SPRINT4.0

HANDBOOK

A PRACTICAL GUIDE TO IMPLEMENT THE SPRINT4.0 METHODOLOGY

INTELLECTUAL OUTPUT 6

Co-funded by the Erasmus+ Programme of the European Union

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FOREWORD

The Project "**SPRINT 4.0 | Strategic Partnership for Industry 4.0 innovation advanced Training**" is co-funded by the European Commission, Erasmus Plus 2017-1-IT02-KA203-036980, Cooperation for innovation and the exchange of good practices. It started in 2017 and foresees a duration of 36 months. The project is promoted by the University of Pisa (Department of Civil and Industrial Engineering), University of Bremen (BIBA), URL- La Salle, TOI, Fondazione Giacomo Brodolini, SELETTRA, OHS, Barna Steel SA.

A synthetic description of project context, methodological approach and a comprehensive review of best practices collected and discussed by project partners can be found in the project website: www.sprint40.eu.

This Handbook provides a detailed overview of project activities implemented by the project promoter and the partners and in particular: the courses and the **methodological approach**, including a collection of **good practices**; a description of the **general guidelines** and **shared principles**.

1.
INTRODUCTION

This handbook describes an innovative approach that mixes theory and practice into a program where Universities, Technology Providers and Target Companies work together to create new professional profiles able to manage the impact of the fourth industrial revolution on companies. This guide will help European Universities and Research Institutes to design new courses and to adapt their curricula to the innovations and the opportunities brought by Industry 4.0. The guide is designed to be easily transferable and exploi able to other Universities

LINK BOX

Further information are available in the following links:
About - https://www.sprint40.eu/about/

1.1 Project context

The studies conducted by Staufen[1] between 2014 and 2016 reveal a scenario in which the opportunities offered by the Industry 4.0 turn out to be an unexplored frontier by most companies. At European level, around 75% of managers are not sufficiently skilled on Industry 4.0 topics. Nearly 70% of Italian companies surveyed said they had not yet done anything about Industry 4.0 or started an initial study.

The studies show that the company functions in which the Industry 4.0 can have the greatest impact are the production, logistics, sales, and research & development, but often companies lack the knowledge and skills needed to embrace the new paradigm. The situation within the company shows that both the awareness and the skills of employees with respect to the 4.0 subjects are very limited regardless of the business function taken into consideration.

One of the major obstacles to the development of Industry 4.0 is the lack of digital culture within European companies and its spread can only happen by training highly professional figures.

In this context the partnership recognized that entrepreneurs and future employees need to increase their skills and competencies for what concern digitalization and Industry 4.0.

To face these needs, the Project proposed to create an innovative approach for training and support, aimed at increasing the successful im-

[1] AG Staufen - Deutscher Industrie 4.0 Index 2017

plementation of Industry 4.0 innovations and initiatives of European companies and ventures.

Indeed, the project was designed for students (from bachelor/Master courses or PhD students), but also industrial players that will work in digital Industry, but do not have all the competencies to face the new era of digitalization of the industry.

THE FOURTH INDUSTRIAL REVOLUTION AND HIGHER EDUCATION

The impacts of the emerging the Fourth Industrial Revolution technology in economic and environmental terms alone will require a drastic rethinking of the curriculum within higher education to enable students both to understand the individual technologies in detail and to be able to thoughtfully analyze and predict the evolution of connected systems of technology, the environment and socio-political systems.

The Fourth Industrial Revolution STEM curriculum[2] will need to focus on emerging technologies - robotics, AI, IoT, biotech - to provide a workforce not only able of developing new applications and products, but

[2] Science, technology, engineering, and mathematics (STEM) is a broad term used to group together these academic disciplines. Rather than teach the four disciplines as separate and discrete subjects, STEM integrates them into a cohesive learning paradigm based on real-world applications.

also able of interpreting the effects of these technologies on society and using their training to provide sustainable and ethical uses of science and technology.

More than any particular content area, curriculum needs to help students develop the capacity for ethical reasoning, for awareness of societal and human impacts, and to be able to comprehend the impacts of Fourth Industrial Revolution technologies on people, so they are trained to not only increase our material prosperity but also to improve our social and cultural fabric.

Higher education needs to recognize the need of adapting and scaling up these new Fourth Industrial Revolution forms of education rapidly to assure the sustainability of our environment and economy, as well as to sustain the relevance of higher education as a responsive and vital component of society. Taken together, these new forms of Fourth Industrial Revolution education will prepare both students and faculty for leadership roles in a world of rapidly accelerating change, with a curriculum that develops both technical mastery and a deep awareness of ethical responsibility toward the human condition.

