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Z-BRE4K

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Strategies and Predictive Maintenance models wrapped around physical systems for Zero-unexpected-Breakdowns and increased operating life of Factories

Z-BRE4K

Deliverable D5.5

White Paper on transferability and take-up of Z-BRE4K system

Work Package 5

Integration & Testing - Validation

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Executive Summary

Abstract	This deliverable reports barrier and obstacles that technical partners faced during Z-BRE4K solution implementation. Details about HOLONIX, ATLANTIS, TRIMEK and INNOVALIA are reported. Moreover, methods to overcome these issues are described. This report is in the form of White Paper that highlights some features of the Z-BRE4K solution. Further obstacles/barriers and methods used to overcome them, lessons learned, etc., will be considered, elaborated and presented if necessary within WP6 during the upcoming TRL7 project level considering the entire Z-BRE4K solution
Keywords	Barriers; obstacles; issues; methods; Z-BRE4K solution.

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0.3	Pablo Salvo, INNOVALIA	Chapter 4.3 and Chapter 4.4 contribution	24.03.2020
0.4	Daniel Gesto, AIMEN	First review of D5.5	25.03.2020
1.0	Serena Albertario, HOLONIX	Final version of D5.5	26.03.2020

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ABBREVIATIONS

Abbreviation	Name
ILM	i-Live Machines

1. Introduction

Main objective of Deliverable D5.5 is to describe all obstacles and barriers that Z-BRE4K partners found to achieve project objectives. Focus is on methods used to overcome issues, reporting technical and non-technical requirements for transferability and take-up of Z-BRE4K solution.

Goals, possible barriers and obstacles have been reported since the proposal writing. In this document these elements are stated and all partners involved in development of Z-BRE4K solution described how they solved these barriers to achieve the accomplishment of their component.

This report is in the form of White Paper that highlights some features of the Z-BRE4K solution. Further obstacles/barriers and methods used to overcome them, lessons learned, etc., will be considered, elaborated and presented if necessary within WP6 during the upcoming TRL7 project level considering the entire Z-BRE4K solution.

2. Z-BRE4K solution

The Z-BRE4K solution includes eight scalable strategies at component, machine and system level. Here below the eight strategies are reported to describe the value brought in Z-BRE4K:

1) The prediction occurrence of failure based on evidences (Z-PREDICT);

2) The early detection of current or emerging failure (Z-DIAGNOSE);

3) The prevention of failure occurrence, building up, or even propagation within the production system (Z-PREVENT);

4) The estimation of the remaining useful life (RUL) of assets (Z-ESTIMATE);

5) The management of the aforementioned strategies through event modelling, KPI (key performance indicators) monitoring and real-time decision support (Z-MANAGE);

6) The replacement, reconfiguration, re-use, retirement, and recycling of components/assets (Z-REMEDIATE);

7) The synchronization remedy actions, production planning and logistics (Z-SYNCHRONISE);

8) The reservation of the safety, health and comfort of the human workers (Z-SAFETY).

Working at Z-BRE4K solution, partners found several barriers and obstacles. They faced up with and overcome them as explained in Chapter 3.

3. Market barriers and obstacles

Analysing the market, during the proposal writing, these barriers and obstacles have been found.

From an industrial point of view, the main obstacle hindering the scalability of the proposed approach is its holistic inspection and monitoring to ***achieve zero-unplanned breakdowns***, which requires individual studies respect to the target solution. For this reason, the Z-BRE4K models have to be fine-tuned ad-hoc (e.g. CAD/CAM files). Besides, the control systems are designed based on the outcome of the simulation and the specific stages of the chain that need to be controlled. Nevertheless, Z-BRE4K by its nature is designed to be scalable and adaptable to three different demonstrators, in order to tackle the different production needs.

Another barrier is the behaviour of companies. Most manufacturers and designers are ***reluctant to share their data*** creating a possible obstacle for Z-BRE4K. This is even harder when Z-BRE4K's new prediction and simulation models need studies for each application. This obstacle could be overcome through the documentation and the long evaluation of the requirements for setting-up Z-BRE4K that will allow a roadmap of simple steps to install technologies developed in the project allowing its quick development for any application. Regarding the sharing of data, Z-BRE4K will design specific messages and approach these companies individually having a "trial-period" signing non-disclose agreements (NDAs) to suffice their will of secrecy. The progress of Industry 4.0 over the next years will exponentially increase the number of cyber-physical systems in the production lines, thus facilitating the implementation of Z-BRE4K after the project.

