D4.3

Smart Factory Experimentation Report

WP4 Smart Factory Trials: instantiation, adaption, experimentation

Document Owner: PIACENZA
Contributors: Ignacio Arconada (TRW), Oscar Lázaro (INNO), June Sola (INNO), Pierluigi Petrali (WHIR), Mauro Isaja (ENG), Alessandro Canepa (PIAC), Marco Masetti (SOFT), Jesús Benedicto (ATOS)
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Please avoid using BPI. Replace all by BPI (Business Performance Indicators) throughout the whole document. The indicators defined using the ECOGRAI simplified method are not Key indicators, referring to Guy here. Also add BPI to list of abbreviations.

The Executive Summary states that the document contains “Final values of the BPIs”. BPI are measured three times during FITMAN, namely ToBe1, ToBe2 and ToBe3 values. So far only ToBe1 and ToBe2 have been collected. The final BPI (ToBe3) will be collected at M26.

Note also that Chapter 4 #Trial 5: PIACENZA do not contain any values for the indicators.

Section 1.2: The Deliverable d4.3 is due at M24 (not M21)

Section 1.2: We have only 10 trials in FITMAN (not 11)

Section 1.2: Please align with Amendment #3, D7.2-3-4-5-6 FITMAN Recommendations and Best Practices M24 Merged together into D7.3 (first edition)

iii. New: D7.4 FITMAN Recommendations and Best Practices Final Edition M30

Section 4.2 (Piacenza) Experimentation Plan. The content of the RoadMap table is unclear.
- What Months?
- What is the meaning of 1, 2 and 3 on the columns?

Some minor comments inserted in the text. Also yellow highlighting is used
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Executive Summary

D4.3 – Smart Factory experimentation report - summarizes the activities of Task T4.3 - Running Experiments for Smart Factory Trials.

The three WP4 trials have conducted in the Smart Factory facilities provided by the three manufacturing enterprises. Other main beneficiaries, one per trial, have heavily involved with the aim of scientific/technical support. ATOS has been responsible for transferring results from other WPs to WP4 and for the overall technical coordination of the Smart Factory trials. In comparison with its original version the partner involved have become TRW (automotive), Piacenza (textile), and Whirlpool (white goods).

In order to accomplish with the objective of the T4.3, the document is structured in order to reflect the following information for each Trial in the Smart Factory domain:

- Is defined the final workflow diagrams of each BPs integrating all the components, including the new Specific Enablers coming from the Open Call.
- Is described the experimentation plan carried out by each trial and also the procedure for the data gathering.
- Is indicated which data has been measured and processed (e.g. the outputs of the system) and how they have been gathered. Mainly gives visibility about:
  - What data has been measured and managed in the trial
  - Type/size/volume of the data
  - How the BPIs have been measured using these data
  - Final values of the BPIs

In the final composition of this deliverable, the different Trials from the Smart Factory domain have participated actively. To provide the specific and technical content of the deliverable, a new chapter in the FITMAN Trial Handbook has been created in order to request for the concrete required information. It is also very important to remark that the work done has been as much aligned as possible with WP5 and WP6, which are responsible for the Digital and the Virtual domains respectively.
### Acronyms and Abbreviations

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
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<tbody>
<tr>
<td>FI-PPP</td>
<td>Future Internet Public-Private Partnership</td>
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<tr>
<td>FoF</td>
<td>Factories of the Future</td>
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<td>SF</td>
<td>Smart Factories</td>
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<td>Use Case</td>
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<td>GE</td>
<td>FI-WARE Generic Enabler</td>
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<tr>
<td>RI</td>
<td>Reference Implementation</td>
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<td>SE</td>
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<td>Trial-Specific Component</td>
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<td>FITMAN Platform</td>
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<td>TP</td>
<td>Trial Platform</td>
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<tr>
<td>TIC</td>
<td>Trial Integration Component</td>
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<tr>
<td>BPI</td>
<td>Business Performance Indictor</td>
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1. INTRODUCTION

1.1. Overview

This deliverable includes the history of the Smart Trials experimentations and the monitoring of the continuous evolution of the three pilot systems of Smart Factories, since Task 4.3 is in charge of the 3 Smart Factory trials at the different end user sites. It will also be responsible of coordinating the trial execution and of gathering the related best-practices and lessons learned. Trials have been performed in various phases, which have been coordinated with the release of instantiations of FITMAN SE. This task has also ensured that knowledge has been timely spread among the testing sites, to reduce experimentation ramp-up phases to the minimum. In this task, various user groups have been involved in the experimentation of FIWARE platform at the various sites.