1.2 Project objectives

Based on the new training and business needs that have emerged in recent years, the project aimed to:

- Providing target groups with a full set of skills in both Industry 4.0 and entrepreneurship fields;
- Promoting the collaboration between universities and industry and facilitating the transfer of innovation and the knowledge exchanges;
- Providing students with a full set of skills to increase their employability;
- Providing students with entrepreneurial skills in case they would like to start their own business in an Industry 4.0 related sector;
- Creating an innovative educational model to be adopted by other Universities.

The training courses have been designed to cover both the managerial concepts as well as the enabling technologies. The courses had a strong orientation towards the industry's needs and problems and will provide the students with the knowledge to create flexible, problem-oriented solutions.

Industry 4.0 is a paradigm that concerns all of Europe. However, some of the EU countries have more experience and specific interests in the domain of them have already conducted experiences that they could be shared. We selected the partner countries and built our team according

to some considerations: Germany is the pioneer of Industry 4.0 and an industrial power, Italy is one of the most important markets in EU and the second manufacturing leader in Europe, Spain is growing fast after a period or crisis, also thanks to an increased focus on IT (central in Industry 4.0 paradigm). These countries have already started working on Industry 4.0 for addressing educational and training needs.

European cooperation was also essential for mainstreaming the project results. Thanks to the Partnership's networks, the project results reached a vast number of people among the target groups not directly involved in the project and other interested stakeholders.

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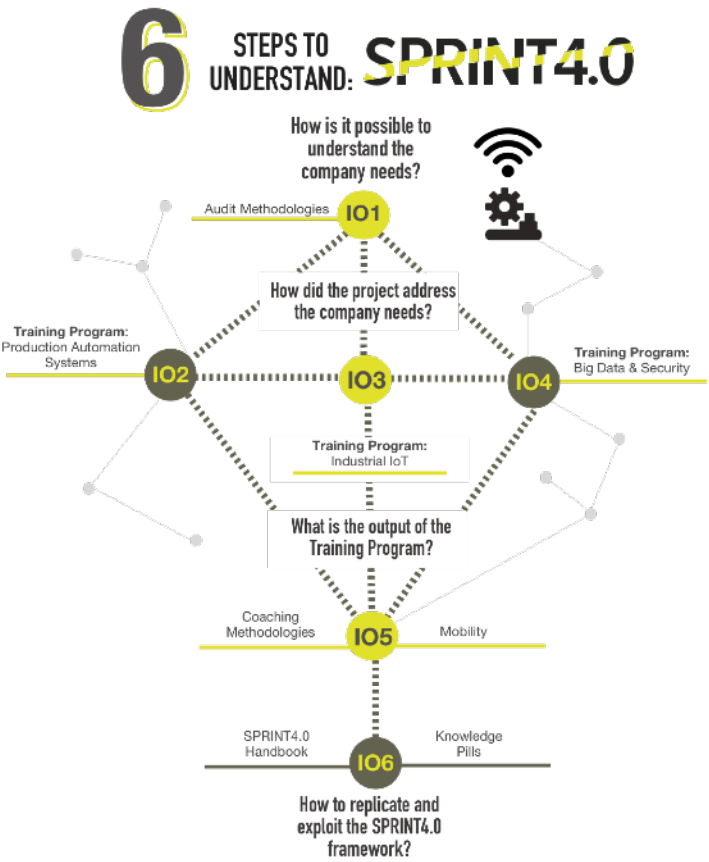
Further information are available in the following links:
SPRINT4.0 Final Video:
www.youtube.com/watch?v=fMHQWFDR5gA

1.3 Activities

The implementation of the project was focused a roadmap that aimed to describe the steps required to understand the SPRINT4.0 approach. In particular, the implementation is driven by key questions depicted in the following scheme.



HOW IS IT POSSIBLE TO UNDERSTAND THE COMPANY NEEDS?

The starting point of the project is to understand the company needs. The aim is to fill the gap between the actual demand of companies in terms of skills and technology. In order to answer to this question an assessment system, called **Audit**, has been developed for the Intellectual Output 1 (IO1).

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Further information are available in the following links:
Results - https://www.sprint40.eu/results/

HOW DID THE PROJECT ADDRESS THE COMPANY NEEDS?

