	Addressing the comments from EC	MAG

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1 Introduction

Properly set system of Key Performance Indicators (KPIs) brings objectives into the foreground therefore enabling the decisionmaker to understand the performance and health of his/her business or parts of the business. Based on findings he/she can make critical adjustments in execution to achieve operational, tactic and strategic goals.

Figure 1: From vision over strategy to KPIs

Since KPIs link goals with objectives and strategies, it is important to obtain measurable values that demonstrates how effective and efficient are business, support and decision-making processes either on level of production process, department, unit or the overall company, often including also the surrounding business environment.

For the purpose of the FACTLOG project measuring a FACTLOG Solution as a toolkit applied on the FACTLOG pilot cases should confirm (or not) not only the contribution of the FACTLOG Solution in individual pilot improvements such as for example time-to-production, cost reduction, resource consumption, revenue increase, but should also assess the overall financial viewpoint on level of the individual pilot case, as well as on level of the FACTLOG project.

In the following version(s) of the deliverable, the view over financial impact in comparison with the investment estimated to be required for the FACTLOG Solution will be added with intent to “translate” it into business-wise language to indicate return on investment, payback period, total cost of operation and similar[2]

[2] Many of these indicators in combination of D7.5 and D8.8.

2 The rationale behind KPIs in FACTLOG

KPIs as measurable values show the effectiveness of a company's business objectives. KPIs increase transparency of the company performance and direct its management in prudent decision making to improve or optimize processes.

With clearly defined KPIs it is easier to give accountability to the specific team members and achieve transparency. Systems and processes to measure KPIs reinforce business intelligence to enable business development based on more informed decisions.

Connecting company's strategy with measurable operational goals gives to the decision makers an opportunity to identify gaps in direct efforts to reach the goals faster. Analyzing performance patterns over time and with an integrated overview over the company measuring day-to-day operations with KPIs help to optimize business strategies.

This document prescribes the procedure for determining KPIs, which are then, combined with the cost price, selling price and required rate of return, one of the bases for the buyer's decision on sufficient profitability to be achieved in case of purchasing an AI solution.

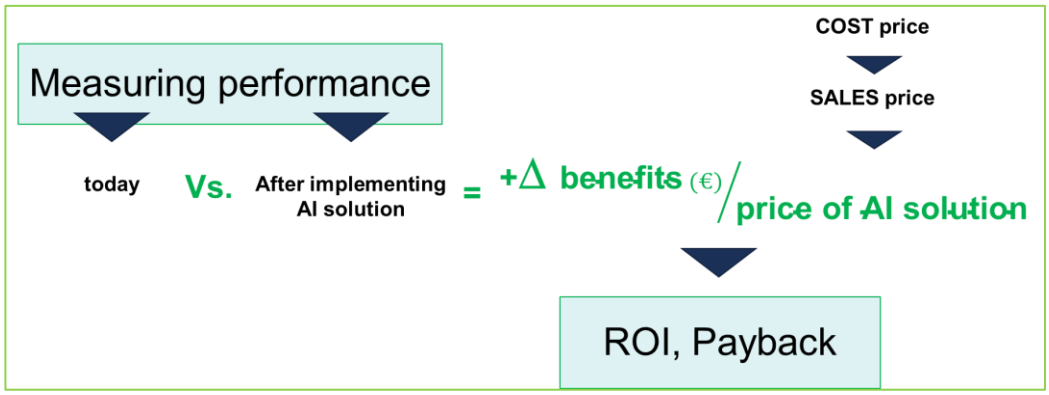


Figure 2: Benefits… Cost price… Sales price… Profitability

2.1 Connecting KPIs with business

The KPIs are essential to set for validation and impact assessment of the set KPIs system to verify if the developed AI Solution functionalities are supporting the improvement of the production /business process in FACTLOG pilot cases to the extent of planned financial impact on their successfulness in form of improved efficiency of productivity of the process.

Impact	There are several main changes in the plant setup that are expected from the project: optimisation in the main chemical process to achieve the same quality of fuel; optimisation of the energy consumption and minimisation of the CO2 production; optimisation of the number of installed sensors and actuators; automation and feed stock flexibility; decrease the operation failures from 42% to 10%; decrease the operation costs from 8 experts/plant to 2 operators/3 plants; and decrease CO_2 due to optimised process from 25% to 35% for different types of feed stock.			
KPI	Today	with FACTLOG		
		Per single machine		
		KPI measure	Financial impact p.a.	Reasoning
KPI1: Efficiency	150 litters of fuel per hour	450 litter of fuel per hour	2,3 mil €	Adjusting plant for different feedstocks
KPI2: Failures	42% of the working time	10% of the working time		Continuous 4 shift production
KPI3: Plant operators	8 per plant	2 per three plants	0,6 mil €	Advanced functionalities of AI

Figure 3: Financial impact planned by the FACTLOG process for one of the pilot cases

2.1.1 Connecting KPIs with Exploitation Strategy and Impact Creation

In addition, the presented work is also important to set **Exploitation Strategy** and evaluate **Impact Creation** when aiming for the market implementation of the developed AI Solution rounded as fully integrated marketable AI product**.** A general checklist for exploitation of the FACTLOG validated results to be used as a guidance, is:

1. perform validation and impact assessment of AI functionalities to be rounded **as it would be an integral marketable AI product**
2. prepare and execute an effective exploitation plan that reflects the **key exploitable results**
3. different types of exploitable results **(knowledge, methods, agreements, networks, technologies)** are clearly identified and controlled by the KPI system and their direct and indirect **value and impact** for different stakeholders are considered
4. **doable action plan** for exploitation **(actual use of the results after project funding)** is prepared containing goals countered with appropriate measures **(KPIs, strategic map)**
5. **describes concrete measures** to ensure that the results meet real needs, and will be taken up by potential users **(business model & business plan)**
6. describes the **roles and responsibilities** of FACTLOG partners in exploiting results or supporting results of exploitation

The input provided by activities of the FACTLOG project should form a firm basis for the KPIs validation since it:

- translate customer's strategic intent and directions into measurable goals, and
- connect the required performance resources to them and measure them.

The very basic guideline in determining the KPIs is that the KPIs should be:

- specific: to estimate or even measure improvement of the present state at the origin of the problem identified
- measurable: to have possibility to employ relevant analytics
- attainable: to assess and acquired as well as manipulate relevant data and information describing the process
- relevant: to avoid irrelevant data an information and make the system understandable for non-engineering user
- time-bound: to enable sufficient frequency of data and information acquiring

This allows that direct **(financial)** impact on the success of the company is explored. The impact is directly visible and measurable in the company’s financial statements - income statement, balance sheet and cash flows.

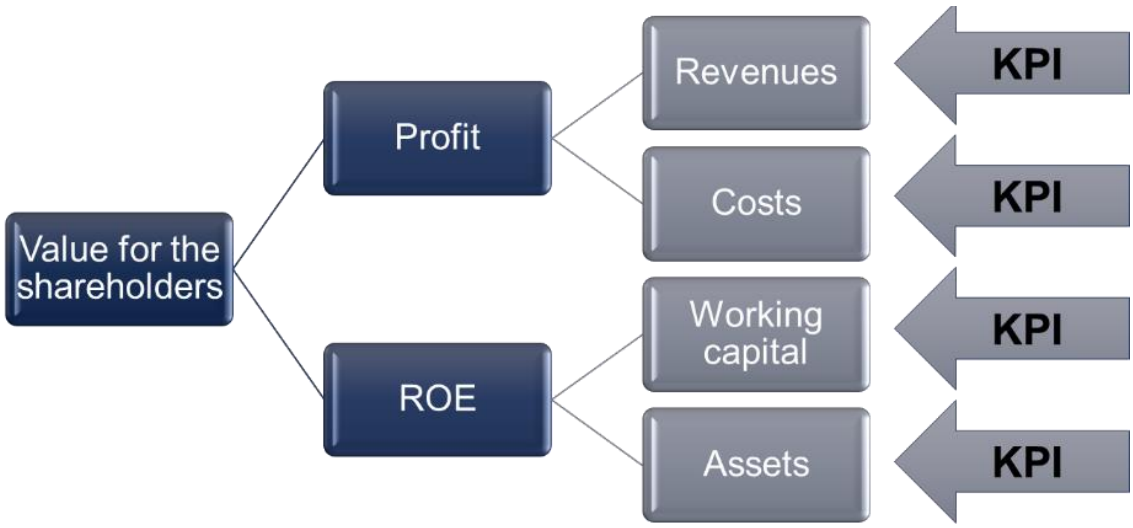


Figure 4: Measuring impact on performance

2.1.2 Connecting KPIs with Business Vision & Strategy

Defined and measure frequently KPIs from all company levels and for all business areas are connected with KPIs in a strategic map, a simple graphic that shows a logical, cause-and-effect connection between strategic objectives.

The intention is to vastly improve any strategy communication effort for goals and objective to be clearly understood on all organizational levels of the company.

KPIs and the strategic map (illustrative in Figure 5) with indicated (yellow dots) organization areas that FACTLOG Solution would have impact to be assessed at the customer side

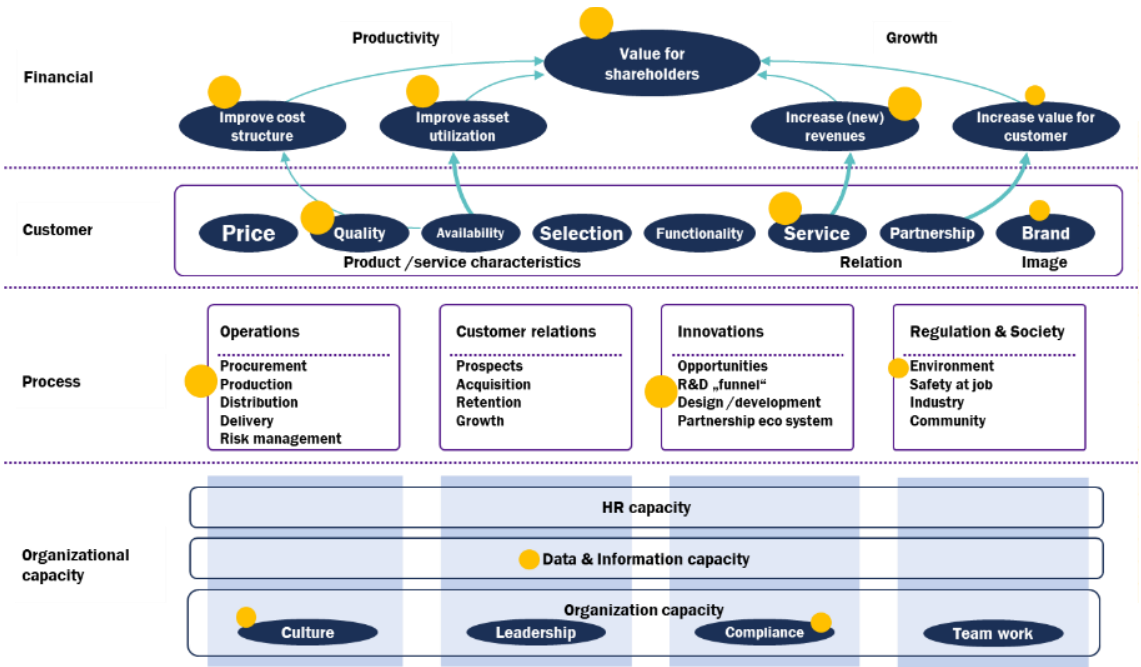


Figure 5: KPIs and the strategic map (illustrative)

3 Designing the KPIs system capable of validation

To keep focus and business common sense while preparing FACTLOG results for impact creation few questions are important to be understood when defining the performance indicators and the KPIs:

- WHAT to disseminate? PRODUCT - knowing FACTLOG product
- WHY to buy the product? BENEFITS – delivered by product functionalities
- WHO will buy it? MARKET – user profile, segmentation, potential
- HOW to sell? PLAN – business model & GO-TO market strategy

1st step in defining market success is definition of the FACTLOG product and its functionalities that would bring (financial) benefits to the customer who would buy FACTLOG Solution.