The three WP4 trials have been conducted in the Smart Factory facilities provided by the three manufacturing enterprises TRW (automotive), WHIRLPOOL (white goods) and PIACENZA (textile). Even three main IT providers’ beneficiaries, one per trial namely Innovalia, Engineering and Softeco, have been heavily involved to provide their scientific/technical support. ATOS has been responsible to transfer results from other WPs to WP4 and of the overall technical coordination of the Smart Factory trials. An overall cross-trial Smart Factory committee, led by POLIMI, has been appointed in order to harmonize the development of the experimentations, share experiences and to identify common requirements and needs to be reported at the overall FITMAN project management committees.

1.2. Contribution to other WPs and Deliverables D8.1 role

The D4.3 - FITMAN Smart Factory experimentation report will be delivered at month 24.

- D4.3 is part of WP7.1 Synthesis of Use Case Trials Experiences: all the results of the 10 Use Case Trial Experiences of the project, including interaction and feedbacks to stakeholders, are collected and the relative data flows into D7.2 FITMAN Smart-Digital-Virtual Factory Trials Experiences, according to the guidelines stated in WP2 (FITMAN Verification & Validation Method).
- D4.3 provides additional information to FIWARE Chapter I (Applications/Services Ecosystem and Delivery Framework) so that some recommendations could be issued and collected in D7.2-3-4-5-6 FITMAN Recommendations and Best Practices M24 Merged together into D7.3 (first edition)
- D7.4 FITMAN Recommendations and Best Practices Final Edition M30
- Additional data are provided to FIWARE Chapter II (Cloud Hosting) and V (Interface to Network and Devices), so that some improvements may be made in D7.3 FITMAN Trials Recommendations to Cloud Hosting & Interface to Network.
- D4.3 gives useful hints to FIWARE Chapter III, entitled Internet of Things, and the Chapter IV, Data and Context Management. The 10 experimentations conducted will contribute to TF Chapter III and IV, so that some recommendations could be issued and collected in D7.4. FITMAN Trials Recommendations to Internet of Things and Data Context Management.
- As for Privacy-Security-Trust, D4.3 may enrich FIWARE Chapter VI. Information arisen could be collected in a synthetic document D7.5 FITMAN Trials Recommendations to Privacy-Security-Trust.
- D4.3 also contributes to D7.6) FITMAN Trials Guidelines and Best Practices for FI PPP Programme Coordination Chapter VI, in particular for the business and sustainability aspects of FI in manufacturing.
- The overall objective of WP8 is to support Phase III Use Cases Expansion proposals and projects with the FITMAN relevant knowledge and assets as well as to evaluate
the FITMAN Phase II Trials (D4.3 included) in view of their possible future expansion.

- The comparison among the data of D4.3 and the other user cases has been done in **D8.1 FITMAN use case Trials comparative evaluation**: the document has been included a technical-business comparative analysis of FITMAN Trials, according on the method developed in WP2, in order to identify strengths and weaknesses in the view of their large scale expansion. It allows an easy comparison of specific performances and identification of inconsistencies. Comparison approach provides appropriate information granularity level to support “zoom-in” and “zoom-out” and to elicit significant hints from heterogeneous industrial/business environments.

- On the basis of the comparative analysis of D8.1, **D8.2 FITMAN expanded Trials proposition and roadmap** informs about the development of a proposition for expansion of each candidate trial. A roadmap is created, with recommendations of appropriate trials to take forward and the technical-economic conditions under which this will be best achieved.

- The overall objective of WP9 is to design and implement an action plan to exploit FITMAN outcomes to industrial targets and to the FI PPP Programme. Of course, the D4.3 gives useful hints to determine **D9.3 FITMAN exploitation action plan and implementation including socio-economic impact (final edition)**, that is the final document describing FITMAN exploitation action plan and socio-economic impact.