Once the company needs are identified, there is the need to address some actions to satisfy those needs. The answer of the SPRINT4.0 project is the development of a 5-day training course focused on giving to the student the right knowledge and skills to acquire. This led to the implementation of three intellectual output:

- Intellectual Output 2 (IO2) - Production Automation System
- Intellectual Output 3 (IO3) - Industrial Internet of Things
- Intellectual Output 3 (IO4) - Big Data & Security

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Further information are available in the following links:
IO2 - Production Automation System - www.sprint40.eu/production-automation-systems/
IO3 - Industrial Internet of Things - www.sprint40.eu/industrial-internet-of-things/
IO4 - Big Data & Security - www.sprint40.eu/big-data-and-security/

WHAT IS THE OUTPUT OF THE TRAINING PROGRAM?

The Training Program implemented as three Educational Packages led to the answer of the next question. The aim of the Training Program is to inform students about technology, methodologies and techniques. However, the SPRINT4.0 approach gives the possibility to face real challenges for the students, by implementing the Coaching Methodologies, output of the Intellectual Output 5 (IO5).

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Further information are available in the following links:
Results - https://www.sprint40.eu/results/

HOW TO REPLICATE AND EXPLOIT THE SPRINT4.0 PROJECT?

This innovative approach of training it has been useful for companies, universities and students. SPRINT4.0 aims to provide to the international scenario an approach ready to be replicate in other universities with other topics. In order to make possible this exploitation the Intellectual Output 6 (IO6) provides an understanding of the approach publishing a series of Knowledge Pills and this handbook.

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Further information are available in the following links:
Knowledge Pills - www.sprint40.eu/knowledge-pills/

2.
THE SPRINT4.0 APPROACH

This section describes some of the steps required to understand the SPRINT4.0 approach. In particular:

Section 2.1 Audit Methodologies: it answers to the question on "*how is it possible to understand the company needs?*"

Section 2.2 Educational Packages: it answers to the question on "*how did the project assess the company needs?*"

Section 2.3 PrEtotype Competition: it answers to the question on "*what is the output of the training program?*"

Section 2.4 Coaching Methodologies: it answers to the question on "*what is the output of the training program?*"

2.1 Audit methodologies

Facing the challenges coming from the Fourth Industrial Revolution can open different levels of difficulties depending on the typology of the company taken into consideration. On the one hand, big corporations seem to be much more ready to deal with the new paradigm, on the other hand SMEs often lack the awareness and the resources to join the revolution. The audit methodology helps companies to understand possible opportunities and threats coming from Industry 4.0. It supports companies during the first steps of identifying and implementing solutions based on Industry 4.0 concepts.

Its goal is to provide auditors with a guide to follow when performing the Industry 4.0 assessment. It gives the auditor an overview on reference models at the basis of the assessment and explains how to conduct the evaluation correctly by investigating each relevant aspects of companies' organization.

The development of the audit methodology should include the main approaches, standards, and models already used by researchers and practitioners to analyze other dimensions of companies such as processes and management systems. The audit methodology proposed in the project was inspired by management systems standards (ISO 9001 and ISO 19001) and Industry 4.0 reference model (DIN SPEC 91345:2016 standard). These reference models have been complemented by Acatech STUDY that focuses on providing an approach to investigate companies' Industry 4.0 maturity index.

The audit methodology must be designed to create a path that would raise the awareness of entrepreneurs regarding the level of digital maturity of their companies, and that would favour the implementation of the most suitable solutions according to the current situation of the company. The audit methodology provides the company with a detailed picture of its digitalization level by investigating all the different business areas.

HOW TO PERFORM AN ASSESSMENT

The assessment should be conducted by an external auditor (who has the basic skills to understand the Industry 4.0 technologies and to evaluate the organizational structure and the corporate culture) through a visit to the company lasting at least one day.

The first part of the visit should take place through an interview with some managers of the company involving the person who best knows the business processes). Instead, the second part of the visit should take place in the operational unit of the company (i.e in the factory) so that the consultant conducting the assessment can see with his own eyes the company's reality.

The visit has the purpose of filling a check-list that represents the starting point for the preparation of the assessment report.

To perform the audit most efficiently, it is crucial to design a plan which identifies the rules to perform and iterate the assessment over time. The auditor is the key person for the execution of the audit, she or he is an expert concerning such kind of activities and has the responsibility to lead the audit. The auditor merges the knowledge on the topic of the audit to lead with a deep understanding of the audit requirements, which enables her/him to evaluate the compliance between the evidence and the audit requirements. Moreover, the auditor might have

some personal attitudes which can facilitate the execution of the audit among which independence, integrity, impartiality, and confidentiality. The ideal profile to perform the Industry 4.0 maturity assessment is a consultant that already executed audit for quality and environment management systems.

