Cloud-based **R**apid **E**lastic **MA**nufacturing

WP7 – Piloting & Validation: Use Case I: Machinery Maintenance

D7.1.1: Use Case I Machinery Maintenance Definition

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Contributing Partners: ALL except TCO

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This use case document acts as a guide during the project and will be used by all partners to stay focused on the main ideas and goals of the machinery maintenance use case. Although the Description of Action and Project Vision Consensus Document give a first introduction to the machinery maintenance use case, there are still many details that need to be described in order to understand the current setting of the scenario and its future evolution and benefits within CREMA.

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This deliverable is subject to final acceptance by the European Commission.

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Executive Summary

The purpose of this CREMA deliverable *D7.1.1 Use Case I Machinery Maintenance Definition* is to develop a common understanding of the machinery maintenance use case, which involves two of the CREMA industry partners, namely FAGOR and GOIZ. In the further course of the project, this document will be used as a guideline to implement and test the CREMA platform including technical specification, configurations and test scenario development for the machinery maintenance use case.

The CREMA Use Case I Machinery Maintenance Definition is organized as follows:

- **Current Machinery Maintenance Scenario:** This section explores the current scenario, details how FAGOR performs machinery maintenance of installed stamping machines (e.g., form presses) and the prevailing practice of communication for ordering spare parts and error handling.
- **Desired Scenario for CREMA:** This section describes a future in which the enhanced machine monitoring and intelligent decision making, higher collaboration and situation awareness will enable the FAGOR's Cloud platform based on the CREMA Cloud components.

Based on the above sections, this document will be used to guide the evaluation that will be detailed in the next version of the deliverable (in December – D7.1.2 Use Case I Machinery Maintenance (Revisited)).

Roles: FAGOR will lead this task as a domain knowledge partner, all partners (except TCO) will be responsible for ensuring the use case has the correct focus (e.g., aligning to CREMA architecture and components or positioning with TCO use case), and IKER, as one of the main technology partners of FAGOR and vice lead of this task, will be in charge of building the integration between current and future CREMA platform enhanced capabilities.

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1 Introduction

CREMA – Cloud-based Rapid Elastic MAnufacturing – is a project funded by the Horizon 2020 Programme of the European Commission under Grant Agreement No. 637066.

This deliverable contains the details of the machinery maintenance use case and represents the work to be carried out beyond the particular use case requirements. Concretely, this document will facilitate the common understanding of the use case including the current scenario, desired scenario for CREMA, and the potential benefits that CREMA will provide to industry stakeholders.

1.1 Use Case Overview

The machinery maintenance use case involves two main industrial partners: FAGOR[1] and GOIZPER[2] (GOIZ for short):

- **FAGOR** is a company specialized in custom design, manufacturing and servicing forming machine tools, form presses and complete stamping systems for worldwide customers such as Gestamp, Volkswagen or Audi. These automated machines include sophisticated production technologies and high-level quality standards for all components.
- **GOIZ** is a company specialized in engineering, designing, manufacturing and supplying power transmission components from metal forming machines such as clutch-brakes, cams and intermittent rotary units for different types of applications. As the leading clutch-brake manufacturer in Spain, it is the common partner for all FAGOR form presses.

On the daily basis FAGOR requires high availability from stamping machines' (i.e., form presses in this use case) components due to the high costs of production downtimes and the potential impact on delivery times of new components to their own customers. An overall reduction of unscheduled downtimes and machine breakdowns will significantly improve FAGOR market position and customer service. To achieve this it would require not only an on-line remote monitoring of installed machines but also an efficient management of spare-part suppliers and Technical Assistance Service (TAS) teams. Here is where CREMA comes in.

Using the Cloud Manufacturing services offered by CREMA, FAGOR aims to create a network of interconnected companies along its supply chain, from customers to spare-part supplies and TAS companies for an efficient end-to-end condition-based maintenance management, as well as a continuous real-time monitoring of installed machines and surrounding components (e.g., GOIZ clutch-brakes).

1.2 Deliverable Purpose, Scope and Context

The purpose of this deliverable is to provide a detailed guidance on use case specification and help with requirements capture, so we can have a clear picture of the full scope of the machinery condition-based maintenance scenario and position for latter measurement, evaluation period (D7.1.2). With this aim, this Use Case I Machinery Maintenance

[1] http://www.fagorarrasate.com/
[2] http://www.goizper.com/en/

Definition Document details the current machinery maintenance scenario (what and how things are being tracked), underlying hardware and tools, and the desired scenario within the CREMA approach.

The Use Case I Machinery Maintenance Definition scope is to have more details surrounding the presented use case for applying CREMA.

1.3 Document Status and Target Audience

This document is listed in the Description of Action (DOA) as "public", since it validates the real applicability of CREMA in industrial, real-life settings and thus can server as a reference for future adoption in Cloud Manufacturing and Industrial Internet scenarios.

Moreover, although this document is mainly aimed at the projects partners, it can be helpful for the wider scientific and industrial community, e.g., as a motivating scenario in scientific publications.