However, there are ***no widely accepted standards in the market for the communication among shopfloor*** h/w and s/w assets and metrology sensors and inspection systems, especially with respect to the data being exchanged and processed (emphasised at EFFRA conference, September-2016). To combat this barrier, Z-BRE4K built with architecture interoperability from the outset, using the concept of machine simulators which may be fed with different physical models of machine systems; IDSs and Data Connectors for interfacing with any metrology/inspection. Z-BRE4K by following widely used standards and working early for its standardisation and certification will make easier its compliance with the already deployed systems.

4. Partners Involved

Mainly technical partners have been involved in overcoming barriers and obstacles to achieve the Z-BRE4K solution.

4.1 Holonix

Holonix has been involved in Z-BRE4K project, proposing his I-Live Machines platform. I-Live Machines is a platform thought for machines' producers that want to have real-time information about their machines and about the status in which they are when products have been sold to their customers. The platform enables to have a picture of all linked machines, for each one it's possible to have details about his production. In Z-BRE4K project, end users SACMI linked his machines sold to his customer CDS. Thanks to ILM, SACMI could monitor the situation to his customer, having information on possible issues and breaks to his machines. At the same time, ILM is a useful instrument also for customers as CDS that could have real-time information of their production, knowing eventual break-down. In Z-BRE4K project, SACMI and CDS monitored the production of "Total caps" and "Total Waste" in a specific timeline. They could have information about the machine status, about their molds, temperature, etc.

Moreover, ILM gave the possibility to have alarm management and maintenance activity management. Through alarm management, it's possible to count and monitor alarms, make analysis on those and understand why they happened. Through maintenance activity management, CDS operators could insert maintenance activities done as preventive, corrective or change of settings actions.

Holonix faced up with some barriers and obstacles during the ILM implementation and development in Z-BRE4K project. They are explained in chapter 4.1.1 and related methods in chapter 4.1.2.

4.1.1 Barriers and obstacles faced

Barriers and Obstacles	Description
Data ownership	Data gathered through ILM in Z-BRE4K project belong to the customer of the machine producer. For this reason, some obstacles emerged when also the producer is interested in having visibility of those data.
Data sources	Data comes from machines installed at the customers' factory, sometimes connection's issues between data sources and ILM could cause gaps in data communication.
Maintenance activities' list	ILM in Z-BRE4K project enables the possibility to insert maintenance activities done by the operators. Sometimes, operators don't use in a correct way the instrument or don't indicate all the activities done.
Data repository	Data gathered contribute to create an historical data repository. Often, a huge amount of data is available but not analysed in the right way.
User acceptance	Users are not always ready and willing to accept new tools and applications in their daily work, as they usually believe that they hinder their work.

4.1.2 Methods to overcome

Barriers and Obstacles	Methods to overcome
Data ownership	To overcome the issue from data ownership, several roles have been created accessing to ILM. Definition of roles have been set discussing with producer and customer about which data they could have the visibility and which others not.

Data sources	Data comes from machines installed at the customers' factory, sometimes connection's issues between data sources and ILM could cause gaps in data communication. For this reason a continuous monitoring of data gathering is guarantee with also notification when some gaps happened. This gives the possibility to intervene as soon as possible and to avoid any kind of missing information.
Maintenance activities' list	ILM in Z-BRE4K project enables the possibility to insert maintenance activities done by the operators. Sometimes, operators don't use in a correct way the instrument or don't indicate all the activities done. This obstacle is also connected to the user acceptance of an instrument. Several workshops and lessons are organized in order to train people on the correct usage of the application.
Data repository	Data gathered contribute to create an historical data repository. Often, a huge amount of data is available but not analysed in the right way. Holonix is working also to integrate ILM with a tool of data analytics in order to enable users to use data in the correct and more useful way. Data analysis is very important to understand main issues and break during production for example, or to improve some actions during work.
User acceptance	Users are not always ready and willing to accept new tools and applications in their daily work, as they usually believe that they hinder their work. Workshops and lessons have been organized to train people and to teach how useful the instrument is and how it could improve their work and minimize some actions.

4.2 Atlantis

Z-BRE4K DSS is a component which implements risk assessment methods and computes KRIs, FMs and FEs and produces suggestion to help the decision-making procedures. The suggestion concern improved predictive and JIT maintenance. The design of the DSS system is based on the Z-BRE4K strategies and its main principles try to simulate much of the strategies logic.