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Link to download the **Audit Methodologies**
https://www.sprint40.eu/wp-content/uploads/2018/10/IO1-Audit-Methodologies.pdf

2.2 Educational packages

The Training Course will aim to support students in elaborating on actual Industry 4.0 applications. It will be designed to cover both the managerial concepts, as well as the I4.0 enabling technologies, and it will provide the students with the knowledge to create flexible and problem-oriented solutions. It is appropriate that the design of the Training Course will be performed by each Academic partner in each participant country, with the support of the partner companies and the partner provider of technologies.

To involve student participation, one of the incentives that could be used is the recognition of the ECTS internal recognition process. It is, therefore, necessary to structure the duration of the course to make internal recognition possible; for example, the average duration of the course in the Sprint 4.0 project was between 25 and 30 hours.

The structure of the course must be as blended as possible, to encourage constant involvement. An idea could be to provide, during the first two days, about 4 hours of lessons introducing the general aspects of Industry 4.0 (Common lesson), to contextualize the whole course and to introducing the specific classes, during the 3rd day. The last two days will focus on practical with the introduction of pretotype competition.

Below is a brief description of the characteristics of the lessons:

- The common parts aim to outline the definition of Industry 4.0 using a market-oriented approach, to understand how the technologies are fitting the needs of the market and companies, and a business-oriented approach, understanding how technologies could solve problems in each stage of the value chain.

- The specific lessons will leverage the strong background that each University has in the specific topic both in research and technology transfer.

Each method or technology dealt in the course should be presented as follow:

- Description;
- Main advantages;
- Main disadvantages;
- How each technology connected to the other elements in the company (elements of Industrial IoT);
- Real Cases.

One of the course aims to give the students the proper tools to solve the challenges.

APPLICATION PROCESS

Since the course will be designed for students and industrial players, each university will active a promotion process using the University channels. Through communication tools such as brochure, posters, etc., the activation of the course will be channelled on the University website and showcases, on the project website, but also on the several communication platforms of the local environment, to connect with the industrial players.

To participate, the candidate will apply for the course following a selection procedure. The general idea could be the following:

1. Compile the selection form;

2. Evaluate the candidate (compliance with the requirements and ranking);

3. Communicate to the candidate the results of selection process.

It is possible to extend the suggested procedure due to possible specific University requirements (such as intra-faculty/department enrollment procedures).

The submission of the application form aims at assessing the commitment and the real effort that participants would be willing to put on the course activities. As agreed by the partnership, students from Humanities will not be admitted, while the focus will be just on students from technical and business faculties. In order to be selected, a candidate will be evaluated following basic and extra requirements

The basic requirements are:

- English
- Communication Skills
- Context knowledge

The extra requirements are:

- Technical and Content Knowledge of the specific field of course
- Experience (work, travels, extra-curricular course, projects, etc)
- Motivation

To select a candidate there will be no oral interview, so that, the selection form should address the evaluation of the needed skills.

THE EVALUATION

Course evaluation is a fundamental feature for monitoring the achievement of the project objectives. Surveys are easy to create and download and provide an efficient way to monitor and evaluate learning, saving time for educators while delivering interactions for learners. Among the planned activities, it is possible to launch quizzes, polls and questions, receive exit tickets or ask instant student feedback.

It may be useful to handle daily and end of course surveys to evaluate the single lessons and identify thematic clusters, such as:

- Clearness of course objectives and coherence of the agenda structure
- Interactivity of the course
- Relevance of the topics presented and quality of the delivery
- Relevance and usefulness of exercises and project works
- Overall evaluation of the course

LINK BOX

Further information are available in the following links:
IO2 - Production Automation System - www.sprint40.eu/production-automation-systems/
IO3 - Industrial Internet of Things - www.sprint40.eu/industrial-internet-of-things/
IO4 - Big Data & Security - www.sprint40.eu/big-data-and-security/

2.3 PRETOPTYPE COMPETITION

One of the peculiarities of the project is a launch of prEtotype competition to select the teams that will be awarded a free coaching support path consisting of two parts, one conducted by the Universities, another conducted in transnational mobility within the target companies.

After about 4 hours of introduction to the challenge (during the Training Course), the students will have one month to develop their prEtotype in a group of 2-3 members. Delivery and the positive evaluation of this assignment will allow the Universities to recognize ECTS for the students, which could be an incentive.