1.4 Abbreviations and Glossary

A definition of common terms and roles related to the realisation of CREMA as well as a list of abbreviations is provided online under http://www.crema-project.eu/wiki.

1.5 Document Structure

This deliverable is organized as follows:

- **Section 1 (Present Status of the Machinery Maintenance Use Case):** Presents the status quo of the machinery maintenance use case, including stakeholder roles and hardware/software tools.
- **Section 2 (Desired Scenario in CREMA):** Positions the use case from the CREMA point of view and details how the use case can be aligned to different CREMA components.
- **Section 3 (Conclusion):** Provides the conclusions of the document and prioritizes use case potential benefits to support later requirements generalization.

2 Machinery Maintenance Use Case Definition

CREMA approach would be an excellent choice for developing the next generation of FAGOR/GOIZ Cloud Manufacturing platform, as it is exactly the kind of Cloud Manufacturing approach that CREMA is targeting. For instance, resource virtualization, data processing, and workflow-based elastic collaboration would allow FAGOR to implement the whole machinery maintenance platform, following a predefined workflow and using highly integrated tools. These features will be core to Industrial Internet of Things (IIoT)[3] (or Industrial Internet[4], Cloud Manufacturing [LWT+10] [ZLT+14], Smart Factory [LCW08] [WLS+10]) as we will align smart machines, operational practices and humans in a dynamic but coordinated operational force.

2.1 Current Machinery Maintenance Scenario

The current service and maintenance process for integrated customer support, repair and maintenance is quite inefficient and by that it means a very high financial cost required to shore up (poorly) on-site errors. The following section describes the current monitoring and maintenance practices for form presses and custom machine components.

2.1.1 Big Picture and Roles

The following description is a high level overview of how FAGOR is currently undergoing machine monitoring and maintenance service, as well communicating with spare part suppliers (GOIZ) and TAS teams. The current form press machinery monitoring and maintenance process is illustrated in Figure 1. In the current practice, the machinery monitoring and maintenance process is intended to be procedural, but actually it is quite reactive and manual. After installing a new stamping press, passing all its crash tests and received customer confirmation, the installation starts to operate under normal conditions for approximately 15 years of 30400 hours of continuous use. For each new installation, FAGOR provides a standard warranty to all purchasers. By agreeing to these terms, the customer acknowledges that FAGOR TAS has opted to cover phone and email inquiries. Once warranty is expired (after 2 years), the customer can solve different machine-related issues by its own maintenance personnel or contact FAGOR again for a particular maintenance repair under regular inquiries.

Regarding monitoring and alerting, nowadays FAGOR and GOIZ do not continuously collect machine/component data and monitor communications from multiple sources, customers and equipment types. In case of machine-level or component-level error, the customer telephones the FAGOR TAS member with instructions to commence answering. The TAS team maintains a spreadsheet to track customer issues requiring on-site intervention and minor remote checking (around 89%), or doubts clarification (11%) (see Figure 2). At this point, it is possible to transfer the issue from the TAS team to the specialized developer team. If necessary, the responsible for resolving the issue can also make a team viewer remote connection to see online status or even can ask for a video record. Trough remote connection, the developer or TAS member responsible for collecting and repairing the error cause can access machine-level and component-level logs through accessing the SCADA (HMI) and PLC.

[3] http://www.accenture.com/us-en/technology/technology-labs/Pages/insight-industrial-internet-of-things.aspx
[4] http://www.ge.com/stories/industrial-internet