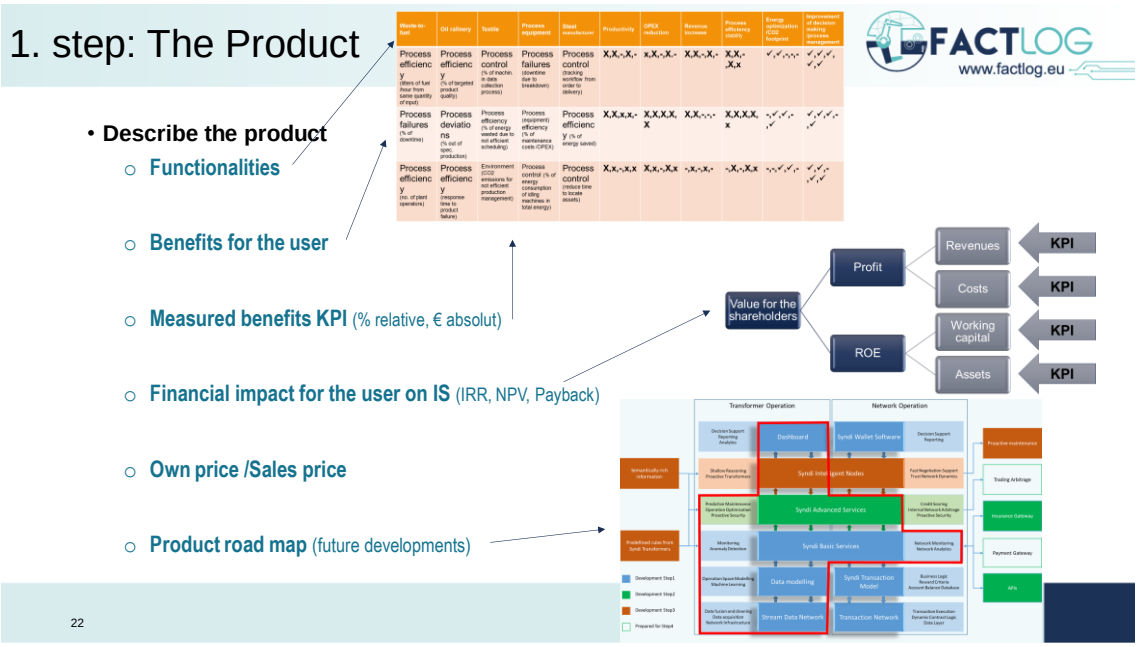


Figure 6: How to define FACTLOG product and its functionalities

The customer will buy AI solution if it **(the AI solution as a product, consisting of its functionalities)** will solve her/his challenges. For the FACTLOG, indicated challenges **(Figure 7)** are indicated on 3 levels:

1) challenges that are detected in the production /business process, that are influencing soundness of the process, and are
2) resulting in poorer either efficiency, productivity or simply managerial decisions
3) impacting overall successfulness of the company performance

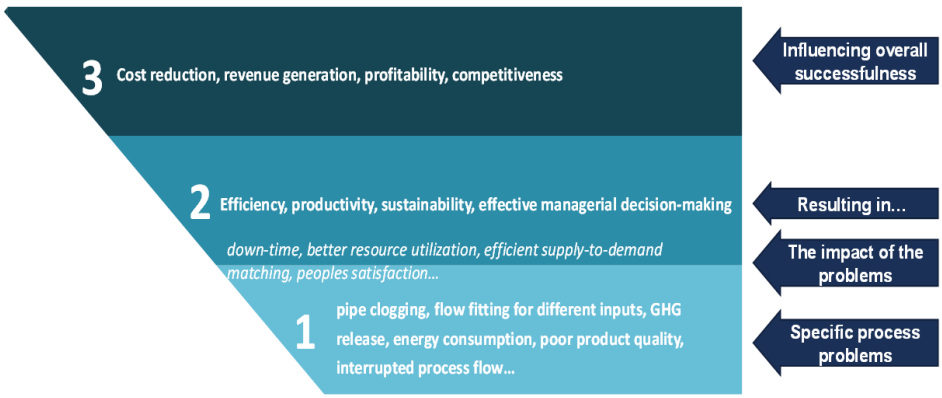


Figure 7: Three level hierarchy of problems impacting company's performance

KPIs are defined based on identified Key Success Factors **(KSF)**. KSFs are lever to be pushed in order to improve performance of the system to the extent that would result in important impact on company's overall successfulness. Therefore, to define KPIs it is necessary to identify KSFs that are relevant for the customer to run the business **(production)** process. Standard process that runs in every company in the world can be defined as shown in Figure 8.

Figure 8: Standard business process

Indetermination of the KPI, the primarily focus **(from perspective of the customer)** is on:

- product, e.g. great quality, low price, best price/performance
- production, e.g. high efficiency and productivity

Secondary focus comes from the market perspective… great product with best price/performance produced efficiently means:

- cashed market potential through sales of the product
- satisfied customer and its user experience with the product detected by UX and **(repeated)** aftersales as a result

As said, KPIs are based KSFs and are measuring key characteristics of the e.g. production process optimization. This is having direct impact on financial performance of the company. If we analyze KSFs of the FACTLOG project as identified for the purpose of exploitation strategy and impact creation **(D8.8)**, it is obvious that all KSFs relevant for the pilots are considered and mainly defined within "Customer, Product, Market" under "Convincing financial benefits of the FACTLOG Solution". The benefits of creating AI solution to improve productivity or efficiency of the production /business process brings financial benefit for those who would use the FACTLOG Solution. This is the main driver of the successful market penetration as designed under the Exploitation Strategy and Impact Creation **(D8.8)**.

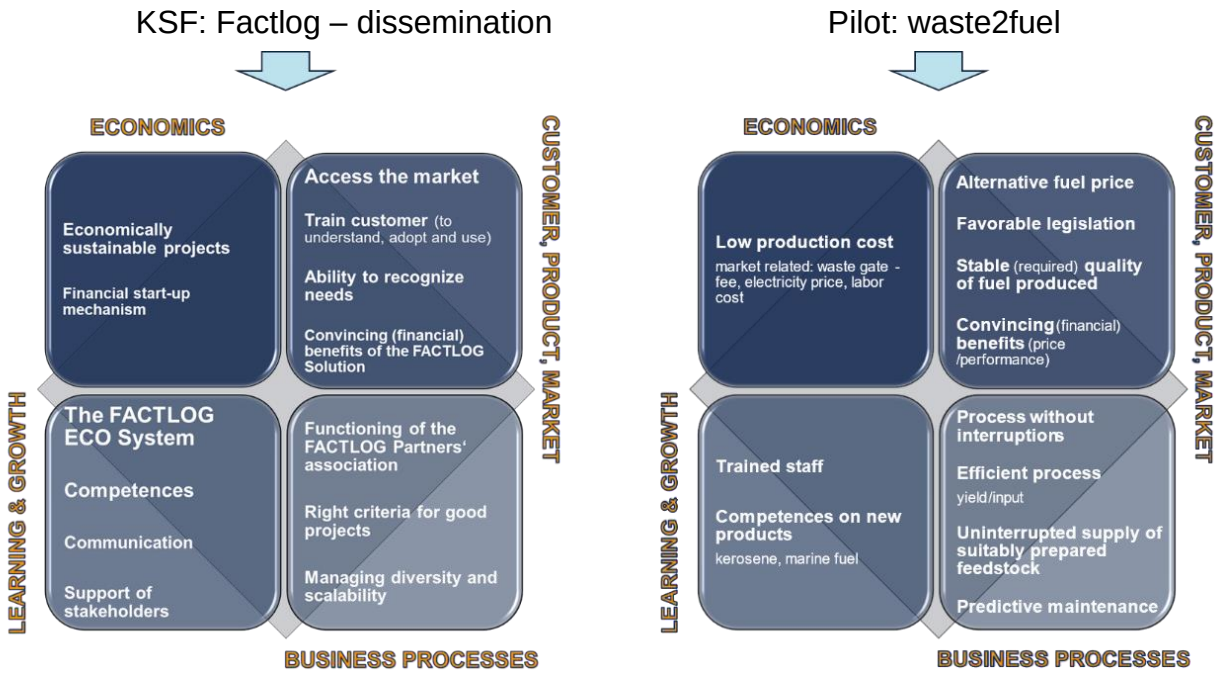


Figure 9: KSFs identified for FACTLOG exploitation strategy and impact creation (D8.8)

For the purpose of the FACTLOG each of the pilots indicated their intention to join the project by providing challenges and expectations indicated in some generic improvements. They all want to improve **(production /business)** process in order to result in overall better financial performance. The indication of relevant purpose is basically indication of future KSFs that should govern the approach of developing AI solution. Most important indicated purposes from process efficiency **(failures, deviations…)**, to its better control for each FACTLOG pilot are analyzed in Table 1.

						optimization of the** (production) **process					
	Waste-to-fuel	**Oil refinery**	**Textile**	**Process equipment**	**Steel** manufacturer	**Productivity**	**OPEX reduction**	**Revenue increase**	**Process efficiency** stability	**Energy optimization /CO2 footprint**	**Improvement of decision making /process management**
PRIORITIES	Process efficiency (litters of fuel /hour from same quantity of input)	Process efficiency (% of targeted product quality)	Process control (% of machin. in data collection process)	Process failures (downtime due to breakdown)	Process control (tracking workflow from order to delivery)	X,X,-,X,-	x,X,-,X.-	X,X,-,X,-	X,X,-,X,x	✓,✓,-,-,-	✓,✓,✓,✓,✓
	Process failures (% of downtime)	Process deviations (% out of spec. production)	Process efficiency (% of energy wasted due to not efficient scheduling)	Process (equipment) efficiency (% of maintenance costs /OPEX)	Process efficiency (% of energy saved)	X,X,x,x,-	X,X,X,X,X	X,X,-,-,-	X,X,X,X,x	-,✓,✓,-,✓	✓,✓,✓,-,✓
	Process efficiency (no. of plant operators)	Process efficiency (response time to product failure)	Environment (CO2 emissions for not efficient production management)	Process control (% of energy consumption of idling machines in total energy)	Process control (reduce time to locate assets)	X,x,-,x,x	X,x,-,X,x	-,x,-,x,-	-,X,-,X,x	-,-,✓,✓,-	✓,✓,-,✓,✓

X … high importance, x … lower importance; ✓ … mentioned; . …not mentioned;

Table 1: Indicated purpose of FACTLOG pilot to participate the project

The emphasis is on improving several aspects of the production process of the pilots: process efficiency by avoiding deviations and failures, better process control and also the aspect of preserving the environment. As a result of the AI solution to be developed, the pilots expect increase in process stability resulting in better productivity, decrease in operational costs as well as higher revenues. The impact of the last two is directly shown as an impact financial successfulness of the company.

	Process efficiency	Process control	Process failures	Environment	Productivity	OPEX reduction	Revenue increase	Process efficiency stability	Energy optimization /CO2 footprint	Improvement of decision making /process management
freq.	7	4	3	1	8,5	10,5	6	10,5	7	13
freq. & prior	14 2x3 + 3x2 + 2x1	6 2x2 + 2x1	7 1x3 + 2x2	1 1x1	17,5 3x3 + 3x2 + 2,5x1	20,5 2,5x3 + 5x2 + 3x1	14 3x3 + 2x2 + 1x1	22 3,5x3 + 4,5x2 +2,5x1	14 2x3 + 3x2 + 2x1	25 5x3 + 4x2 + 4x1
	1	3	2	4	***3***	***2***	***4***	***1***		

X-expressed by the selected KPI (power: 1)
x-expressed in problem description & measured (power (0,5)
Priority of the KPI = as listed in the application (power: 3 high, 2 moderate, 1 low)

Table 2: Ranking the KSFs according to their importance delivers priorities of KPIs.

According to the prioritized issues to be addressed by the developed functionalities of an AI solution, the importance within the FACTLOG as presented in the word-cloud.

Figure 10: Higher priority issues to be addressed by the developed AI functionalities

3.1 Contributions of the FACTLOG Pilots

To validate the KPIs system and assess the impact the following is important:

- definition of the expected product /functionalities

- qualitative (description) and quantitative (simulation) presentation of how functionalities meet the problems that were indicated by the pilot cases[3]
- confirmation of the suitability of the KSF and KPIs set in the FACTLOG project, display of KPI formulas, inventory of the architecture for the calculation of the necessary data (example in Table 3)

KPI	Today	with FACTLOG						
		Per single machine						
		Target	Reasoning	AI solution /functionality /product	Target Vs. Simulated Financial Impact p.a.	Is achievement of target endangered?	KPI confirmed as appropriate?	Recalculation of the impact needed?
KPI1: Efficiency	150 l /h	450 l /h	Adjusting plant for different feedstocks		2,3 Vs. 2,0 m€ =87%	No	Confirmed	Potentialy adjusted in V3 (2,3 → 2,1 m€)
KPI2: Failures	42% idle	10% idle	Continuous 4 shift production			No	Confirmed	No
KPI3: Plant operators	8 /plant	2 / 3plants	Advanced functionalities of AI		0,6 Vs. 0,7 m€ =117%	No	Confirmed	No
NEW KPI?								