- The overall objective of **WP10** is to manage all coordination and control elements of the project execution, granting a successful completion and delivery of results in the full respect of the budgeted costs and time. Of course, D4.3 is be part of **D10.2 Project activity report M24** (the 2nd periodic report including activity report), as well as **D10.4 Project Impact assessment report**, that includes the final monitoring and reporting of socio-economic impact assessment, and **D10.6 Final Report**, The Final Report as per EC guidelines to be provided at the end of the project.

- D4.3 may also contribute to **WP11** (Dissemination and FI PPP Collaboration), giving useful information in the final document **D11.2 FITMAN dissemination action plan and implementation including FI PPP collaboration (final edition)**: that is the final dissemination plan and actions reporting, including the actions related to the FI PPP Programme.
2. #Trial 2: TRW

2.1. Final Business Processes

*Business Process 1*

*Business Scenario 1: Risk Modelling -> Business Process 1: Risk Cataloguing*

Risk cataloguing is making use of best practices to support the risk prevention system allow not only predefining the expectation of preventive measures in the organization procedures, but also a continuous monitoring of the processes.

For the purpose to persist the scientific knowledge with normalized specifications, the risk repository is necessary to set up following the procedure of cataloguing, design and evaluating risk. As the contents of the normalization are described as manuals, it is convenient to store their protocols in the common relational SQL Database.

The universe catalogue is required to create by health complied with the existing European regulations of analyzing the rules applicable to manufacturing equipment for solutions and technologies that can help overcome the security issues as required.

However the common repository provides a large amount of rules covering vast types of industrials, which is not all useful for a specific manufacturing organization, neither could be changed by non-professionals who are from the local factory. Hence, to set up the local repository of each factory is also essential in order to be customized in line with the specific scenario of the manufacturing industry and patronized profile, apart from the capability of synchronizing with the remote common risk repository due to the need.

There are occupational diagnosis protocols for standardization of safety processes, such as Care Plans or Clinical Pathways, designed by professionals in order to ensure that the process can be understood, repeated and non-ambiguous.

Moreover, the decision support system works with risk patterns that require a human interaction, either to provide additional information or to select preferred option in front of a multiple selection. Thus the user–friendly human machine interface (HMI) will bring up the convenience for both programming workers such as technicians, network administrators and non-programming professionals like safety experts, prevention managers to make the work plans, update profiles of workers, or inspect the status of sensors and communications system.
Workflow diagram

Figure 2-1 Risk Cataloguing Workflow

Business Process 1: Risk Cataloguing

Business Process 2
Business Scenario 1: Risk Modelling -> Business Process 2: Evaluating Consistency of the Preventive Process

The process of assessing an easy customized repository with a comprehensive and authorized risks classification and effective prevention plans for the workers covering the whole manufacturing life cycle is based on scientific knowledge for active risk prevention technology.

The evaluation tool ensure that the risk types/levels and prevention actions accordingly are not contradicted to each other. And the correlations-workflow can be processed following the regulation and legislation of authorities like OHS and specific company’s policies.

Along with risk prevention evaluating process, the risk preventive services rely on service of authentication control and identity/attribute assertions which can be handled by TSC Security Policy Assessment tool - SAM.
**Business Process 3**

**Business Scenario 2: Risk Detection and Information -> Business Process 3: Risk Monitoring**

The use of non-intrusive sensor systems like image sensors, on one hand can benefit monitoring the worker’s physical conditions and the working environment, including environmental conditions and the state of the machinery interacting with the worker. On the other hand, the introduction of wireless communications in the factory of the future will also facilitate the deployment of distributed and mobile sensing applications to improve the factory’s productivity and worker’s health and safety.

After the large amount of sensing data sent to the network between different layers, the major challenges faced by the wireless communication and IoT networking modules is the propagation of conditions including obstructions and interference to cause instability of wireless communication.

As the major part of risk monitoring system TSC, the ergonomics application will provide functions like Characterization of the environment, worker, device and session, Network settings, Ergonomic Control, and Module results by means of the detection of hazards related to manual load handling and awkward postures, i.e., ergonomic risks. The main objective of the tool is to monitor the positions performed by workers, identifying the inclination or deflection ranges adopted and the numbers of times per minute were performed during these movements.
As assistance of the monitoring tasks, the collision detector will detect multiple moving objects within the same scene, as well as place them in 3D space relatively to the camera position; also providing the ability to determine the distance between various objects or persons to avoid collisions.