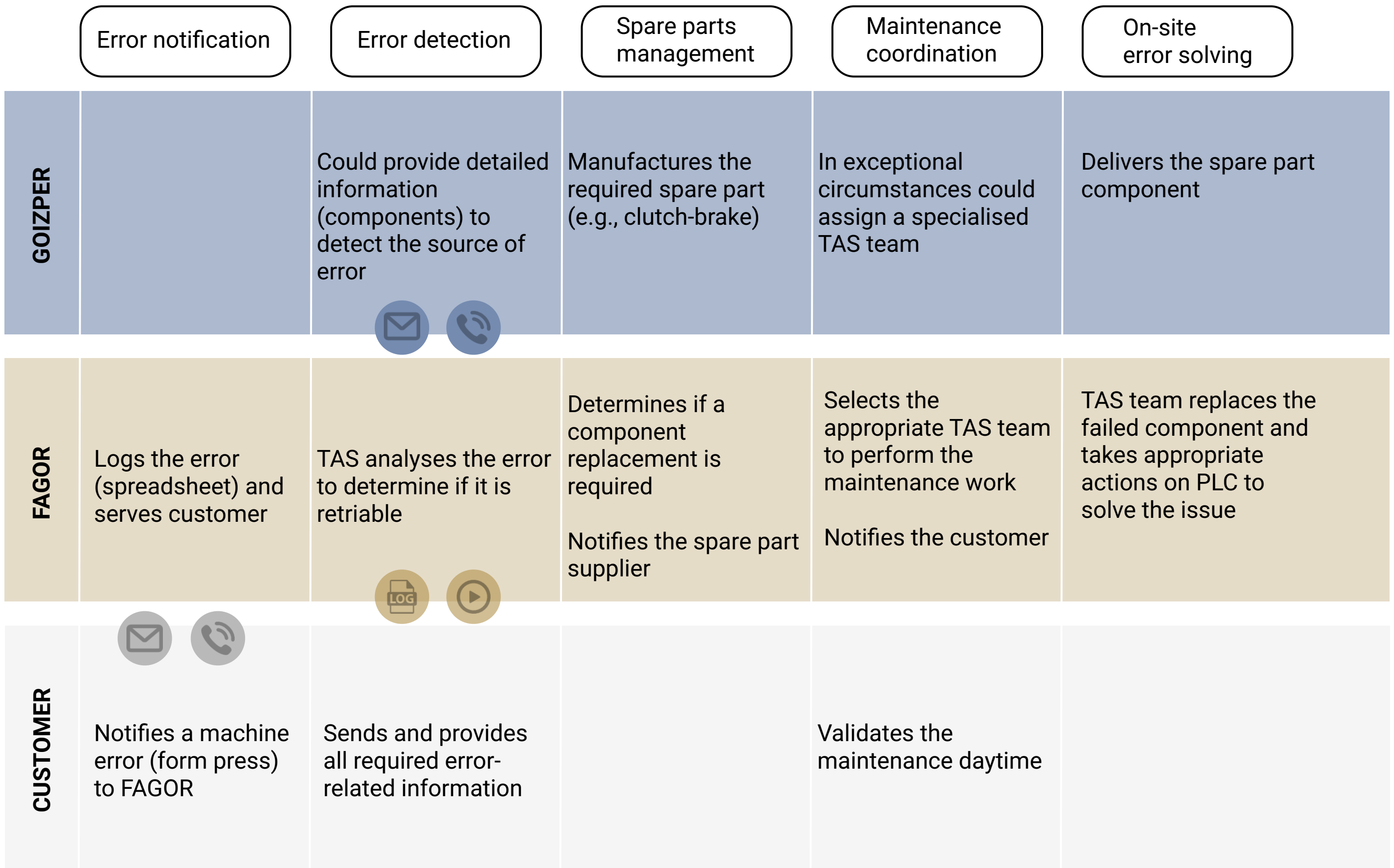

Figure 1: Current Machinery Maintenance Scenario (Blueprint)

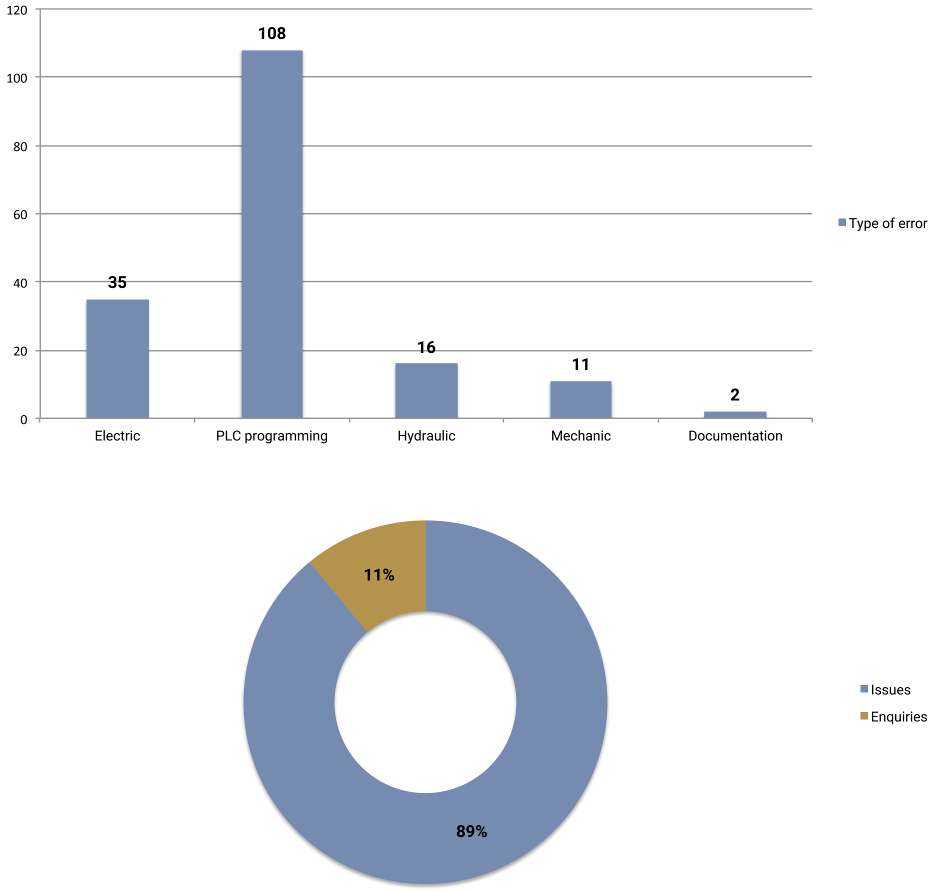

Figure 2: Common Error Types from FAGOR in 2014

This way specific PLC and sensor parameters such as hydraulic valve trigger or clutch-brake pressure can lead to significantly different calibrations and status errors. Through exercises, FAGOR and its spare part suppliers such as GOIZ have explored many error sources and identified the main causes of errors. We can classify FAGOR *machine-related errors* into three main categories:

- **Seizure of Bushings:** it is generally understood by seizing the fault that occurs when two pieces that slide over each other, one fixed and one movable, become stiff or welded together. Common causes are: misalignment (bushed incorrect), strange bodies inside mounting cavities (normally dirty), clearance incorrect mounting, and bad use of the machine (centre loads, over execution, or poor lubrication, etc.)
- **Fissures:** refer to the appearance of fissures or cracks in the structure of the machine. Common causes are: defective assembly, bad design (e.g., bad dimensioned vibrations), bad use of the machine (e.g., excessive tonnage).
- **Clutch-brake errors:** this type of error is mainly related to the premature wear of the clutch brake. Common errors include: poor calibration and bad clutch assembly, among others.

Table 1: Common clutch-brake related alarms

Logic	Alarm
Hydraulic group temperature> 85	Temperature too high in the hydraulic group.
Incoming temperature + 35 < Out coming temperature	Temperature too high inside the clutch-brake
Clutch Brake pressure > 100	Too high clutch brake pressure
Clutch Brake pressure < 55	Too low clutch brake pressure
Braking torque < X	Not enough brake torque
Clutching torque < X	Not enough clutch torque
Braking angle > X	Braking time too long
Calculated braking angle ≠ Braking angle (from machine)	Error in the braking angle calculation
Incoming caudal < X	Too low incoming caudal
Motor axis speed > Application axis speed	Slipping
Motor axis speed > Motor axis theoretical speed	Too high speed

Such types of errors can be further classified according to the *type of error* such as (i) electric issue, (ii) PLC programming issue, (iii) hydraulic issue, (iv) mechanic issue, (v) documentation-related issue. For example, in 2014 PLC programming issues became a mainstream type of error (see Figure 2). This means that an improvement in the reduction of PLC programming issues and online machine monitoring will contribute to the improvements and quality of each installation, and thus customer satisfaction.

In the current scenario, some errors can be fixed remotely; however, most of them require an on-site intervention. In case of clutch-brake errors, which can be indeed supported by GOIZ, FAGOR TAS operators collaborate with other GOIZ TAS operators to fix the error before the replacement moves on. If the installed clutch-brake cannot be fixed for any reason, GOIZ will manufacture a new clutch-break for the customer free of charge. Concretely, *clutch-brake related errors* could be classified as follows (see Table 1): (i) clutch slipping, (ii) braking angle going too big, (iii) lubricating oil heating, and (iv) slow clutching.

After assigning the TAS team commissioned to perform the intervention, both companies, i.e., FAGOR and GOIZ, review the maintenance plan to schedule the required clutch-brake delivery and TAS staff to perform the work at the right time. Once the clutch-brake is installed and tested, the maintenance action is marked as fixed in the event log (spreadsheet) and prevents this instance of the error from being listed again.

The aforementioned monitoring and maintenance procedure is not only applied to clutch-brakes but also for all FAGOR machine components. Within such procedure, we can distinguish the following *roles*:

- **TAS team member (F-TASTMEM):** is responsible for continuously monitoring, evaluating, and adjusting potential standard or non-standard errors.
- **TAS manager (F-TASMAN):** is the responsible for the management of a significant customer base and TAS team coordination.
- **Project developer (F-PRJDEV):** is the team member (e.g., electronic engineer, software engineer, mechatronics, etc.) that initiates and develops each customer project.

- **Product engineer (F-PROENG):** is the product designer for machine and customer-specific installation design.
- **Procurement assistant (F-PROCAS):** ensures that FAGOR has a constant supply of materials or equipment for both internal and customer provisioning.
- **Spare-part supplier (F-SPRSUP):** offers, manufactures and/or delivers spare-parts of equal quality to those bought by the manufacturer (FAGOR). GOIZ

2.1.2 Hardware, Tools and Operating Systems

During the last years a number of software tools have been developed and adapted. However, Siemens and Beckhoff have been widely used throughout the machine to perform a number of functions. Specifically, the following *software* is installed in FAGOR form presses:

- Step 7 v5.5 for PLC programming[5]
- Tia Portal v13 for SCADA HMI[6]
- Simotion v4.4 for axis control[7]

This software is accompanied by the following *hardware*:

- Standard PLC: Siemens CPU 315/317/319, Siemens CPU 400, OMRON and Allen Bradley.
- PLC Safety: Siemens CPU S7-300/400 family, Siemens S7-1500 Safety, PILZ PSS 3000, PILZ PNOZMulti, and PILZ PAS 4000.
- PLC Motion: Beckhoff CX family, Rexroth MAC-8, and Simotion 445D.
- Touch Panel (TP1200, TP1500 with Tia Portal)
- Industrial PC (IPC477D for Tia Portal and IPC477C for WinCC flexible)