One way of organizing/programming the PrEtotype Competition could be the following:

- Introduction of the two challenges on the second to last day;
- The challenges will be presented by companies through a structured presentation to explain the cases to solve. Companies will also show the challenge canvas already prepared;
- Q&A on the challenges on the last day of the course;

- Companies will be also available for giving clarification on their challenges during the month of prEtotype preparation with each group;
- The prEtotypes will be presented common guidelines among the students, and they will be presented to the University, to the target company involved and the companies;
- Teams will be evaluated by the partners taking in consideration the Target Company objectives and applicability of the proposal as pilot case;
- The team winning the competition will receive a certificate for the challenge (plus the ECTS). All the other teams will receive a participation certificate (plus the ECTS)

HOW IT WORKS THE MOBILITY

The mobility and the possibility of testing the new solution within the company represents an excellent experience for students and entrepreneurs. The mobility activities can regard a selected group of students participating in the programs and involve a selected group of participants in the activities promoted and developed within the SPRINT4.0 program. Each sending institution (better if Partner Universities) will select a startup team consisting of a maximum of 2 participants. Each team will participate in the mobility within one of the partner companies for a period sufficient to develop the prototype.

The selection of participants can be made in each sending institution using a specific assessment form. Since mobility aims to help innovative startups to reinforce their business ideas by experiencing a real entrepreneurial environment the criteria should be identified starting from the principles of:

- the originality of the idea/project;
- business idea innovative potential;
- feasibility of the idea;
- experience and background of teams' members.

To ensure the success of experimentation should be designed a framework within which the Sending Institutions (e.g. Universities), while the Host Organizations (e.g. Partner Companies) are in charge of receiving the participants, offering them a training program and supporting them in the business development.

Furthermore, before starting mobility, the Sending Organization and the Host Company should identify a Tutor that will be the contact person for the participants involved in the exchange and will write a learning Agreement, dedicated to the learning outcomes that each participant has to achieve through the mobility. University and participants will draft a list of objectives and a possible program and will share this document with the Hosting Companies.

2.4 Coaching methodologies

During the mobility, Target Company staff works closely with the students, implementing a pilot project to develop a proof of concept. With a coaching methodology it is possible to enable co-creation experiences within Target Companies, University and students.

These coaching methodologies merge a technology-oriented approach with a real problem-solution focus driven work.

One of the goals of this coaching activity is, to support the students implementing their application to have a better understanding on the effectiveness of the workshops done during the Training Courses and the results of what the students design as Pretotype. The mobility, supported by the coaching methodologies, will help students to put into practice what they learnt during the course, and will give the Target Companies the possibility to guide them to reach tangible results to develop Industry 4.0 applications solving real problems.

The "application oriented" coaching methodology is based on a monitoring and evaluation plan that can help to ensure the right quality of skills acquisition for the students. It is important to have a monitoring and control the collaboration as a good understanding of the impact that it can have both on the students and host companies.

A structured workload plan could support students in the development of their projects, assigning the achievement of specific tasks and setting during weekly meetings.The weekly meeting aims at assessing the status of Solution Implementation and Specification. Every meeting has the objective to report all the activities performed by the students during the mobility, updating the status and describing any changes occurred in the development of the Proof of Concept.

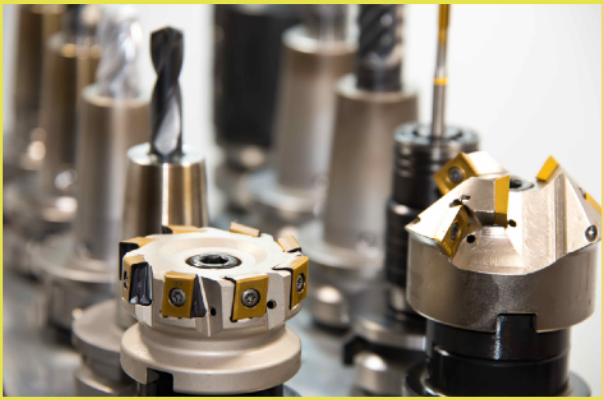
At the end of the mobility period, it may be useful to draw up a final report whose goal is to check the results of the work done by the students during their mobility, like:

- Problems occurred during the month;
- What are the tasks missing to finalize the prototype;
- What are the resources missing to complete the prototype
- What is the additional time needed to complete the prototype
- What are the additional resources needed to complete the prototype