Moreover, the area manager application under researching is designed to find the orientation of the machine movement could cause a collision between machine and workers.

**Workflow diagram**

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**Business Process 3: Risk Monitoring**

![Risk Monitoring Workflow Diagram](image-url)

**Business Process 4**

**Business Scenario 2: Risk Detection and Information** -> **Business Process 4: Risk Intervention and Communication**

The workflow diagram below shows how the system coordinating different services trigged by the prevention system, involving safety coordinator’s intervention:

In order to connect different components of the prevention systems together, especially non-interoperable system which automatically triggers training, task reorganization, and workplace adaptation and information, the Context Broker GE working as the middleware to play the important role of coordination.

In the case of directing to the corresponding services, the Context Broker GE is connected to IoT gateway GE tightly such as Data handling GE, which decided the relevant action plan to prevent the risk identified. Once the execution is carried out, the middleware calls the corresponding back-end services in order to give protection of workers. In addition, the NEC IoTBroker and Orion Context Broker will support the end user like the safety coordinator to
register, query, subscribe and publish alerts about the event occurred and the area where it has been produced (i.e. the assembly line), but not about which operator has been the source.

Furthermore, as some analysis results have to base on periodical statistics, the Dynamic CEP SE from the open call project is capable of extending the ability of CEP GE by adding the analysis functionality accumulated event data in real-time, and generates immediate results in response to changing conditions.

The preventive action plans can be activities which are automatic like sending an email or invoking a service. On the other hand, if human intervention is required, activities will act as wait states, for example human tasks or waiting for an external service to return results.

In terms of end users, once the risk is detected, the corresponding service, such as alarms/messages will be sent through TSC Security Policy Assessment tool - SAM to both the prevention technician and the safety coordinator, in addition to the worker himself. Due to ethical issues, the shipping information will be anonymous, except in the case of the operator, who will have access to all data generated about him.

After receiving these alerts, the implementation of the preventive actions that best suits the situation will be deployed. Thus, the Dynamic Visualization and Interaction SE from open call will be introduced to the system to offer the visualization of the ergonomic movement in 3D view and mark the color depending on the risk level events generated by the CEP engine in the TRW factory shop floor. In the case of the workers, who will be prompted to correct the mistake and fix the problems are supposed to receive the advice or training materials.
Workflow diagram

Figure 2-4 Risk Intervention and Communication Workflow
2.2. Experimentation Plan

Experimentation plan for phase I & II

After completed the phase I of the iteration of instantiating related FI-WARE generic enablers and specific enablers with the legacy ergonomic risk monitoring system, we have had a first version of the results achieve goals across four business processes as following:

- For BP1: Risk cataloguing
  The catalogue and evaluation tool for Risk & Prevention Action modeling will allow the coherent design of the prevention strategy by adapting REBA, NIOSH and OCRA standards in order to optimize the information process.

- For BP2: Consistency of the Preventive Process
  The risk factors and corresponding prevention actions will be checked not only by the technicians but also by the system, in order to design a complete and coherent prevention strategy.

- For BP3: Risk Monitoring
  To realize the new risk monitoring systems which monitors risk factors in real time, detecting and give the feedbacks in an intuitive interface for both workers and prevention technicians.

- For BP4: Intervention and Communication
  As a result, the workers, technicians and coordinators will have real information and the instructions they have to follow in order to assure that the risks disappear or that the consequences are minimized.

On top of the first phase development, we aim at enhancing and completing services covered both the security assessment and cloud-based real-time web based services of FITMAN-Ergopal risk prevention system. The enhancements and expected results for all of these four business processes are listed below:

- For BP1: Risk cataloguing
  Provide more interactive interface to allow user like risk prevention experts and prevention technicians adding risk types/levels and corresponding preventive action plans through visualized web interfaces, so as to have a clear statistic from monitoring the risk factor type and its corresponding accidents.

- For BP2: Consistency of the Preventive Process
  Require enhanced methods for privacy and data protection, ensuring no unauthorized and adequate usage of the individual information is made to prevent the replay of human errors.

- For BP3: Risk Monitoring
  Detect critical conditions by reasoning on event data or historical data; react by generating new warning/alarm prevention workflow and dispatching them to a notification system.