[5] http://w3.siemens.com/mcms/simatic-controller-software/en/pages/default.aspx
[6] http://www.industry.siemens.com/topics/global/en/tia-portal/pages/default.aspx
[7] http://w3.siemens.com/mcms/mc-systems/en/automation-systems/mc-system-simotion/pages/motion-control-system-simotion.aspx

2.2 Desired Scenario for CREMA Approach

A major concern when remote monitoring a form press and inherent components is its rapid response and maintenance when an error occurs. The costs and time course of error detection and correction can be a little daunting. This issue leads to several difficulties:

- The machine is only monitored when an error/issue is reported. Such reactive monitoring does not reflect the overall general picture of machine/components status.
- FAGOR and spare parts do not have an overview of the status of the machines, neither of installed components.
- The availability and response time of spare parts is not known in advance. Therefore, FAGOR cannot forecast of spare parts in case of breakdowns.
- There is a lack of coordination when dealing with breakdowns and customers. Communication among different stakeholders (FAGOR, spare parts, customers, and TAS teams) must be efficient.

A major expectation from CREMA is to obtain solutions to address these limitations and improve the current machine monitoring and condition-based maintenance process in terms of efficiency and flexibility. Using CREMA Cloud platform FAGOR aims to create a network of interconnected companies along its supply chain, from customers where their machines are installed, to spare parts suppliers and certified TAS companies which perform different intervention tasks such as periodic maintenance, component replacements or breakdown repairs.

CREMA will allow collecting machine-level and component-level data in a real-time fashion, as well as customer and location-aware data. Time-series coming from machine will be store in the CREMA cloud storage for later analysis by a set of pre-defined indicators (KPIs) via the CREMA Dashboard. This way not only FAGOR but also spare part suppliers such as GOIZ will be able to have a real-time snapshot of each specific machine operations.

In the event of a component-level error, CREMA Monitoring and Alerting would trigger an event to evaluate different alternatives in order find the most efficient solution in terms of response time and cost. Such event will trigger a maintenance process considering different spare part suppliers, TAS companies, intervention costs and response times.

This maintenance process will search a suitable spare part supplier and a TAS company from the CREMA marketplace based on pre-defined criteria, and notifies involved stakeholders when new component is ready for delivery. The system will consider customer related data (e.g., location, contract type, etc.) to make an appropriate decision-making. At this point, CREMA collaboration tools will facilitate the communication among involved stakeholders to coordinate component delivery, shipping, and on-site replacement appointment.

2.2.1 Data Collection and Virtualization (UC-F.1)

Data collection and virtualization will provide means to exploit machine data from stamping presses and other valuable data sources such as MES or ERP systems in an attempt to virtualize real-world assets and services.

T4.1 CREMA Data Model, Model Library and Profiles (T4.1). In case of machine maintenance use case we will need to monitor machine-level data and component-level data. For instance, we might consider the time-series described in Table 2 from FAGOR/GOIZ.

Table 2: Machine-level (ML) and component-level (CL) data for FAGOR/GOIZ use case.

Variable	Data Type	Source (ML/CL)
Cylinders and rods efforts	Integer	ML
Total strokes	Integer	ML
Die reference	String	ML
Die total strokes	Integer	ML
Machine speed/cycle time	Float	ML
Height regulation	Float	ML
Truck inclination	Float	ML
Hydraulic valve trigger	Boolean	CL
Line pressure	Float	CL
Clutch-brake pressure	Float	CL
Motor axis speed	Float	CL
Application axis speed	Float	CL
Incoming oil temperature	Float	CL
Out coming oil temperature	Float	CL
Hydraulic group temperature	Float	CL
Oil caudal	Float	CL