Table 3: Estimation of the developed AI Solution functionalities

- confirmation that the developed functionalities enable the achievement of the planned financial impact announced in the FACTLOG project and (for the purposes of interim reporting) a rough estimate of how much of the predicted financial impact can already be achieved with the developed functionalities in the current phase **(expressed in%)**

and further elaboration will be done in D7.6:

- validation and financial impact assessment for the pilots and integration on level of FACTLOG starting by evaluating the appropriateness of the KPI used for the overall FACTLOG AI Solution as an integral product
- measuring and verifying the reduction in measurable KPIs brought about by the use of the FACTLOG toolkit to set the KPIs system
- calculating resulting resource reductions will be translated into return on investment, hence allowing their assessment them from a financial viewpoint
- if necessary – AI solution modification
- reporting on evaluation of the system effectiveness and its impact on business operation also in connection of Exploitation Strategy and Impact Creation

3.1.1 Procedure to obtain sufficient basis to set up KPIs system

Steps to be taken for each pilot case are:

- defining or confirming already defined KSFs
- defining /confirming KPIs
- defining the product: developed functionalities for each Pilot[4]

[3] JEMS pilot did not meet its objectives, especially with regards to the integration of the FACTLOG system to its plant since there is not yet an operative plant in Slovenia.

[4] JEMS pilot did not meet its objectives, especially with regards to the integration of the FACTLOG system to its plant since there is not yet an operative plant in Slovenia.

- confirming that functionality development is targeting Impact as planned

3.1.1.1 Defining or confirming already defined KSFs

- for each Pilot KSFs are mapped **(Figure 11)**
- connecting KSFs with prioritized issues to be addressed by the developed functionalities of an AI solution **(Figure 12)**

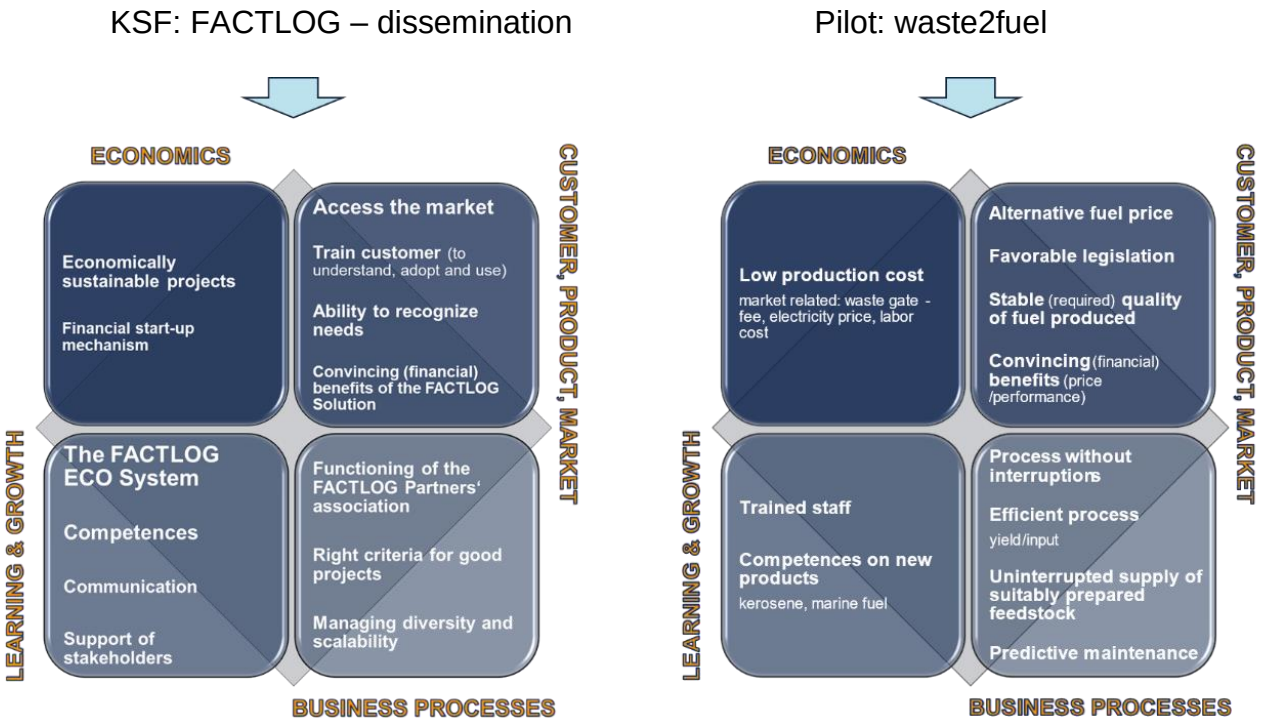


Figure 11: Mapping the KSFs

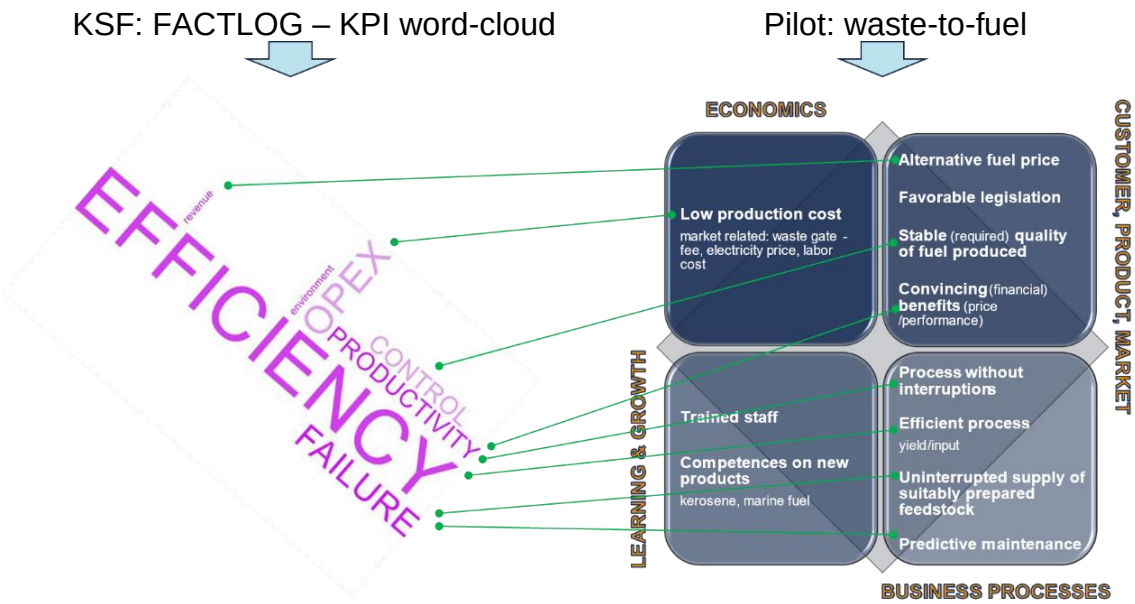


Figure 12: Connecting KSFs with prioritized issues

3.1.1.2 Defining /confirming KPIs

- checking existing KPIs as submitted in the FACTLOG project proposal
- supplementing, adding and confirming KPIs to be used
- KPI record in the form of a formula **(Figure 13)**
- describe how the KPIs are **(to be)** measured in the real-environment **(Figure 14)**

Impact	There are several main changes in the plant setup that are expected from the project: optimisation in the main chemical process to achieve the same quality of fuel; optimisation of the energy consumption and minimisation of the CO2 production; optimisation of the number of installed sensors and actuators; automation and feed stock flexibility; decrease the operation failures from 42% to 10%; decrease the operation costs from 8 experts/plant to 2 operators/3 plants; and decrease CO_2 due to optimised process from 25% to 35% for different types of feed stock.			
KPI	Today	with FACTLOG		
		Per single machine		
		KPI measure	Financial impact p.a.	Reasoning
KPI1: Efficiency	450 litters of fuel per hour	450 litter of fuel per hour	2,3 mil €	Adjusting plant for different feedstocks
KPI2: Failures	42% of the working time	10% of the working time		Continuous 4 shift production
KPI3: Plant operators	8 per plant	2 per three plants	0,6 mil €	Advanced functionalities of AI

KPI definition:

$$KPI1 = \frac{output\ (litters\ of\ fuel)}{time\ (hour)}$$

$$KPI2 = \frac{time\ idle\ (hours)}{nr.\ of\ shifts\ x\ 8\ x\ days\ á\ week\ (hours)*}$$

$$KPI3 = \frac{nr.\ of\ direct\ labor\ (FTE)}{nr.\ of\ plants\ capable\ to\ be\ operated\ (number\ of\ devices)}$$

KPI calculation frequency:

continuous

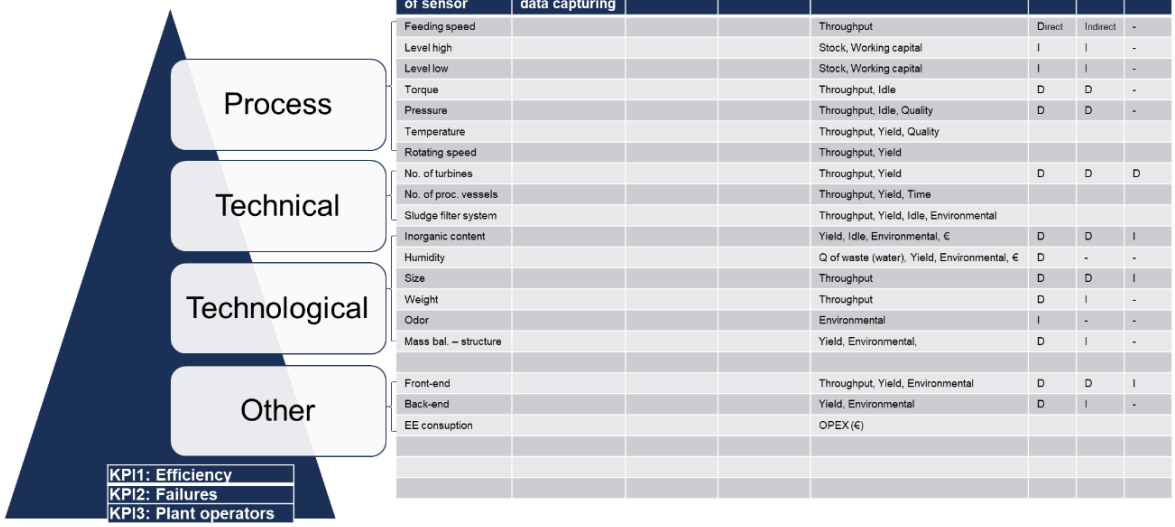
day /week /month**

#count

*3 shifts = 3 x 8 x 5 = 120 hours á week
4 shifts = 24/7 = 120 + Sat & Sun = 168 hours á week

**acc. to Q-management plan

Figure 13: Confirmation of KPIs and their record in the form of a formula



Source /type of sensor	Frequency of data capturing	Extra 1	Extra 2	Pis	KPI1	KPI2	KPI3
Feeding speed				Throughput	Direct	Indirect	-
Level high				Stock, Working capital	I	I	-
Level low				Stock, Working capital	I	I	-
Torque				Throughput, Idle	D	D	-
Pressure				Throughput, Idle, Quality	D	D	-
Temperature				Throughput, Yield, Quality			
Rotating speed				Throughput, Yield			
No. of turbines				Throughput, Yield	D	D	D
No. of proc. vessels				Throughput, Yield, Time			
Sludge filter system				Throughput, Yield, Idle, Environmental			
Inorganic content				Yield, Idle, Environmental, €	D	D	I
Humidity				Q of waste (water), Yield, Environmental, €	D	-	-
Size				Throughput	D	D	I
Weight				Throughput	D	I	-
Odor				Environmental	I	-	-
Mass bal. – structure				Yield, Environmental,	D	I	-
Front-end				Throughput, Yield, Environmental	D	D	I
Back-end				Yield, Environmental	D	I	-
EE consuption				OPEX (€)			