- For BP4: Intervention and Communication
  The worker will received customized training sessions. Moreover, the technicians will have a global vision on the factory, receiving reminder about the frequency of risks, areas with worst rates after the new deployment.
**Experimentation plan for phase III**

As a final phases of the whole system, not only to assess the impact of the FITMAN system instantiation, but also report and communicate this impact in the manufacturing and production activities thanks to FI technologies deployment.

- For BP2: Consistency of the Preventive Process
  Emphasize on decreasing the number of accidents and incidents after the installation of the Ergopal risk prevention system with all GE/SEs. Meanwhile, the system is targeting at optimizing the catalogue of risk factor and it prevention actions, thus reduce the human errors during the design of prevention strategies.

- For BP3: Risk Monitoring
  Ensure the continuous non-intrusive sensing systems to be verified and validated in the factory environment. In addition, extend the ability of the system by open call SE, so that risk detections, alarms and warnings can be generate efficiently.

- For BP4: Intervention and Communication
  Optimize the display of web-based feedbacks for varies of end-users by integrating the 2D/3D visualization of the events and notifications, which could be prompted to correct the mistake and reduce the ergonomic problems.
2.3. Data Gathering and Analysis

Measured and Gathered Data

Here you can find the several parameters and data that have been measured and collected in order to be able to calculate the BPIs related to the TRW trial. You can find not only the definition of the value, but also the source and the type of data gathered.

- **Average time invested and the reduction of inefficiencies (time) in the broad application of current regulations and standards.** Source: prevention technician. Type: seconds
- **Number of employees with lost days.** Source: factory data from prevention office. Type: employees
- **Number of lost days.** Source: factory data from prevention office. Type: days
- **Number of hours worked by employees.** Source: factory data from prevention office. Type: hours
- **Number of risks configured.** Source: Prevention office & Ergopal. Type: risks
- **Number of preventive actions defined.** Source: Prevention office & Ergopal. Type: preventive actions
- **Number of variations of the formula of the risks.** Source: Ergopal. Type: variations
- **Number of systems deployed.** Source: Ergopal. Type: systems
- **Number of number of risks detected by the system + number of alarms activated + number of messages & warnings send.** Source: Ergopal. Type: risks + alarms + messages
- **Number of training sessions.** Source: Prevention Office. Type: trainings

Calculation & Final Values of BPIs

Once we have collected the previous information, the calculation of the final values of the BPIs have been performed following this procedures for each of them.

**BS1PI 1: Number of standards and regulations (added) in the repository after/before the DV/AV implementation during a period.** Final value: % change from CURRENT and FUTURE VALUE.

With the new system, the time invested in the full application of these standards and the range of information controlled (parameters controlled) will be optimised, not changing the costs. If the target value is reached by 5%, the time invested in the full application of these standards and the range of information controlled (parameters controlled) will be optimised, not changing the costs.

The calculation of this BPI has been done following this formula:

$$
\text{Recution of time} = \left( \frac{|\text{new time} - \text{current time}|}{\text{current time}} \right) \times 100
$$

The final value of this BPI at this stage of the trial is: 6%

**BS1PI 2 / BS2PI 1: Number of accidents and incidents in the factory after / before the DV/AV implementation during a period.** Final value: % change from CURRENT and FUTURE VALUE.
Ensure that the system is able to reduce the number of injured workers, if the reduction of 10% in the level of frequency and gravity, the result is considered as **good**. If the reduction reached 15% in the level of frequency and gravity, the result is considered as **Very good**.

The calculation of this BPI has been done following these formulas:

\[
\text{Level of frequency} = \frac{\text{number of employees with lost days} \times 200.000}{\text{total number of hours worked by employees}}
\]

\[
\text{Level of gravity} = \frac{\text{number of lost days} \times 200.000}{\text{total number of hours worked by employees}}
\]

\[200.000 = 2.000 \times 1.000,\text{ which comes from:}\]
\[2.000 = \text{number of hours performed by a worker in one year in the United States (since TRW is an American group).}\]
\[1.000 = \text{ratio for number of workers. It is the basis for comparison between the different facilities of TRW around the world.}\]

The final value of this BPI at this stage of the trial is: **13%**

**BS1PI 3: Number of risks that has been defined using the new system after / before the DV/AV implementation during a period.** Final value: % change from CURRENT and FUTURE VALUE.