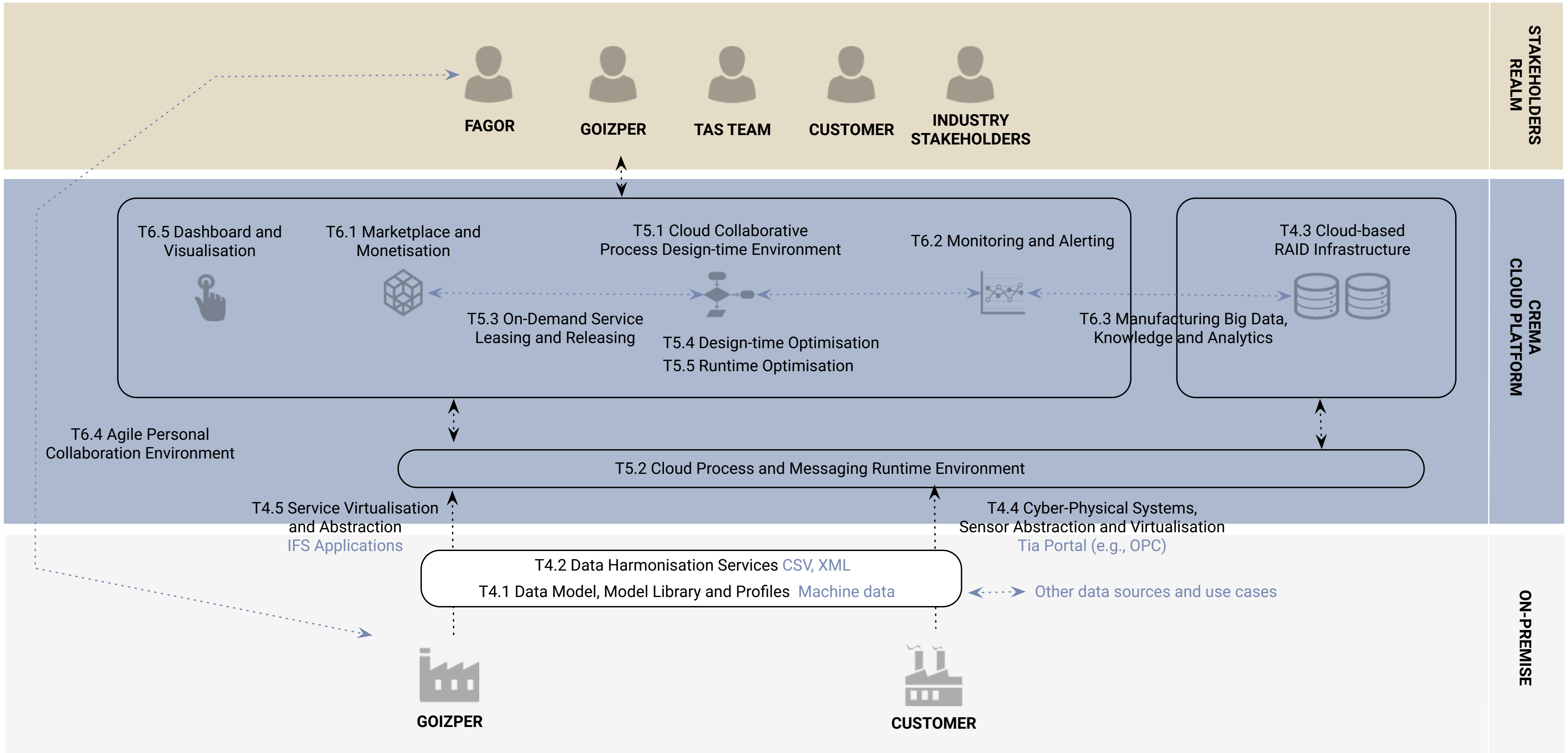

Figure 3: Desired Machinery Maintenance Scenario for CREMA

T4.2 CREMA Data Harmonization Services (T4.2). This will mean having a common data format to access, share and understand data. In case of FAGOR, log files are now using comma delimited CSV and XML formatting; however, such formatting will be deprecated in favor of specifying data formatting data harmonization services.

T4.4 CREMA Cyber-Physical Systems, Sensor Abstraction and Virtualization (T4.4). This will provide access to different manufacturing-related machine data sources, such as in [SGW+14]. In this particular case, FAGOR will use this subcomponent to provide an abstraction layer (e.g., via model mapper) on top of *Tia Portal* (FAGOR SCADA) software in order to access machine-level and component-level data.

T4.5 CREMA Service Virtualization and Abstraction (T4.5). This subcomponent will allow integrating data from existing software systems such as ERP and MES, as well as provide means to allow a rich semantic service description for them. In this use case GOIZ we will need to interface IFS Applications (http://www.ifsworld.com/en/solutions/) (i.e., the ERP system used by GOIZ) with the CREMA platform (e.g., via a virtual specification API) in order to be part of CREMA manufacturing processes, e.g., clutch-brake maintenance and replacement. Hence, new clutch-brakes will be made on-demand when customers (e.g., FAGOR) orders.

2.2.2 Data Storage and Cloud Infrastructure (UC-F.2)

CREMA Data storage and Cloud infrastructure will provide a secure and reliable data storage for exchange and storage of machine-level and component-level data.

CREMA Cloud-based RAID Infrastructure (T4.3). One of major concerns here is the data security and privacy, making sure that time series from FAGOR machines get appropriate access rights. Although CREMA will provide a public cloud, it would be desirable if public cloud can build a private cloud and gain more control. Regarding data management, different storage types for unstructured machine data (e.g., OpenTSBD, HDFS, HBase) and structured data management (e.g., Postgres for customers related and TAS data) will be required.

2.2.3 Machine Status Monitoring, Alerting and Analytics (UC-F.3)

Data coming from form presses need to be collected in order to monitor current manufacturing processes according to predefined KPIs.

CREMA Monitoring and Alerting (T6.2). As part of the CREMA Dashboard, when a critical threshold of a KPI is met, the alerting system will generate events that will be taken into account by existing processes and authorized users. In this use case, we will monitor clutch-brake related smart alarms (see Table 3 for further information) and perform more analysis to calculate clutch-brake related KPIs.