Figure 14: Sensors for measuring data to construct KPIs

3.1.1.3 Defining the product: developed functionalities for each Pilot

- definition of the KPIs and identification of the value creation and its impact starts with good knowledge of the **product characteristics** and **product functionalities** and what **benefits** these functionalities bring to the customer who will buy FACTLOG Solution. Equal understanding of these by both, the technical partner that developed the AI

Solution **(or part of its functionalities)** is vital for further elaboration on how to measure the KPIs

- setting general architecture of the AI solution that would be provided to the Pilot **(Figure 15 for the waste2fuel pilot – different approaches for different industries represented by the pilot cases could be taken)**

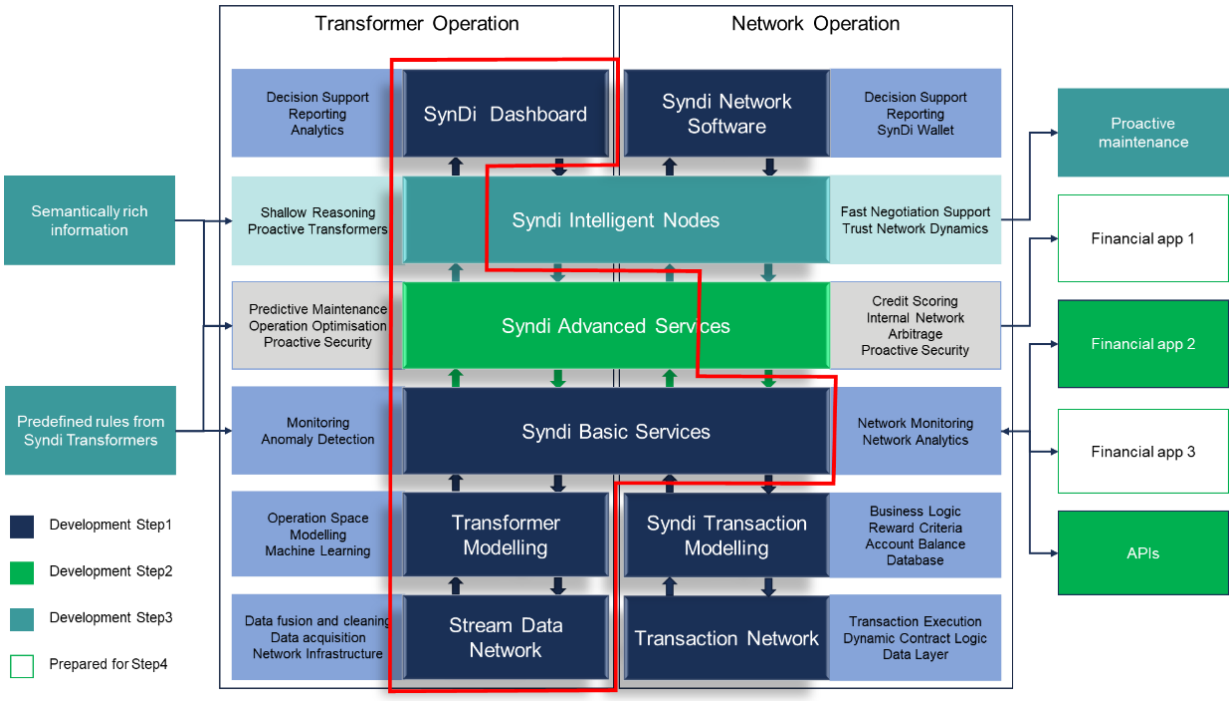


Figure 15: General architecture

- if appropriate, divide the general structure in several packages: basic that will be developed within the FACTLOG project and those that are planned to be developed latter to round-up the individual AI solution functionalities as an integral product **(Figure 16 for the waste2fuel pilot)**
- FACTLOG solution functionalities and products to be developed are mapped **(Table 4)**

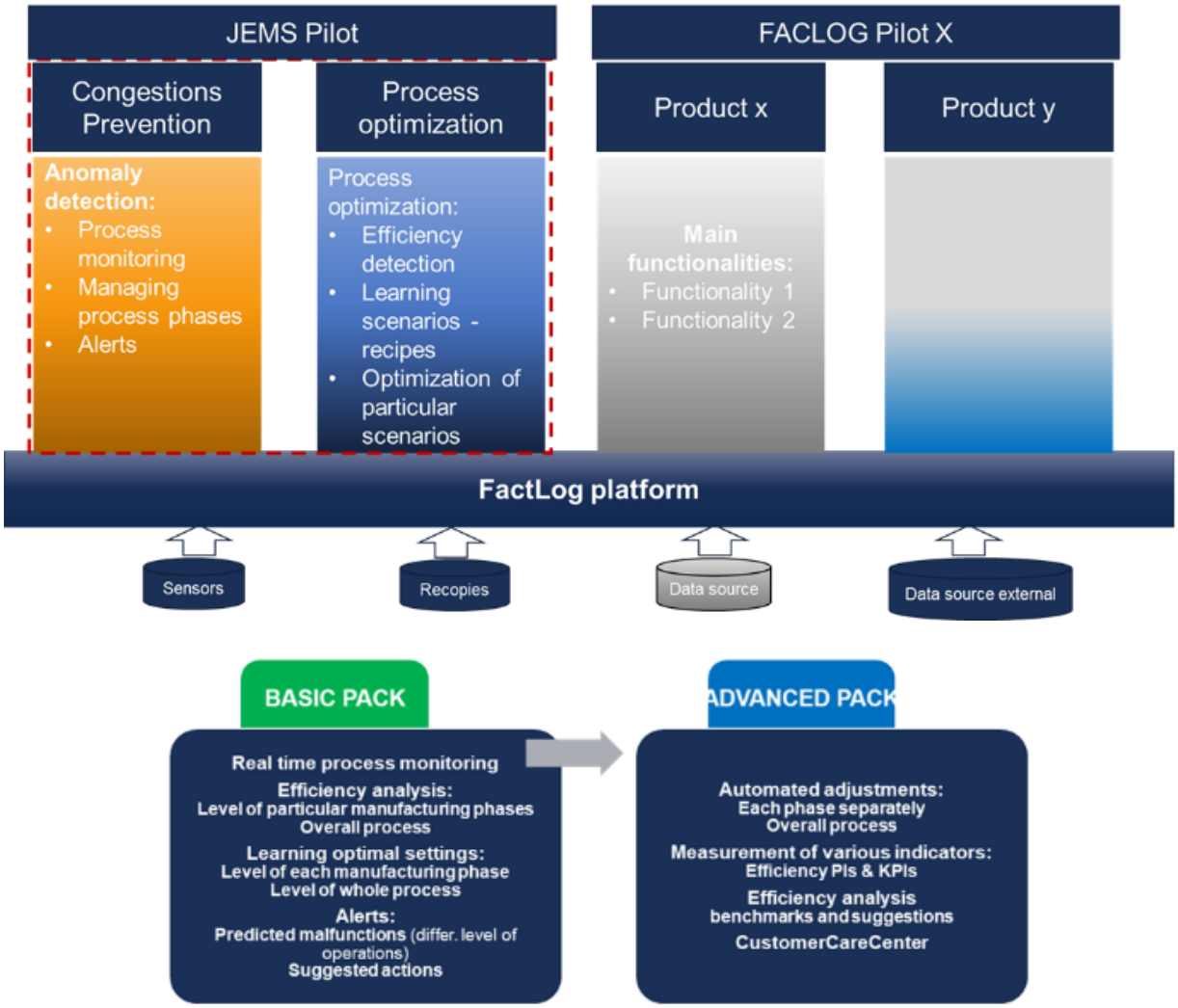


Figure 16: The solution can be divided into product packages

				Main KPI								Product							
												Basic Pack				Advanced Pack			
Asset	Sub-asset (if part of group)	Description of functionality	Owner	KPI1	KPI2	KPI3	KPI4	KPI5	KPI6	KPI7	KPIX	Product1	Product2	Product3	Product4	Product5	Product6	Product7	Productx
Analytics For Cognition																			
	Variation Detection	Detecting and agregating outliers (variations) in a multivariate dataset. Aggregation can be done on different semantic levels. It contains set of methods applicable in different cases. Two main groups: statistical methods (like MEWMA) and machine learning (mainly clustering). It includes also the calcultion of the root-cause	NISSA	X		X						X	X				X		
	Model Discovery	Creation of the models of the usual/normal and unusual behaviour from past data. It includes cases of unknown unknowns when the data is not available for the behaviour to be modeled (like tool wearing). It is realized as a complex processing pipeline. It can be combined with the variations and anomalies detected in other components	NISSA		X	X						X							
	Situation Analyzer	Real-time data analysis and detection of the situations of interests, based on data-driven models and CEP patterns. It includes aslo the prediction of the predefined situations	NISSA			X	X							X			X	X	
Data-driven methods and tools for cognition																			
	Anomaly Detection	Anomaly detection is the simple component that works on top of sensor streams. It can detect unusual values or movement of values in the MES streams.	Qlector																
	Prediction	Data driven models, that can predict certain values that are measured (sensors ali virtual sensors).	Qlector																
	Simulation	Monte Carlo simulations based on ERP and MES and people data. Simulations can evaluate work orders time tables, efficiency of certaion teams on particular tasks, etc.	Qlector																
	Insights	Based on simulations, insights descibe pains and potential actions to improve the situations. For example, "due to probable requirement of triple tool change within an hour on Monday, you need to employ 3 persons that are capable of performing tool change".	Qlector																
	StreamStory	Streamstory is a component for advanced exploration analysis. It converts a multitudie of datastreams into the state-graph, where each typical state of sensors is represented by a typical state. Streamstory identifies all the states (even anomalous ones). Each state can be described and interpreted. Streamstory can analyze trensition through these states and can build a transition model (prediction in which state the model will be in a while).	JSI																
	Stream Classification	A machine learning model that predicts a label from the sensor stream data. For example, is there an upcoming malfunction in the next hour (YES/NO). Needs a set of labeled historic data to learn.	JSI																
	Generative models	A machine learning model that predicts the output values of a processing unit from the input values or the system values in the next state from the current. The main difference from the classification models above is that the generative models can be used for simulation of the system.	JSI																
Robust optimization engine		Generic engine which can get different optimization algorithms/models and execute them in different pilot configurations	MAG/AUEB																
Pilot-specific Optimization models/algorithms																			
	BRC Model	Optimization Module (Template) that provides a production schedule for the BRC shopfloor based on a Mixed Integer Programming Model and which takes into account Orders, Machines, Processes (currently) and cranes, maintenance (potentially future)	AUEB/UNIPI																
	TUPRAS Model	Optimization Module (Template) that provides a set of settings for the different process units for TUP to drive on-specs recovery of LPG	AUEB/UNIPI																
	Piacenza Model	Optimization Module (Template) that provides a production schedule for the Weaving Stage of PIA pilot, based on a Mixed Integer Programming Model, while taking into account Orders, Machines, Processes, Workers, Setup Times	AUEB/UNIPI																
Knowledge Graph		knowledge graph (KG) model is used to define the pilot use case and process model concepts based on one unified ontology. Factlog platforms and tools can exchange the information through the knowledge graph models.	EPFL																
Cleansing		A unified framework for detecting and removing errors and inconsistencies from data in order to improve the quality of data.	MAG																
Persistance layer		It will offer the persistence services required by all FactLog components	MAG																
Message & Service Bus		It will facilitate all interactions among FactLog modules, as well as between FactLog and manufacturing entities	MAG																
Data Adapters		A unified solution for accessing information provided by heterogenuous systems under a common transactional interface	Pilot-specific results																

Table 4: FACTLOG solution functionalities & products to be developed are identified[5]

[5] Example. For details, please see D8.8. Form and content are subjected to changes.