The system will allow setting up risks that can happen in the factory, specifying concrete parameters and thresholds to detect them.

The detail of configuration of risk factors will be increased at least 30%, thus the risk number will increase along with the new configuration.

The calculation of this BPI has been done following this formula:

\[
\text{Increase of n° risks} = \frac{|\text{new n° risks} - \text{current n° risks}|}{\text{current n° risks}} \times 100
\]

The final value of this BPI at this stage of the trial is: **40%**

**BS1PI 4: Number of preventive actions using the new systems after / before the DV/AV implementation during a period.** Final value: % change from CURRENT and FUTURE VALUE.

The system will allow setting up preventive actions, linked to the risks detected. If the preventive actions are increased by 30%, it means the risks prevention is improved.

The calculation of this BPI has been done following this formula:

\[
\text{Increase of preventive actions} = \frac{|\text{new n° actions} - \text{current n° actions}|}{\text{current n° actions}} \times 100
\]

The final value of this BPI at this stage of the trial is: **30%**

**BS1PI 5: Number of human errors in the design of prevention strategy planning after / before the DV/AV implementation during a period.** Final value: % change from CURRENT and FUTURE VALUE.
The new FITMAN system will have a registry to store the modifications in the system. If the number of variations in the values of the formulas and parameters of the risks will be set, then the reduction of human error rate should be reduced at least by 10%.

The final value of this BPI at this stage of the trial is: 10%

**BS2PI 2: Number of deployed monitoring systems after / before the DV/AV implementation during a period.** Final value: % change from CURRENT and FUTURE VALUE

Have an overview of the new IT equipment and infrastructures deployed in the selected types of production lines. If one more sensor deployment could increase 55% information than only one sensor, then system is considered as good detection quality.

The calculation of this BPI has been done following this formula:

\[
\text{Increase of systems} = \frac{|\text{new } n^{th} \text{ systems} - \text{current } n^{th} \text{ systems}|}{\text{current } n^{th} \text{ systems}} \times 100
\]

The final value of this BPI at this stage of the trial is: 70%

**BS2PI 3: Number of risk detections, alarms and warnings set up after / before the DV/AV implementation during a period.** Final value: % change from CURRENT and FUTURE VALUE

It determines the effectiveness of the systems to risk detection and preventive actions deployment. If the increase of the rate of risk detections, alarms and warnings reach 65%, the risk detection is efficient.

The calculation of this BPI has been done following this formula:

\[
\text{Increase of detections} = \frac{|\text{new } n^{th} \text{ detections} - \text{current } n^{th} \text{ detections}|}{\text{current } n^{th} \text{ detections}} \times 100
\]

\[\text{N}^{th} \text{ detections} = \text{number of risks detected by the system} + \text{number of alarms activated} + \text{number of messages & warnings send to the different actors}\]

The final value of this BPI at this stage of the trial is: 80%

**BS2PI 4: Number of training sessions regarding safety after / before the DV/AV implementation during a period.** Final value: % change from CURRENT and FUTURE VALUE

Probe the increase in the awareness of the importance of H&S adoption in the TRW factory. The target is to increase 25% of training session because of prevention actions.

The calculation of this BPI has been done following this formula:

\[
\text{Increase of training} = \frac{|\text{new } n^{th} \text{ training} - \text{current } n^{th} \text{ training}|}{\text{current } n^{th} \text{ training}} \times 100
\]

The final value of this BPI at this stage of the trial is: 35%
Rationale behind using percentage values:
TRW trial will use percentages of improvement and decrease of the business performance indicator as measuring unit, avoiding the usage of absolute values. The main reason for this choice is the misuse that external users can do with current data of TRW, getting them out of context and creating non-desirable image for a worldwide leader branch in the automotive sector. Due to this unfortunate and possible situation, TRW will use percentages comparing current and future values of each indicator. Additionally, the most important target of TRW due to business performance indicator is to not only assess the impact of the FITMAN system instantiation, but also report and communicate this impact in the manufacturing and production activities thanks to FI technologies deployment. In order to reach these objectives of assessment and communication, percentage values of TRW indicators are as useful as absolute values, since they are able to reflect the evolution of the business processes in the factory.
3. #Trial 4: WHIRLPOOL

3.1. Final Business Processes

Main objective is the integration of components coming from the FITMAN Open Call; more specifically, some of the enablers proposed for the Smart Factory domain by the MagniFI consortium: Dynamic Semantic Observation, Dynamic CEP and Dynamic Visualisation and Interaction. The objective try to enhancement capabilities of the production-grade phase two system, but limited in scope to an experimental testbed which will run in parallel with the consolidated FITMAN solution.