Table 3: Smart clutch-brake alarms

Error	Logic	Alarm
Clutch Slipping	-Clutch brake pressure OK -Clutching torque OK -Motor axis speed > application axis speed	Overload
Clutch Slipping	-Clutch brake pressure < Theoretical clutch brake pressure	Clutch brake too low pressure

	-Motor axis speed > application axis speed -Clutching torque < Theoretical clutching torque	
Clutch Slipping	-Clutch brake pressure OK -Clutching torque (from pressure) ≠ Clutching torque (from speed) -Motor axis speed > application axis speed	Oil or friction material in bad condition
Clutch Slipping	-Clutching torque (from pressure) OK -Clutching torque (from speed) NOK -Piston displacement NOK -Motor axis speed > application axis speed	Sheets wearing
Braking angle too big	-Calculated braking angle = Braking angle (from machine) -Calculated braking angle > Theoretical braking angle -Braking torque NOK -Valves delay OK -Main springs pressure OK	Oil or friction material in bad condition
Braking angle too big	-Theoretical braking angle < Braking angle (from machine) -Theoretical braking angle < Calculated braking angle -Braking torque NOK -Valves delay OK -Main springs` pressure OK -Piston displacement NOK	Brake side sheets wearing
Braking angle too big	-Theoretical braking angle < Braking angle (from machine) -Theoretical braking angle < Calculated braking angle -Braking torque NOK -Valves delay OK -Main springs` pressure NOK -Piston displacement OK	Main springs fatigue
Braking angle too big	-Theoretical braking angle < Braking angle (from machine) -Theoretical braking angle < Calculated braking angle -Braking torque NOK -Valves delay OK -Main springs` pressure OK -Piston displacement OK	Dirty oil
Lubricating oil heating	-Consumed power > Theoretical power -Out coming oil temperature > 85 -Hydraulic group temperature > 60 -Number of strokes/min > Theoretical number of strokes/min	Too many strokes/min
Lubricating oil heating	-Number of strokes OK -Motor axis speed > application axis speed	Slipping of Clutch brake
Lubricating oil heating	-Residual Power > Theoretical residual power -Number of strokes OK	Sheets damaged
Lubricating oil heating	-Hydraulic group temperature > 85 -Theoretical braking angle = Calculated braking angle -Braking torque OK -Valves delay OK -Main springs` pressure OK -Piston displacement OK	No enough cooling capacity
Slow clutching	-Clutch brake pressure (β) < Theoretical clutch brake pressure (β) - Line pressure < Theoretical Accumulator pressure (45bar)	Accumulator without charge
Not enough force to brake	-Line Pressure NOK -Clutch brake pressure NOK	Fluid scape in the line
Not enough force to brake	-Line pressure OK -Clutch brake pressure NOK	Fluid scape in the application entrance

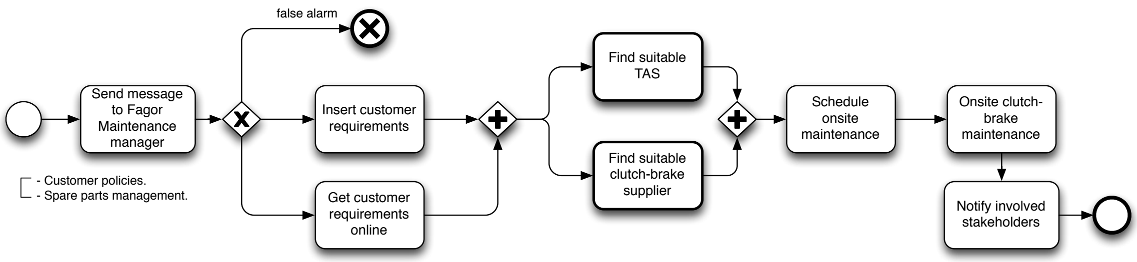

Figure 4: A Preliminary Machinery Maintenance Definition. Placeholder activities are indicated

CREMA Manufacturing Big Data, Knowledge and Analytics (T6.3). From collected time series, FAGOR and GOIZ will be able to derive new insights from historic machine data. For instance, FAGOR would like to obtain maximum, minimum and average from some of the listed parameters in Table 2. The same applies to GOIZ for Table 2 and Table 3.

2.2.4 Process Definition, Execution and Monitoring (UC-F.4)

CREMA platform will have a workflow-based system to model, execute and optimize manufacturing processes such as the FAGOR condition-based maintenance process. When a particular KPI threshold is exceeded the CREMA platform will trigger an appropriate process execution.

CREMA Cloud Collaborative Process Design Time Environment (T5.1). This will allow project developers from FAGOR to model different maintenance processes. For machinery maintenance use case validation, we will define a single process capable of integrating spare parts and TAS teams. An example process is given in Figure 4 using BPMN 2.

CREMA Cloud Process and Messaging Runtime Environment (T5.2). This middleware will integrate different services from GOIZ ERP, as well as virtualized FAGOR data sources and third party applications.