The DSS is a combination of data driven and model driven decision support system. It exploits data inputs of historical and sensorial data, as well as models and methods based on the Z-BRE4K strategies and the risk assessment methods. The system implements a modular architecture with several smaller and independent sub – components. Each sub – component is specifically designed to execute independent functions and operations without interrupting the operation of the other sub – components. The sub – components are developed separately and connected with microservices and they can be reusable. One of the benefits of deploying a modular solution is that the sub – components exist in all integration and installation procedures, but each in each installation, developers are able to activate only the relative ones with the installation. The sub – components which are part of the DSS system are: the Reasoning Engine, the Recommendation Provision, the Maintenance Scheduling, the Event Sources, the Message Queue, the Prediction Module, the Internal Suggestion and Alert System and the Roslyn scripting Mechanism. The system is also integrated with a CMMS which contains a maintenance scheduler for maintenance procedures re - adaptation and there was progress in connecting with IDS connector and creating a containerised version, using docker containers.

4.2.1 BARRIERS AND OBSTACLES FACED

Barriers and Obstacles	Description
Data sources	The existing data on shop floors are coming from the embedded sensors of the machines and the ERP and MES systems on the shop floor describing the manufacturing procedure.
Maintenance activities and procedures not accurately described	Many operations concerning the maintenance on the shop floors are based on the intuition and experience of the maintenance staff. The procedures are not accurately documented and they are performed without exact steps and intervals
Security issues	DSS is a developing application and a security mechanism is not yet implemented.
Shop floor access	DSS is deployed in various shop floors within the Z-BRE4K project. Each shop floor has different security measures implemented and cannot always accommodate a cloud or remote deployment
Message queue reliability	The connection between the data inputs of other components and the DSS happens with messages queues and related topics. The stability and unreliable service when there is not enough data available is one major problem of the message queues.
IDS connectors	IDS connectors are an upcoming technology which will allow factories to interconnect with IoT appliances in the future. The experimental implementation of the IDS connectors within the Z-BRE4K DSS had the disadvantages of the first implementation and all its problems.
Data ownership	Procedures on shop floor create a large amount of data, which are used and processed by the technical providing

	partners. The metadata created can be freely used in the project, but the ownership belongs to the shop floor.
Remote connections on shop floors	Shop floors are protected by fiwares and firewalls and the remote access for installation and integration processes are difficult to achieve.
Stable Internet networks	The installation is done in environments where there is a lot of metal which interferes with the Wi Fi connection with the application. Also, there are limitations to the internet access on the shop floors.
Containerisation	The first version of the application was not designed for containerisation. Containerisation is able by performing a complicated procedure with many steps.
User acceptance	Users are not always ready and willing to accept new tools and applications in their daily work, as they usually believe that they hinder their work.

4.2.2 Methods to overcome

Barriers and Obstacles	Methods to overcome
Data sources	New sensors were installed on the shop floors based on the description of the use cases and the needs the end users presented for their procedures.
Maintenance activities and procedures not accurately described	The maintenance activities were documented and a lean methodology with exact steps were implemented. The documentation of the maintenance activities is inserted in the DSS to created the schedule re – adaptation of the maintenance procedures based on the daily shop floor needs.
Security issues	An authorisation and authentication mechanism is implemented in the DSS solution. The mechanism will authenticate the users with their passwords and allow access in the system based on the correct identification of the user.
Shop floor access	End users were trained to installed the application on the shop floor. The end users also bought dedicated servers and terminals were the component installation is done, creating

	a branch network outside the shop floor's hardware network.
Message queue reliability	Creation a reliable message delivery in the message queues with replays of messages and definition of idle times. Also, definition of idle messages when there is not data in the queue in order the system to remain stable.
IDS connectors	First integration of the IDS connectors with the development of an outside application which allows to transfer messages by tackling the different data base schemas and limitations.
Data ownership	End users clearly declare that the data and meta data belong on the shop floor and the use of it is done only in the project's limits.
Remote connections on shop floors	Configure the applications against the rules of the Fiwares and firewalls of the shop floors in order to work behind the shop floor. Configuration follows the security rules of the shop floor where the installation is done.
Stable Internet networks	Creation of stable Wi Fi networks and chose places on the shop floor where the signal is strong. Also, implement other network solutions on the shop floor, such as dedicated LoRa networks.
Containerisation	Change the development platform of DSS to .Net Core in order to containerise the application with the minimum steps.
User acceptance	Training sessions with the end users are designed in order to train the personnel using the application. Also, based on their comments about the system's user interfaces developments are done for improving the UIs of the system and the user acceptance to increase.