3.1.1.4 Confirming that functionality development is targeting Impact as planned

- Based on the customer's expectation and functionalities to be developed within FACTLOG toolkit, in case of sufficient impact of the AI functionalities, the product will be defined also by:
    - evaluation which AI Solution or its functionality supports /solves /explains the selected KPI
    - comparison of the target **(as planed)** Vs. simulated /real outcome.
        - does the designed solution explain the troubleshooting / improve the process to the extent as intended with the KPI defined in the FACTLOG project proposal?
        - comparison with the target financial Impact p.a. stands as planned by the FACTLOG project?
        - state is the achievement of the targeted impact is endangered: NO / YES / Why? **(This is subject for an interim check before next report)**
    - confirmation of the selected KPIs
        - pilots will advise potential new KPIs – if appropriate
    - foreseeing the potential risk if recalculation of the financial impact would be needed during the V2 phase of the project or is the understated financial impact just mirroring the present development stage of the functionalities

3.1.2 Evaluation of aggregated (financial) impact

- combining financial impact assessed by the use of the KPIs, the evaluation of aggregated **(financial)** impact of the individual pilot cases / FACTLOG project is planned to be presented
- in combination with the results presented in the D8.8, especially the cost price of the developed AI solution, cost price + selected margin of the developed AI solution **(regarding one of the two suggested pricing models)**, the:
    - returns: ROI & ROE **(with average expected debt-to-equity structure of financing the Ai solution)**
    - Payback period based on cash-flows arising from financial benefits obtained by use of the AI solution, and
    - **(Optionally, if WACC[6] as a cashflow discount factor will be disclosed by each of the pilot cases)** the Net Present Value **(NPV)**

  will be calculated /estimated.

Positive values of returns above required return on investment will prove that investment into AI solution as developed within the FACTLOG project is justified **(or not)**. A rough, draft cost-price based preliminary estimation done in this stage reveals that the financial benefits expected are promising and should justified the FACTLOG project **(Figure 17, in this stage to be combined with planned benefits forecasted in the FACTLOG project)**.

[6] Weighted cost of capital

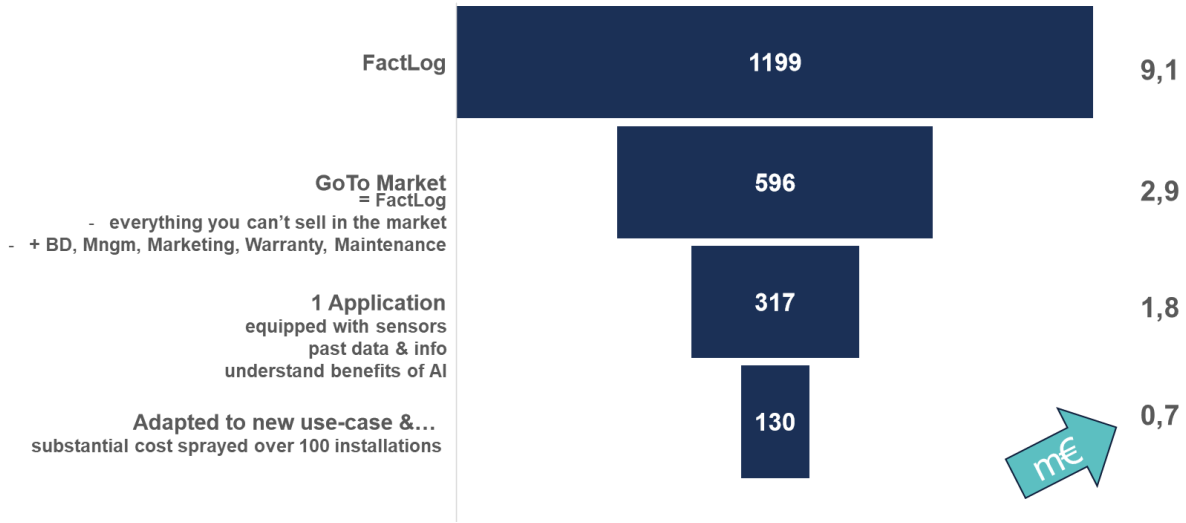


Figure 17: Cost-price based preliminary estimation for comparison with financial benefits

This should also confirm one of the basic missions of EU Horizon projects, that is investments into project development, where a subsequent, post-project commercial approach of selling AI solutions, for many (and not only for the industries represented by FACTLOG pilot cases), allows EU companies to access top AI solutions at a competitive and above all affordable prices. This not only strengthens the EU's development potential and the technological development of EU companies, but also strengthens the competitiveness of the EU economy compared to the economies of the US, China, Russia and others.

Conclusions

The FACTLOG project requires validation and impact assessment delivery. Upon the identified Key Success Factors and proposed Key Performance Factors functionalities, the estimations or even calculations of the KPIs will provide inside view on the improvement of the production /business process enabled by the FACTLOG solution with its functionalities that will have positive effect. As a result, process optimization should mirror better process efficiency and productivity.

In this stage of the project development the aim is to set-up a KPIs system in a way to validate the planned financial impact on AI solution users (the pilots) overall success by using results of the KPIs set.

The document includes business framework that prescribes directs the project solution developers and pilots as users to recognize, estimate or even measure (calculate) the effects of the developed AI solution. The document offers the procedure for determining KPI system, which are then combined with the cost- and sales price of the developed AI solution and the required rate of return on investment that customer(s) would experience if they would buy this AI solution on the market (done in combination of delivery D8.8).

At this stage the project is still developing the AI functionalities to be integrated into FACTLOG AI solution either on level of individual pilot or on level of the project. At the moment it is therefore not possible to present the calculations. The first next step would be comparing the assumed positive effects of the functionalities under development with the project-planned one. Since information needed for the final plan are not yet available and will be added to the next version(s) of this deliverable.

Special focus will be given over the extent of the business impact to which the FACTLOG Solution contributed towards more effective process re-configuration, better use of resource or reduction of waste, as well as stimulating the firms' sustainability activities in general. This will offer the decision makers to decide upon whereas the proposed solution according to the estimated /measured effect are economically viable to be implemented in real- on-line production environment.

Appendix I – Results of FACTLOG intermediate workshops

This appendix reports the results of the first cycle of pilots performed within FACTLOG project. These results refer to the methodology and scope defined in D7.3. The findings of this cycle of workshop will be used to perform improvements in the FACTLOG platform and services, both in terms of features and User Interface aspects.

This annex is structures “per-pilot”, to provide an overview of the results in each industrial context where FACTLOG is deployed.

Waste-to-Fuel Transformer Plants: JEMS pilot

The results collected for JEMS pilot are summarized in this chapter by reporting the average score of the participants’ answers to the questionnaire.

Summary of workshop results

System Usability (System Usability Scale)

ID	Question	Strongly Disagree				Strongly Agree
		1	2	3	4	5
1	I think that I would like to use this system frequently.					✓
2	I found the system unnecessarily complex.	✓				
3	I thought the system was easy to use.			✓		
4	I think that I would need the support of a technical person to be able to use this system.		✓			
5	I found the various functions in this system were well integrated.					✓
6	I thought there was too much inconsistency in this system.		✓			

7	I would imagine that most people would learn to use this system very quickly.					✓
8	I found the system very cumbersome to use.	✓				
9	I felt very confident using the system.					✓
10	I needed to learn a lot of things before I could get going with this system.		✓			
How to score		https://www.usability.gov/how-to-and-tools/methods/system-usability-scale.html				

Perceived usefulness of the Features

Rate how much the features would be useful for your work						
ID	**System Application**	**Not at all**				**Significantly**
		1	**2**	**3**	**4**	**5**
1	Feature 1				✓	
2	Feature 2		✓			
3	Feature 3					✓
4	Feature 4		✓			
5	Feature 5					✓
How to score		5-points Likert Scale (1=-2; 2=-1; 3=0; 4=+1; 5=+2)				

Expected improvements for the second cycle

JEMS pilot did not meet its objectives, especially with regards to the integration of the FACTLOG system to its plant since there is not yet an operative plant in Slovenia. Hence, they will not be involved in the second wave of pilot operations.

User acceptance of the FACTLOG system (Van der Laan questionnaire)

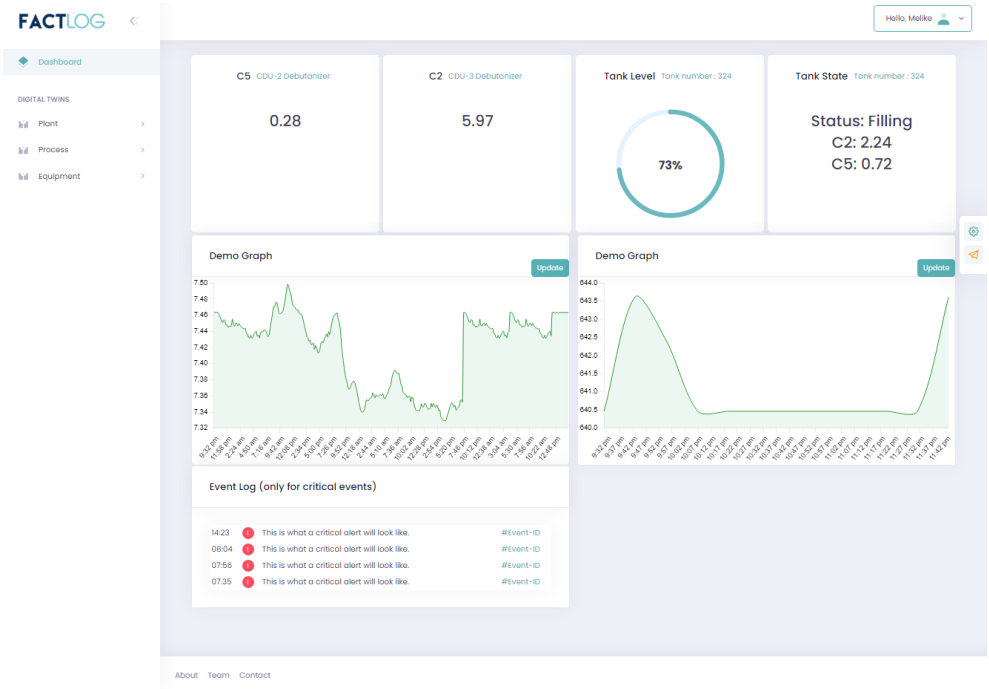
I found the system:						
Useful	✓					Useless
Pleasant		✓				Unpleasant
Bad					✓	Good
Nice		✓				Annoying
Effective	✓					Superfluous
Irritating					✓	Likeable
Assisting	✓					Worthless
Undesirable					✓	Desirable
Raising Alertness	✓					Sleep inducing
How to score			5-points Likert Scale (1=-2; 2=-1; 3=0; 4=+1; 5=+2) Acceptability Threshold = 0 https://www.hfes-europe.org/accept/accept.htm			

Oil Refineries: TUPRAS pilot

Summary of workshop results

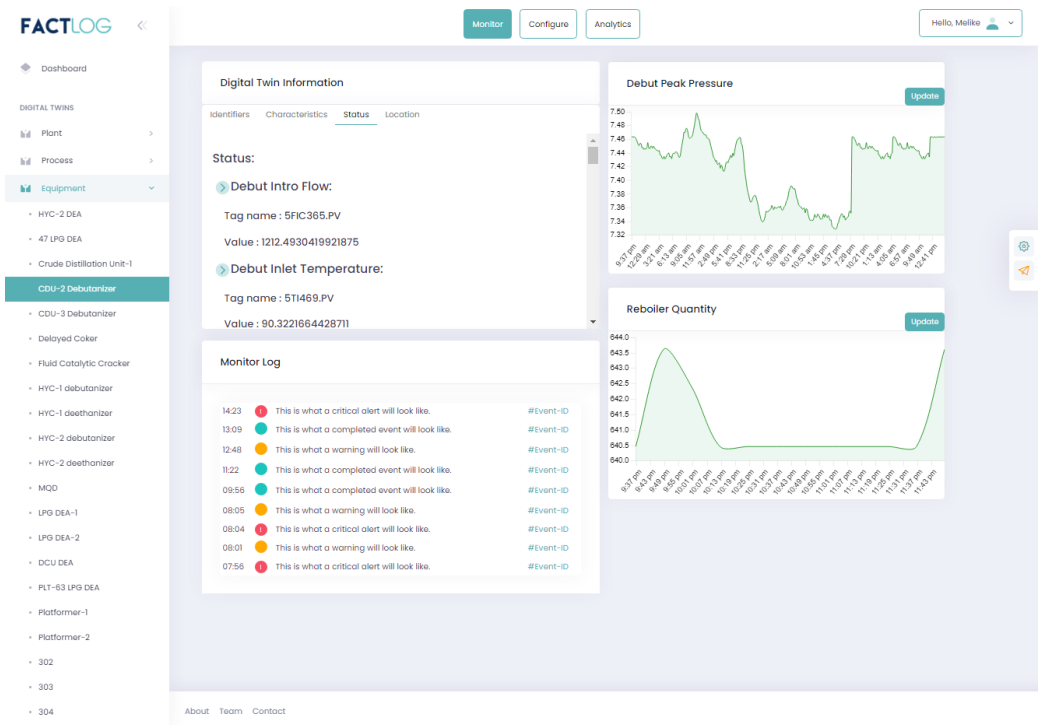
The pilot workshop was arranged with the attendance of the pilot owner, Maggioli and the main technical partners supporting the pilot on the 25th of September. Some experts on human-machine interface and end-user from the TUPRAS side participated to the meeting. Opinions and needs regarding the current version of the FACTLOG platform were expressed. The workshop agenda, which was previously shared with the participants, and a questionnaire were shared with the related participants.