COACHING METHODOLOGIES SCHEMA

Problem Description	In this section, it is necessary to describe the problem of the company where the students are going to solve the challenge presented during the course. It is important to introduce the company, the requirements and the key points of the problem.
Solution Description	In this section it is necessary to describe the solution proposed by the students, with details (technological components, Architecture of the solution)
Scope Plan	In this section, the proof of concept to be deployed. Goal: In one sentence, describe the proof of concept. The purpose toward which an endeavour is directed Objectives: Describe the objectives of the mobility using the SMART criteria (ideally speaking). Work Packages: Divide the work to do to achieve the goal and the objectives.
Chronogram	In this section it is necessary to describe the duration and dependences between tasks
Resource Plan	In this section, the resources for the deployment of the proof of concept are defined. - Resources: Hardware, sensors, software, licences, etc. - Cost limited: This mean that the budget of the project is 0€. It will be preferable to use Open Source software or low-cost solutions for the proof of concept. - Task related: It is necessary to identify the related tasks to the resource.
Quality Plan	In this part it is necessary to define which tests are going to be necessary to ensure the solution. Also, when these tests are going to be deployed and how. Finally, the expected result of this test and the alternatives if the result is not what is expected.

3.
THE GOOD PRACTICE



One of the characteristics of the project was the possibility reserved for students to be able to create their pretotype within the company. The good practice that we report is the experience lived by 5 of the students who participated in the training course of La Salle at OHS, an aviation manufacturing company with some needs and requirements related to design and implementation of a new maintenance plan and logistic forecast.

3.1 Problem description

OHS' current business focuses mainly on aviation industry maintenance services. This industry requires all processes tracked. Every maintained item reported at a given moment as a consequence of it, documentation has to be generated. The first-tier supplier must receive feedback, re-certifications, and reports as soon as possible. Until now, all of this had been done manually.

All information is manually stored in an Excel spreadsheet. Furthermore, each time a report needs to be filled with insights and stored in the spreadsheets, an employee needs to analyse and select relevant information. Both processes are time consuming; thus, this time is wasted, and it could be used in something else.

There are seasonal peaks in which hangars are closed, and the tools are not maintained. After the holidays are over, there are many more tools to be maintained than average, creating peaks and overtime. There should be a pre-alert system that notifies OHS that a critical season is coming and try to get coordinated with the hangar's management staff, so more tools are picked up before the recess starts. The problems to be tackled are:

1. Create a database to stop relying on Excel.

2. Gather all the insights automatically, rather than manually.

3. Avoid daily phone calls.

4. Better seasonal peaks management.

5. Advanced common spare parts purchase.

6. Create reports automatically (just one click).

7. Gather information such as which parts tend to break more often and why, or how many screws get lost.

3.2 Solution description

Most of the OHS's procedures have one element in common, they are made up in an old-fashioned way. One of the most relevant problems detected is provoked using obsolete and inefficient methods instead of automatic ones. A clear example of it is the fact that all data and information registered in excel sheets and, consequently, a cascade of problems emerge.

The app allows OHS employees to log in into the app and select an item identified previously, then set the parameters, e.g. corrosion level, and what needs to be done. After this, the information will automatically be sent to the database. As mentioned before, tools are uniquely identified with an NFC tag. Once the item to be maintained is at the OHS facility in Bremen it is scanned and monitored. Time spent within the facility is measured too. The responsible person will be able to check out in the app if the element being maintained needs a re-certification or not. If it does, the "create report" option selected within the app and a report automatically generated, a copy of it may be printed/sent to the customer if desired. At the same time, a copy stored in the database. When the item leaves the facility, it is detected/scanned again, and it goes out for delivery. The information gathered throughout the previous process will be analyzed with BI and visualization tools. Each role type within the company will have access to a different set of information within the app. This information will be presented in different dashboards to display what is relevant. Moreover, some roles such as "Administrative Staff" will get notifications with important information such as when a peak season is coming. This kind of user will

need to use more secure ways to login to the app, such as two-factor authentication, as they can access restrictive information.

An additional improvement proposal is Machine Learning predictive algorithms to reduce reactive maintenance interventions and establish a more accurate preventive maintenance schedule. Once we have enough data (structured or unstructured pre-processed) it's possible to remove the outliers and clean it up by filtering the noise. Sometimes pre-processing is necessary to reveal additional information that may not be apparent in the original form of the data. For example, converting a time-domain data to frequency domain may help us extract some useful features, also referred to as condition indicators. These used to distinguish healthy from faulty condition.

INTELLECTUAL OUTPUT 6 - HANDBOOK

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STATEMENT OF ORIGINALITY

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