4.3 TRIMEK

As a leading provider of metrological solutions and systems, TRIMEK participates in Z-BRE4K project, incorporating into the industrial environment a metrological solution capable of adapting and connecting in line with the requirements of the production process for the GESTAMP use case. For this, TRIMEK incorporates two different components (M3Gage and M3 Software) in Z-BRE4K, which despite describing them separately, are only one HW and another SW component of the same joint solution.

M3 Gage it does not only consist on a type of Coordinate Measuring Machine (CMM), it is also compound by the rest of physical assets that are required on the metrological framework (3D scanner & part fixed on the checking fixture). This means that M3 Gage is a dimensional inspection system specifically designed for in-line inspection, ergo M3 Gage is integrated in the shopfloor and not in a parallel scenario(laboratory). With M3 Gage, parts can be scanned and through M3 Software, TRIMEK is capable to digitize parts to obtain a virtual part with high accuracy from which different data can later be obtained (geometries, CAD comparison, dimensional deviations…) applying a GD&T analysis.

Regarding M3 Software, as it has been described before, is a module attached to the M3 Gage, draws on the data it generates making a translation from the cloud point to a digital twin of the measured part and with it, conduct geometrical dimensions analysis in order to gain knowledge about the quality of the part.

In addition to M3 Software, TRIMEK has developed the M3 platform that has other tools that increase the capabilities that the metrological framework can bring to the production process. For example, M3 Analytics module is a powerful tool that enables the visualization, the statistics analysis and the reporting operations related to all the data stored in the cloud by means of several algorithms and computational components. The M3 platform serves as a data repository as well as allows the interconnection of information from various sources using a format that can be used by the M3 Analytics module.

In the Z-BRE4K context, M3 Gage and M3 Software are data provider components in order to feed the Machine Learning components that will generate the predictive maintenance guidance. From M3 Gage, data will be gathered remaining operative conditions of the CMM and from M3 Software, quality control data from the dimensional inspection will be gathered in order to correlate it with the stamping and welding process from GESTAMP.

4.3.1 BARRIERS AND OBSTACLES FACED

Barriers and Obstacles	Description
In-field integration	M3 Gage must be integrated in line, this entails the challenge to find a new and optimized layout of the production process, and also is a challenge to operate on the quality control system at the industrial process cadence.
Shopfloor operation synchronization	On the one hand there is the ease of access to the pre-industrial production plant equipped in the AIC facilities to all the participants that we are located in there, but on the other hand, there is a synchronization need between the different stakeholders for the alignment of the use case and project objectives.
Sampling continuity	As it is not a real production environment, this is tested on a testing facility, it is a challenge to properly test all the

	variables that may influence on the production quality and the machine operation.
Fixturing of the stamped parts	SMART FACTORY parts present different models of the same family parts (Nominal, Wide & Narrow), that have a dimensional difference after laser cutting. Due to this, a complication arises when developing a flexible checking fixture that can be adapted to the different models of the part.
Sensors Data	Vulkan type CMM present few sensors integrated on the machine but there is no chance to interact with the machine log to gathered the data defined as required to feed the predictive maintenance analysis of the CMM.
Digitalisation parameters	As the metrological framework will be fed by different models of the SMART FACTORY parts, there is a need to improve the identification system that automatize the scanning program required for every part to be measured.
Data Availability	The data of the digitised part should be available to all people involved in the GESTAMP Use case, but properly protected against visualization by others.
Data Persistence	Every digital copy of the parts measured carries a volume of several MB. Depending on the final number of measurements and the need of a long-term storage, possible needs to expand the storage system must be taken into account.

4.3.2 METHODS TO OVERCOME

Barriers and Obstacles	Methods to overcome
In-field integration	The integration of the M3 Gage with the SCADA/MES system controlling the production system will ease the in-line operation. Anyway, it will be enough to have a proper identification of the stamped parts to provide traceability between the stamping process and the quality control process.
Shopfloor operation synchronization	Improve communication and carry out a greater joint monitoring of the activities carried out in Z-BRE4K related to the use case.