General comments about the platform were very positive and sympathetic. The attendees find personalized layout idea for the dashboard page beneficial. They attach a small comment to this idea. There may be a home page with information that everyone monitors and utilize, and an additional adjustable dashboard (Figure 1). Except for the instrument panel layout, the participants stated that it would be better to show the process flow chart of LPG production lines instead of the digital twin relationship graph. Flow charts are widely used in the refinery process, so it will be easier for users to follow this diagram.



Instead of seeing the full tank volume and the current amount of C5 and C2 in the tank, users want to monitor the filled tank in time series. Also, for the void volume inside the tank C5 and C2 the forecast horizon for the final product will be good for the end user. Moreover, the most relevant parameter for off spec production of any type needs to be specified to determine the origin of the abnormality.

With root cause analysis, they want to find off-spec indicators and for this they want to look at which parameters affect them one by one. For instance, they want to see what are the main parameters affecting C5. The equipment section was found very useful for all types of users, as one could easily see the complete list of LPG production units and final storage tanks.
After the user selects one of the equipment, the monitoring, configuration and analysis sections are available. One final comment, the design may vary as the navigation in these three sections is not user-friendly and the buttons are hard to find. Also, the forecast results shown in the analytics section can be exported to the monitoring section, the additional section for analytics makes the platform more complex. The defined platform snapshot can be seen in the figure below.



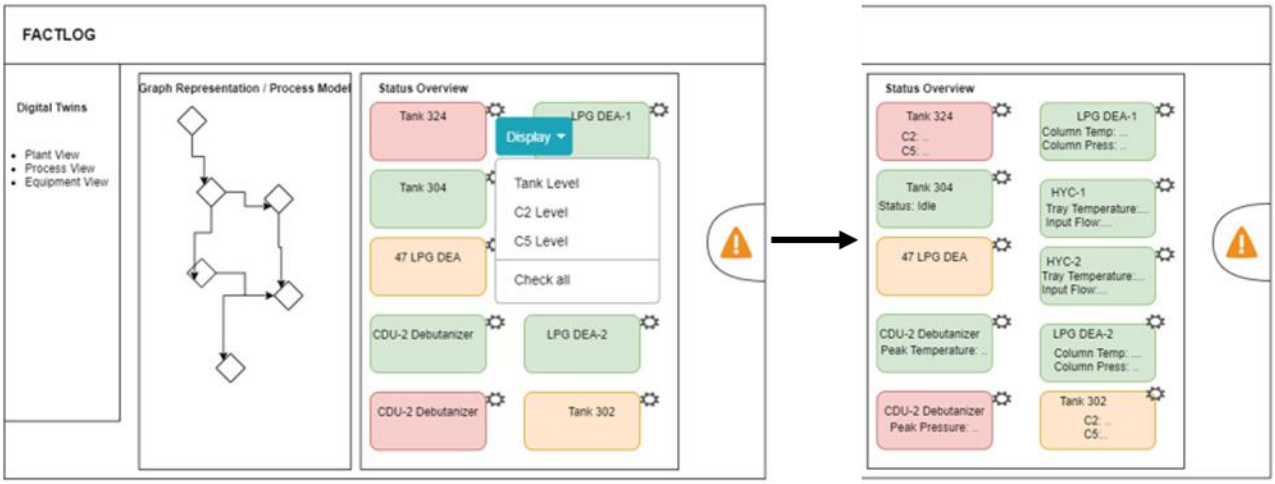
A small comment about navigating the left pane is that the equipment can be grouped into some headings i.e., there are three crude distillation units and if we group them together it will be easier to find similar processes and navigate between them.

Expected improvements for the second cycle

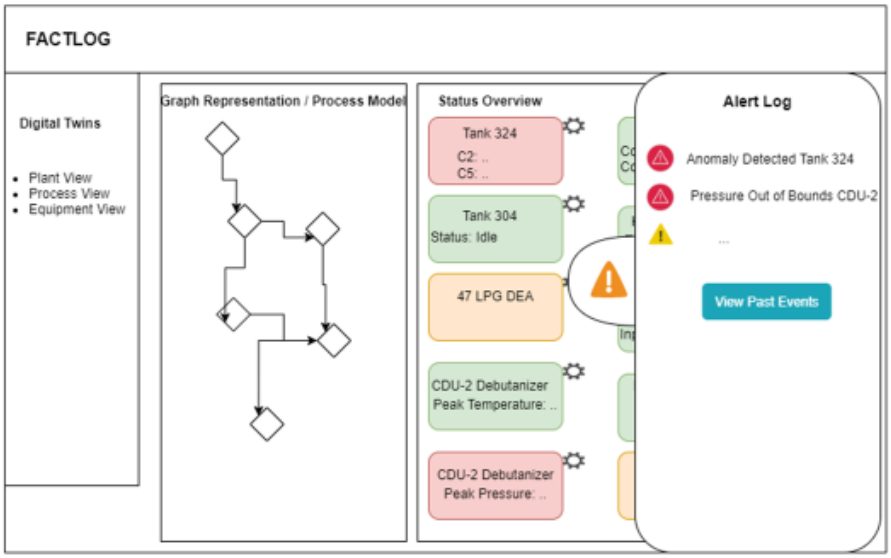
The platform's current version that created for the TUPRAS users' needs some improvements. Some of these improvements are planned and some of them were shaped based on the workshop.

The homepage design is unpractical for the end users since there is no process health check diagram available and the shown KPI's are not enough for process monitoring. Customizing the homepage is necessary for different types of users because each process engineer is responsible for different units in the refinery. The process engineer wants to follow up his own unit. Therefore, it is not necessary to monitor the entire LPG production system for all users. It would be more beneficial to monitor the LPG production flow of process engineer's own unit.

Status overview modification needed since there are so many KPI's effect the LPG quality and color representation is needed to see the faulty units or tanks. Current version only shows the selected unit's instant impurity values for a specific unit and tank status with volume percentage. For easier usage of the platform the status overview part is planned, the related KPI card can be personalized to show the necessary indicators.



The exclamation point is showing the event log and by click, it will expand and the alert log will listed to follow the past events. The extendible menu for the event log will be better since the process and its KPI's are so many to be in same page with these logs to monitor by the user.



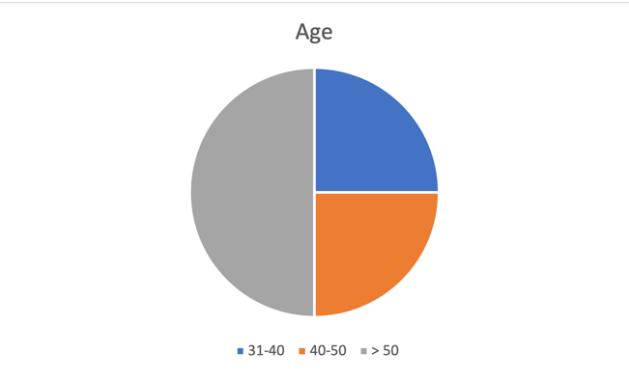
In order to pace up the developments in terms of the user interface biweekly meetings were set with paticipitation of both techincal partners and end users.

Textile Industry: PIA pilot

Summary of workshop results

The first iteration of the workshop to evaluate PIA case has been held on September the 28th. As for the other pilot cases, the main scope of this iteration was to collect a first set of feedbacks regarding the implementation of the FACTLOG platform, with specific focus on the features enabled by the platform and first considerations regarding its usability and acceptability.

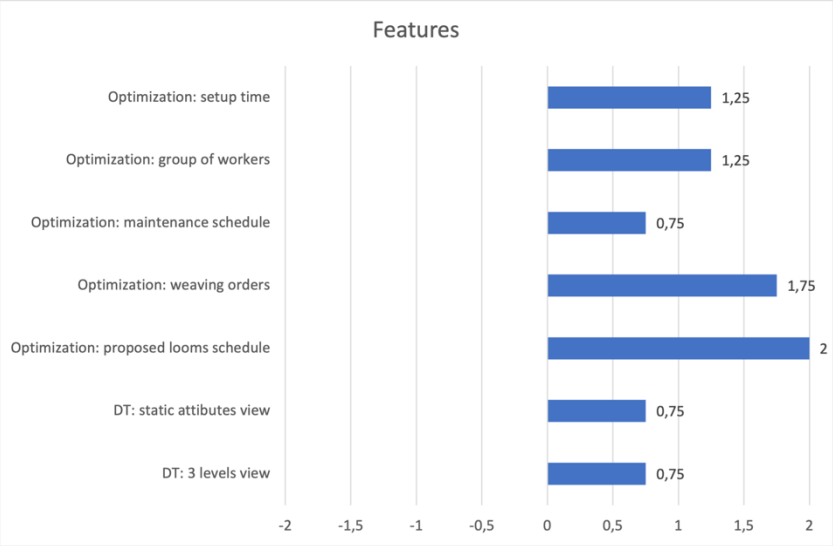
The workshop has been conducted as a remote meeting; 4 participants from the end-user (2 Project Managers + 2 IT Professionals) have been involved in the evaluation; additionally, all technical partners involved in the pilot participated to the workshop, to provide explanations on their enabling technologies, and to facilitate the discussion and the emergence of additional solutions.



The main features implemented in the first cycle of FACTLOG platform for PIA case were related to the Optimization module. As already introduced in D7.1 and D7.3, the pilot case is focusing on the weaving process, so the main feature tested in this iteration was related to the proposed schedule of the looms in the weaving department. Additionally, other optimization features (e.g., the maintenance schedule and the setup time) have been tested, together with the overall digital twin solutions at plant, process, and machine (i.e., loom) level. Additional details on the pilot implementation and the evaluation methodology are reported in D7.3.

Regarding the analysis of the features, they were in general well understood and perceived by the users. In particular, the optimization process enabled by FACTLOG has been considered as a significant added value to be exploited in the real industrial case, able to provide a tangible benefit from an end-user perspective. The most rated feature was the optimization of the proposed loom schedule (+2,00; on a -2 / +2 Likert scoring scale). The other feature considered as crucial, among those already implemented in this first iteration, was the optimization of the weaving orders (+1,75). It is important to highlight that all the features obtained a positive score (i.e., > 0).

The detailed scores are reported in the picture below.

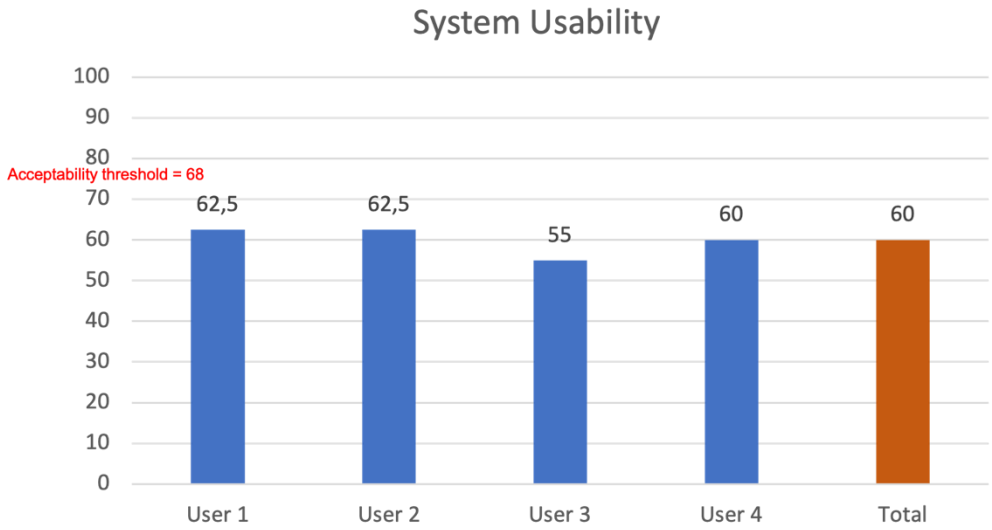


As already stated in the methodological description in D7.3, the other main topic of this evaluation cycle were user interface-related parameters. The discussion had during the workshop allowed to highlight some usability hints to be integrated in the next release of the platform. For example, some views of the platform have been considered as too rich of information, and a more compact view supported by different tabs dedicated to the different functionalities has been suggested. Additionally, the GANTT scheduling view (connected to the optimization features) has been considered as not very intuitive, since it did not provide clear evidence of the delta between the current and the new proposed scheduling, in terms of efficiency and expected benefits. During the workshop, it has been suggested to start in the design improvements from the system currently in place in PIA facilities, to use visualizations and interaction modalities that are already well known and accepted by the users. After the workshop, additional meetings have been already organized to show the platform designers the current system and find design solutions able to integrate the best practice deriving from previous research activities conducted by Piacenza. Visual materials have been also shared, and coherent design will be implemented towards the second project cycle.