CREMA On-Demand Service Leasing and Releasing (T5.3). This will provide functionalities for dynamic selection and integration of virtualized spare parts and TAS services, i.e., different manufacturing services that can be dynamically selected at run time.

CREMA Design Time Optimisation and Runtime Optimisation (T5.4 and T5.5). This will provide the means to optimize maintenance processes, taking into account historic or streaming data. In this case, FAGOR will be able to dynamically change process instances while in operation enabling process flexibility.

2.2.5 Dashboard and Stakeholder Collaboration (UC-F.5)

The CREMA Dashboard provides the user-related functionalities including previously mentioned monitoring and alerting capabilities as well as stakeholder collaboration and marketplace features.

CREMA Marketplace and Monetisation (T6.1). By exposing production services (e.g., clutch-brake availability and response time) in the marketplace GOIZ could monetize its availability. Similarly, different TAS teams can expose their services in the marketplace so FAGOR could select the most suitable one according to each maintenance operation.

CREMA Dashboard and Visualization (T6.5). FAGOR and GOIZ will control and adapt processes from the Dashboard, as well as view any analytical information.

CREMA Agile Personal Collaboration Environment (T6.4). Through the Dashboard, direct interactions between different stakeholders involved in maintenance process will be enabled, e.g., between FAGOR and GOIZ.

2.3 Use Case Summary

FAGOR and GOIZ have been analysing for many years the adoption of new solutions to automate their maintenance processes and monitor installed machines/components using Cloud computing services.

A major expectation from CREMA platform advances is to obtain a clear reduction of on-site intervention costs by monitoring spare-part suppliers, TAS teams and installed machines in a single and coherent Cloud Manufacturing platform. Specifically, CREMA will have a major impact on the involved industrial partners FAGOR and GOIZ as follows:

- **Up to 60% reduction of unscheduled machine downtimes** on customers due to a better tracking of critical machine components performance.
- **15% reduction of machine downtime** on customers because of the increased visibility and on-line monitoring of machines behaviour in customers' plants.
- **Up to 50% reduction of the intervention time** on customers since GOIZ will be able to manufacture in advance components that need to be replaced.
- **25% reduction of intervention costs** by a better coordination between customers, spare part suppliers (GOIZ), and TAS companies.

Beyond the high-level potential benefits, Table 4 summarizes CREMA benefits considering the aforementioned desired scenario.

Table 4: CREMA benefits for machinery maintenance use case

Potential benefits from CREMA	Level of importance for this use case (Low, Medium, High)
Benefits for GOIZ	
An improvement of the offered maintenance service to the customer/final user of GOIZ' component.	H
An improvement of the reliability of the component, increasing its lifetime.	H
A productivity improvement due to intelligent spare parts management.	M
More detailed understanding of the component's behavior, improving re-design and algorithms.	M
It will increase the business volume of TAS service.	M
Possibility of creating a close control loop, adjusting the working conditions of the clutch-brake on-demand.	H

Benefits for FAGOR	
Real-time communication between press stamp machines and CREMA Cloud will be secure.	H
Data collection between form presses and CREMA Cloud will be possible.	H
The integration between FAGOR and its spare part suppliers will be automated in order to gain more efficiency.	M
The availability and knowledge of each TAS team will be monitored.	M
The performance and logs of each installed machine will be accessible in CREMA.	H
Machine and components status will be graphically represented by setting bounds (KPIs) on the graph and offered as SaaS.	H
The machinery maintenance process will be modeled and standardized by using the CREMA process modeling capabilities.	H
The whole machinery maintenance process will be monitored and controlled.	H
TAS's repair time will be reduced, decreasing commissioning costs	H
Press spectrum will be monitored, providing online error checking in a single platform.	M
FAGOR's service platform will be extended.	H
Spare-parts will be ordered on-demand.	M
Benefits for the final user (machine user)	
Preventive maintenance cost reduction. Maintenance will be performed when necessary.	H
An improvement of the spare parts management and SAT service.	H
Continuous monitoring of installed machines.	H
Lifetime monitoring based on performance data.	M
Decrease machine downtimes.	H
New opportunities	
An opportunity to promote a new TAS service adopting new tools and technologies.	M
The possibility to "smartize" discrete and mechanic new components in the market.	M
The machine and component "smartization" will open new markets and offer competitive advantages.	M

3 Conclusion

Through the implementation of the CREMA platform FAGOR expect to improve and automate its condition-based machine maintenance processes and operations, as well as efficiently deal with spare-parts suppliers (e.g., GOIZ) by monitoring key performance machine parameters and suppliers availability. The abstraction and virtualization of press machines, i.e., its PLC/SCADA systems, will be an important part of the project since it will allow direct access to machine data. However, security and privacy concerns will also play an important role, in order to securely access the industrial control system.

Overall, FAGOR aims to obtain a configurable and secure industrial Internet platform capable of collecting data from a variety of machines, remote monitoring of KPIs, automating maintenance processes and allowing smart spare-part selection and communication. The next deliverable (D7.1.2) will present a detailed evaluation including testbeds and metrics to truly evaluate the performance of the CREMA platform in the presented use case scenario.

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