Sampling continuity	Attempts have been made to work with series of manufacturing batches, trying to collect parameters with some continuity of operation.
Fixturing of the stamped parts	The usage of a 3Dscanner, ease the design of the flexible fixturing tool.
Sensors Data	New sensors are going to be installed on the Vulkan type machine in order to gather all the relevant data required for the predictive maintenance analysis.
Digitalisation parameters	SMART FACTORY parts present a QR code so that previous to the measurement, the kind of part is identified.
Data Availability	The usage of IDS Connectors will facilitate the secure exchange of these datasets.
Data Persistence	M3 Cloud Platform should be big enough for the whole quality control and sensor data storage.

4.4 INNOVALIA

INNOVALIA as a recognized as a R&D technology center, leads the Spanish Competence Centre on Cyber Physical Production Systems and is a key partner of the Autoware framework creation. Autoware is a H2020 European project that defines a new Autonomous Factory Ecosystem incorporating new generation tools and decision support toolboxes capable of supporting CPPS and digital services cloudification, robotics systems, reconfigurable cells, etc. providing a more seamless transfer of information across physical and digital worlds. In this sense, one of these tools that the Autoware framework incorporates is the IDS Connector. This is the component that INNOVALIA brings to Z-BRE4K.

An IDS connector is an open IoT edge gateway platform and an implementation of the Trusted Connector in the Industrial Data Space Reference Architecture, following the DIN Spec 27070 and ISO 62443-3 standards with the aim of connecting sensor data with cloud services and other Connectors using a system or protocol adapter.

At Z-BRE4K, INNOVALIA is responsible for the implementation of IDS Connectors on the Gestamp use case, in order to acquire, process and transmit the sensor data coming from the CMM (Component: M3 Gage) and the quality control data coming from the component M3 Software.

In the case of the sensor data coming from the Coordinate Measuring Machine, the machine control will transmit log files (OPC-UA standards) with the sensor data to the M3BOX, that will be the edge computing device acting as IDS Connector. M3 BOX will integrate a system adapter able to collect the sensor data, transform it to NGSI, and publish it on the Orion Context Broker.

In the case of the quality control data coming from M3 Software, this data will be transferred to the M3BOX as well, acting as the IDS connector, but in this case, using the Quality Information Framework (QIF) standard. TRIMEK has built the custom agent (system adapter) that can easily transform QIF into NGSI and then publish it on the Orion Context Broker.

4.4.1 BARRIERS AND OBSTACLES FACED

Barriers and Obstacles	Description
Data sources, interoperability	There are two main different data sources coming to the M3BOX on different standards, these means that there should be included more than one system adapter to transform into NGSI.
Data Usage Control	M3Gage and M3 Software are connected to the M3BOX and all the data flows to it and as it acts as the IDS Connector, there should a management system to control the data published on the OCB.
Secure data sharing	Industrial partners are not entirely comfortable with product and process data sharing and much less through the cloud.
Internet network	Currently the testing facility present some limitations to the Internet access. There are some low frequent temporary drops in the line. This can cause errors in uploading data to the cloud.
Data ownership	As it has been described before, several stakeholders participate in the use case and the global dataset that will be exploited by the Machine Learning tools is generated proportionally by different partners.

4.4.2 METHODS TO OVERCOME

Barriers and Obstacles	Methods to overcome
Data sources, interoperability	Some work has been done previously in order to gather data transmitted in common standards to facilitate the development of system adapters, since similar adapters have probably already been developed previously.
Data Usage Control	Every IDS connector should include the LUCON framework for Logic Based Usage Control. These means that IDS connectors may have the ability to document and control data usage.

Secure data sharing	IDS connector presents the guarantee of a trustworthy data exchange, as each component is certified, verifying the implementation of generally accepted safety standards and mechanisms and also can be identified. It is important remark that data sharing is about a peer-to-peer network, so that only the participants can exchange data bilaterally and there is no central authority that can be corrupted.
Internet network	There is a mid-term future plan for the implementation of 5G on the AIC testing facilities that will solve this problem.
Data ownership	Previous to the exploitation of this data, all stakeholders must agree with the idea that the metadata created can be freely used in the project, but the ownership belongs to the shop floor.

5. CONCLUSION

In deliverable D5.5, HOLONIX, ATLANTIS, TRIMEK and INNOVALIA described the solution they brought in Z-BRE4K project. During this implementation, barriers and obstacles emerged. These "issues" have been overcome through methods described in this document that will be for sure used by these actors, in future development, both in other EU as well as in commercial projects.