From an interaction point of view, a new page to handle the new scheduling has been suggested. This would facilitate the end user to have a synthetic view of the benefits connected to the re-scheduling, allowing him/her to manipulate different parameters (e.g., type and urgency of the order) in one unique visualization able to tangibly show the added value offered by the optimization, and to take subsequent informed decisions. This factor has been considered as crucial since it would foster the role of the Optimization module as a support system for decision-making.

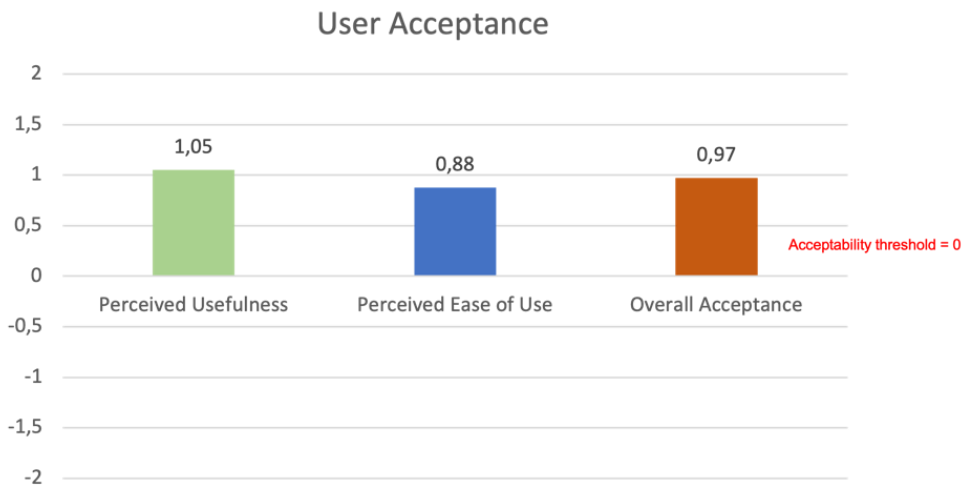
Additionally, in order to measure the system usability, the SUS questionnaire has been administered after the workshop. As shown in the picture below, the system obtained an overall usability score of 60, that is slightly below the acceptability threshold (which is 68). This is mostly due to the comments already highlighted, i.e., some improvements needed to the GANTT visualization page. However, being a preliminary version of the system, the score that is quite close to an acceptable threshold for the usability parameter (which is an indicator strongly affected by subjective factors and habits) indicates that the overall design system is in general well-understood and can improve after the implementation of the

suggested modifications. In order to measure the design improvements in the second development cycle, this score will be used as a baseline for further evaluations.



A very important indicator considered in this cycle was the User Acceptance. This indicator is highly relevant since, differently from the usability, it is less affected by the details on the look-and-feel and the grade of maturity of the prototype. For this reason, this parameter is widely used as indicator of the willingness of the users to adopt a technological system.

From the results shown in the diagram below, it is clear that the FACTLOG platform has been well accepted by the users (+0,97, on a -2 / +2 scale). More in details, both the sub-parameters measured by the Van der Laan questionnaire used in this evaluation obtained a very positive score. The system has been considered by the users as “Useful” (+1,05) and “Easy to be used” (+0,88).



As for the usability, also these scores will be used as a baseline for the evaluation in the second cycle, to evaluate the level of improvements from an end user perspective.

Expected improvements for the second cycle

In the second development cycle, several improvements are expected for PIA case, and some of them derive from the feedbacks collected in the workshop described in this chapter.

From a User Interface point of view, the visualization of the optimization scheduling will be re-designed, in order to be more consistent with the current representation. Additionally, the page used to run a new optimization will be re-organized to facilitate the decision make, clearly showing the expected benefits and the consequences (e.g., in terms of impact on the other orders, on energy consumption etc.). Other design details (e.g., the login mechanism and the users' permissions and rights) will also be rearranged to maximize the usability of the platform.

In this sense, the collaboration between the pilot site (PIA), the technical partner supporting the pilot (DOMINA) and the platform designers (MAG) is already started with dedicated meetings to share current materials and converge towards and improved solution.

Additionally, several other improvements are expected in terms of functionalities. For example, in this first pilot iteration the analytics module has been visualized and discussed as a standalone module, since its integration is still ongoing. In the second cycle the impact of using also pseudo-real-time data to optimize the looms and the plant, especially from the energy consumption point of view, will be evaluated to measure the added value provided by this kind of solution.

Finally, the technical verifications of the modules in the real industrial context will be performed, to evaluate the impact and the actual value provided by the enabling technologies. This will be crucial to estimate the overall impact, and to enable the objective measurement of the KPIs defined in the Grant Agreement, according to the methodologies described in this deliverable.

Automotive Manufacturing: CONT pilot

Summary of workshop results

As it was anticipated in D7.3 deliverable, the workshop on CONT pilot took place on 12th of October 2021 with the remote participation of 19 persons representing the main partners involved in this pilot use cases.

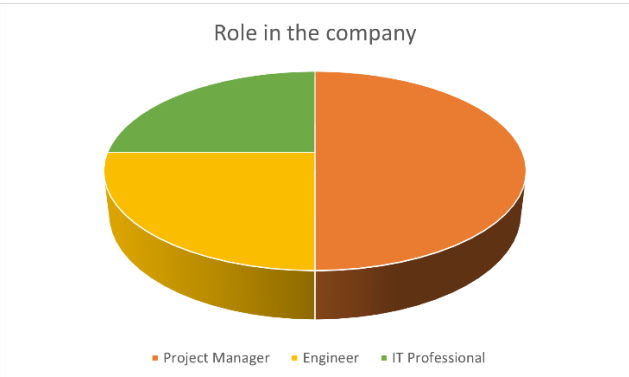
From CONT pilot, the main responsible persons attended the workshop and actively interacted during the presentation:

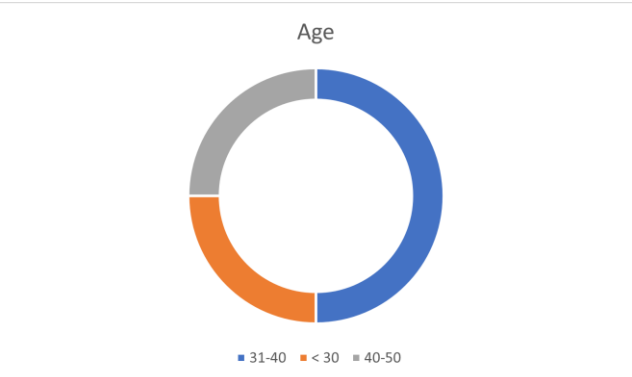
- Mr. Flavius Mihaila – Head of Industrial Engineering
- Mr. Alin Popa - Group Leader Smart Factory Industry 4.0 group
- Mr. Lucian Pavel – Leader of the MES team
- Mr. Bogdan Posa – Automation engineer
- Mr. Ciprian Kamenik – MES Engineer

The workshop was sustained by Mr. Radu Popescu, the technical leader on behalf of SIMAVI, representing the technical partner supporting the CONT pilot. Also, the MAG team, as the platform designer and the representatives of the analytics, optimization and simulation modules were involved in the workshop providing explanations on the development of the modules so far and facilitating the discussion and answering the questions raised by the end users.

As for the other pilot cases, the main scope of this iteration was to collect a first set of feedbacks regarding the implementation of the FACTLOG platform, with specific focus on the features enabled by the platform and first considerations regarding its usability and acceptability.

From CONT pilot, 4 of the 5 participants in the workshop have been further involved in the evaluation process; Their position in the company and their ages are illustrated in the pictures below.



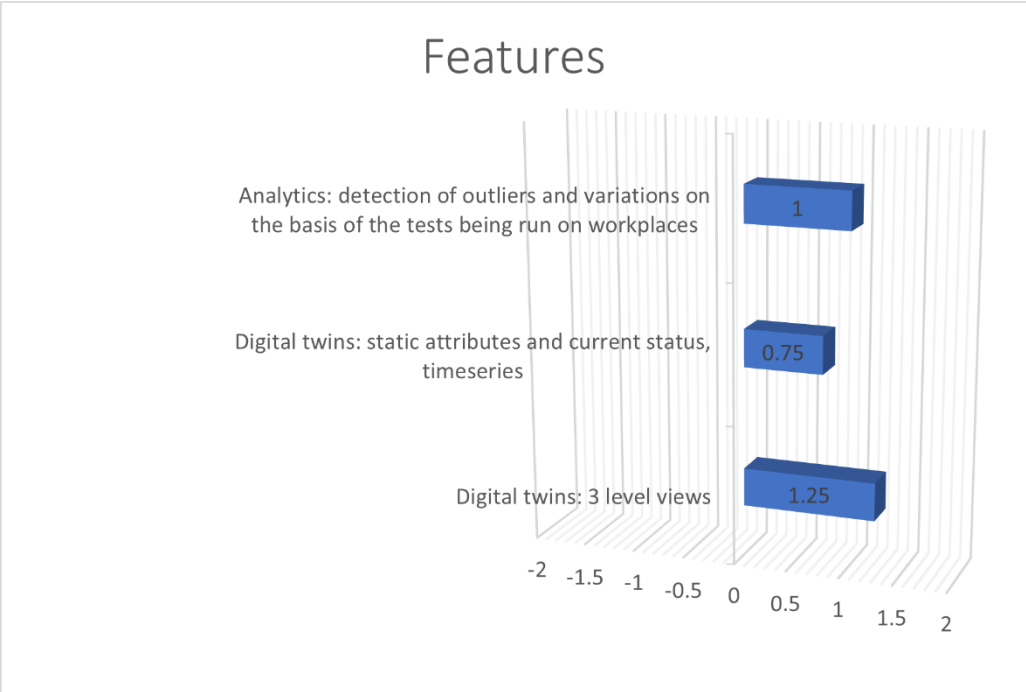


In the context of the FACTLOG project, CONT focuses on Pres-Assembly Line and the Final Assembly area. Considering this, the main features implemented in the first prototype of FACTLOG platform for Conti case were related to the digital twin representation at the plant level, process, and equipment level as well as to the digital twin representation of the static attributes and current status and timeseries. Additionally, the analytics feature represented

by the detection of outliers and variations based on the tests being run on workplaces has been implemented in the platform.

Making an analysis of those features, considering the scores given by the end users involved in the evaluation, the most rated feature was digital twin representation at the 3 levels view (+1,25; on a -2 / +2 Likert scoring scale), followed by the Analytic feature (+1) and DT: static attributes view (+0,75). It is important to highlight that all the features obtained a positive score (i.e., > 0).

The detailed scores are reported in the picture below.



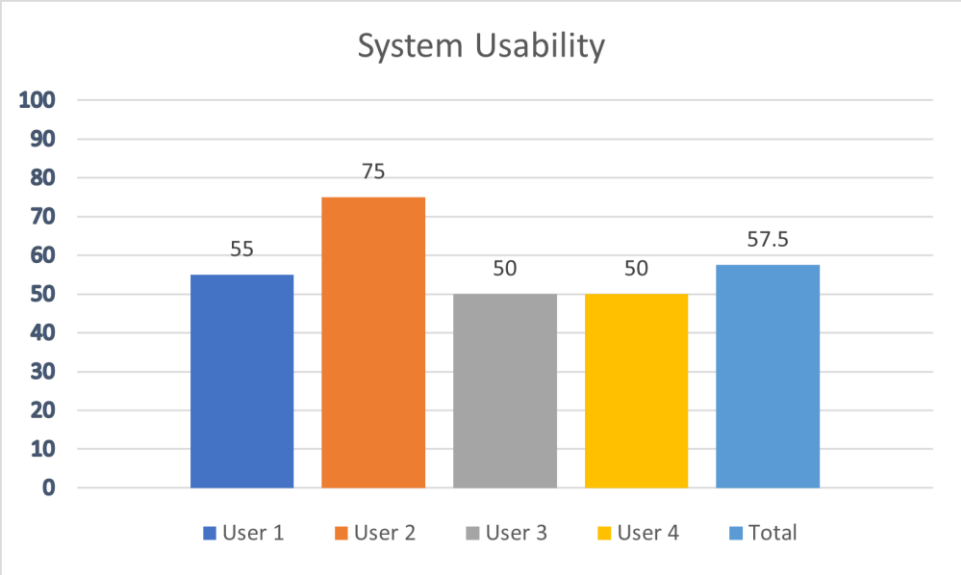
The feedback from the CONT participants regarding the features presented were mainly about:

- the look and feel were good.
- the outliers generated by the analytics should be more visible for the user.
- the user interface should not be overloaded with information.
- the user attention should be focused on the alerts raised by the platform.
- the platform should produce more information based on the data from CONT in order to identify the equipment more susceptible to broke in the near future

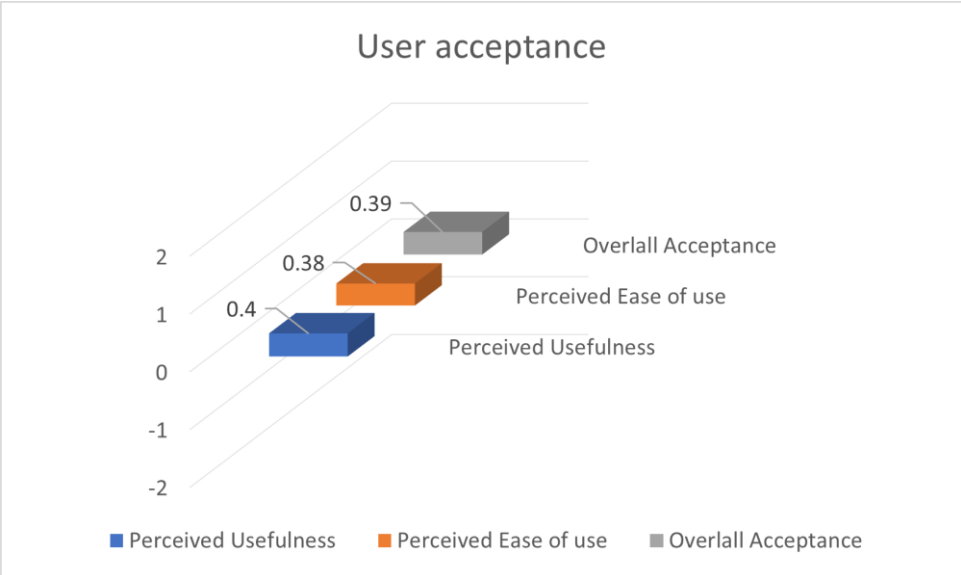
Concerning the optimization and simulation modules, they were discussed as standalone modules because they were not yet integrated in the platform. The results of this modules were presented (like production schedule, resource optimization, machine utilization etc.). CONT participants offered positive feedback. There were discussions about when the optimization and simulation processes should be started, following specific events in the plant, so the output of these modules is UpToDate.

The SUS questionnaire has been administered after the workshop to the end user's participants in order to measure the system usability. As shown in the picture below, the system obtained an overall usability score of 57,5, that is slightly below the acceptability

threshold (which is 68). Being the first version of the system, the score obtained is quite close to an acceptable threshold for this parameter (considered an indicator which is been filtered through subjective elements) and it indicates that the overall design system is in general well-understood and after implementing the suggestions received during the workshop it could be improved.



Another indicator that was considered throughout the questionnaire was the User Acceptance. The results are illustrated in the figure below, and it reflects that the FACTLOG platform has been accepted by the users with a score of 0,39 (on a -2 / +2 scale). It can be concluded that the “Useful” and “Easy to be used” sub-parameters measured by the Van der Laan questionnaire used in this evaluation obtained a positive score: +0,40 and +0,38.



Expected improvements for the second cycle

In the second development cycle the user interface of the FACTLOG platform will be updated according to discussions: real data will be integrated and viewed in the platform, more focus will be on viewing the anomalies and outliers so the operators will easily see the potential problems. The graphs that present trends of measurements will be improved.

The output of optimization and simulation will be integrated in the user interface and will present the optimum order of processing the orders on the production lines.

Meetings with the relevant partners are already scheduled in order to create a workplan for the next cycle. More than this, some of the meetings took place immediately after the workshop to clarify aspects regarding a better presentation of the outliers (with NISSA, MAG, QLECTOR).

Short time after the workshop, the optimization service was deployed and is ready to be tested for integration and then implemented in the production environment.

Steel Manufacturing: BRC pilot

Summary of workshop results

The set-up for the demonstration workshop was to conduct it via Microsoft Teams and have led technical partner Control 2K Ltd to give the demonstration supported by partners from the FACTLOG consortium working on BRC's pilot. The project team consisting of Project manager and team member attended the demonstration, and then from BRC's management side had the Managing director, Operations manager, Planning and Transport manager and Engineering manager in attendance. The demonstration consisted of an initial PowerPoint presentation given to give background for people who were unaware of this and an overall demonstration of the system interface and functions. This then followed with a Q&A at the end for final opportunity to give feedback.

The main features that were demonstrated to the audience were the Digital twin's function that gives an overview of their relationships with each other and level, for example going from factory to Bay 3 process and then being broken down into the individual machines. With this then the status and condition can be checked at each level so for a machine can see its status and condition in detail. This would be beneficial to BRC as this provides a more real-time view of what is happening on the factory floor to management, which then allows more flexible and robust decision-making regarding process changes or maintenance. The next feature is analytics, which is an extension of the digital twin functionality in that it will allow analysis of the production data feedback from the machine with production times analyzed with a target to reach individual cut and bend timings for product. This will then be analyzed to give production timings for individual product batches. The benefit to BRC will be the ability to now have accurate production timings of product batches, as this has been a challenge due to the number of combinations products can be requested as.

The final two main features demonstrated go hand in hand, as it is both Optimization and Simulation. With data fed from analytics the optimization feature can then workout from a current order schedule the time taken for product to be made based on the algorithmic analysis of the timings. With this, machine capability, machine status and the requested product dimensions, the optimization module can then calculate the optimal production scenario to preference make span or reduction of late jobs. This in hand with the simulation feature, which allows the user to see how the production scenario will unfold with metrics like production times and machine usage is of great benefit. It will allow BRC to have greater flexibility in planning production and response to requirements on a day-to-day basis meaning an increase in main KPI achievement.

Generally, the demonstration feedback shows that the demonstration is well received with most stating that it would be easy to use and would not require prior knowledge or technical assistance on the use of the system showing that the system is not overly complex or cumbersome to use. In terms of consistency and feature integration in the system however has been a very neutral response. This is shown by the first set of questions feedback shown below from 4 to13:

4.I Think that I would like to use this system frequently						
Strongly Disagree	1	2	3	4	5	Strongly Agree
		1	3	2		
5.I found the system unnecessarily complex						
Strongly Disagree	1	2	3	4	5	Strongly Agree
		3	2	1		
6.I thought the system was easy to use						
Strongly Disagree	1	2	3	4	5	Strongly Agree
		2	3	1		
7.I think that I would need the support of a technical person to be able to use this system						
Strongly Disagree	1	2	3	4	5	Strongly Agree
	2	2	2			
8.I found the various functions in this system were well integrated						
Strongly Disagree	1	2	3	4	5	Strongly Agree
		1	4	1		
9.I thought there was too much inconsistency in this system						
Strongly Disagree	1	2	3	4	5	Strongly Agree
		1	2	3		
10.I would imagine most people would learn to use this system very quickly						
Strongly Disagree	1	2	3	4	5	Strongly Agree
			2	4		
11.I found the system very encumber some to use						
Strongly Disagree	1	2	3	4	5	Strongly Agree
	1	3	2			
12.I felt very confident using the system						
Strongly Disagree	1	2	3	4	5	Strongly Agree
			4	1		
13.I needed to learn a lot of things before I could get going with the system						
Strongly Disagree	1	2	3	4	5	Strongly Agree
		2	3			

Following on in the neutral responses is the responses in how users found the system with most of the responses showing a neutral perspective with some positivity in its usefulness, pleasantness and overall assisting aspects which is shown in the next table- We believe this is because much of the feature integration was lacking due to data which has been not yet been provided via live data, hence was only a snapshot perspective and hence did not reflect the true functionality of the system. This has been reflected in feedback comments on the demonstration with some citing it as an aspect which needs to be integrated before a true perspective of the system and hence a more realistic version of the software's true functionality can be given. Examples of these are "Need a test view with real data to get a better understanding of the capabilities" and "Not enough useful data presented and unable to understand what benefits the program will have to wait until real data is passing through".

Hence if this can be achieved before the next demonstration we would expect a more holistic type of feedback from the demonstration viewers.

15.I found the system						
Useful	1	2	3	4	5	Useless
		3	3			
16.I found the system						
Pleasant	1	2	3	4	5	Unpleasant
		2	3	1		
17.I found the system						
Bad	1	2	3	4	5	Good
			5	1		
18.I found the system						
Nice	1	2	3	4	5	Annoying
		1	5			
19.I found the system						
Effective	1	2	3	4	5	Superfluous
		1	5			
20.I found the system						
Irritating	1	2	3	4	5	Likeable
		1	3	2		
21.I found the system						
Assisting	1	2	3	4	5	Worthless
		2	4			
22.I found the system						
Undesirable	1	2	3	4	5	Desirable
		1	4	1		
23.I found the system						
Raising Alertness	1	2	3	4	5	Sleep inducing
		1	5			

Table 5: Feedback on questions 15 to 23 of the feedback

In regard to features, even though there was a lack of data that was integrated into the features and hence their true functionality could not be shown to the true extent desired the feedback shows that understanding of the features was comprehended.

This shows in most of the feedback being very positive for all the features usefulness shown in table below:

Feature	Not useful at all	Not very useful	Neutral	Quite useful	Very useful
Digital twins: 3 level views (plant, Bay 3 process and machine)			2	2	2
Digital twins: Visualization of static attributes and current status		1	2	1	2
Analytics: Calculaiton of processing times per capable machine for each job to be scheduled		1		1	4
Optimization:Optimal scheduling of jobs assignments to Bay 3 machines, towards minimization of the total production time (makespan) and any number of late jobs			1	2	3
Optimization: Type of job (coils, bars, bent bars)			2	3	1
Optimizaiton: Current availability of machines (breakdowns)				3	2
Optimization: Machine capabilities and set-up times			1	2	2
Optimization: Calculated processing times			1		4
Simulation: Various metrics on the produced schedules e.g. completion times, machine usage etc			2	1	3

Table 6: Feedback on features

Even though feedback is very positive on these features currently there is also some neutral feedback which both could change in the next demonstration, this is due to when live data is incorporated more realistic function of the features become apparent hence possibly causing the feedback to change positively or negatively. However, all the features generally well received, this is backed up about a statement on the objective of getting the real-time data in “The key objective is to make the system provide 'real time data' to allow order status tracking v's expected completion time”. If the analytics, optimization, and simulation features work correctly this will achieve the objective and hence these features are very much of high importance. Only question posed during the demonstration was on the optimization feature as to how often it will be performed by the system.

Expected improvements for the second cycle

The main actions that will be addressed for the next demonstration as per demonstration feedback and current project path are as follows. First being digital twins ensuring that the feature has data being fed into from actual sensor feedback from machines and cranes to ensure this feature has true functionality. The next is real-time data, this is a key part of demonstration feedback and hence needs to be achieved for the next demonstration to enable complete feature integration. The final aim will be to achieve a concrete optimization solution that also addresses the necessary function of the question asked which is how often BRC will expect the optimization scenario and simulation to be run.

From the demonstration feedback and next steps, we believe that the aim for the final demonstration will be towards the end of 2022 or start of 2023