In particular, Dynamic Semantic Observation and Dynamic CEP are expected to broaden the range of monitored shop-floor events and to apply AI techniques to their analysis, in such a way that the FITMAN solution may pro-actively detect critical situations with little or no hard-coded event processing logic. At the same time, Dynamic Visualisation and Interaction should provide an alternate, more advanced end-user terminal for Whirlpool personnel, which will improve the real-time situation awareness on the assembly line.

The final architecture of this implementation is reflected below:
3.2. Experimentation Plan

The complete experimentation has been conducted in two different production sites and in different phases. The original BS implementation, conducted in Naples factory started officially September 1st, after a pilot phase in which, 1) the system has been tuned up in order to make sure the filtering of events to generate alarms was consistent and relevant, and 2) the users got acquainted with the mobile device and with the system.

System tune up

After the installation of the FITMAN platform and it connection with the GRADACO data generator, the frequencies of events has been carefully examined and the filtering mode (e.g. by model, SKU, etc.) has been decided in accordance with the final users. The scope of this stage has been important to set up the overall threshold after which alarms has to be generated.

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<th>Station CODE</th>
<th>Station</th>
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<th>Potential Recipient</th>
<th>Business benefit</th>
<th>Measure</th>
<th>Feasibility</th>
<th>Current Frequency</th>
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<tbody>
<tr>
<td>4</td>
<td>WUBI</td>
<td>Station 4A and 4B Bearing Insertion</td>
<td>Sequence of Defects; Process Drifting (SPC)</td>
<td>Team Leader; Quality Process Manager</td>
<td>Anticipate problem resolution (e.g. Maintenance intervention); avoid productions stop and reduce defects.</td>
<td>OEE + BBPM, FOR + DEFP</td>
<td>Medium</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>WUSI</td>
<td>Station 5 Seal Insertion</td>
<td>Sequence of Defects; Process Drifting (SPC)</td>
<td>Team Leader; Quality Process Manager</td>
<td>Anticipate problem resolution (e.g. Maintenance intervention); avoid productions stop and reduce defects.</td>
<td>OEE + BBPM, FOR + DEFP</td>
<td>High</td>
<td>0,055%</td>
</tr>
<tr>
<td>11</td>
<td>WUBR</td>
<td>Station 10 Tub Welding (Branson)</td>
<td>Product Defect; Machine stop; SPC (Process Drifting)</td>
<td>Quality Manager; IE, Maintenance</td>
<td>Anticipate problem resolution (e.g. Maintenance intervention); avoid productions stop and reduce defects.</td>
<td>OEE + BBPM, FOR + DEFP</td>
<td>High</td>
<td>0,01%</td>
</tr>
<tr>
<td>23</td>
<td>ASFT</td>
<td>Functional test (100%)</td>
<td>Pattern or sequence of defects</td>
<td>Quality process</td>
<td>Direct feedback to operators causing defects lead to improvement of their operation</td>
<td>FOR + DEFP</td>
<td>Low</td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>ASNT</td>
<td>Normative Electrical Test</td>
<td>Sequence of multiple faults</td>
<td>Quality Process; Quality Manager</td>
<td>Unsolicited verification process; problem prevention (e.g.epidemic problems)</td>
<td>FOR + DEFP</td>
<td>Medium</td>
<td></td>
</tr>
<tr>
<td>26</td>
<td>ASZH</td>
<td>ZHQ (3%)</td>
<td>&quot;A&quot; defect (data from DCS)</td>
<td>RDC Manager; Quality Manager; Factory Director</td>
<td>Block potential faulty batch</td>
<td>SIR</td>
<td>Medium</td>
<td></td>
</tr>
<tr>
<td>27</td>
<td>ASZHB</td>
<td>ZHQ (3%)</td>
<td>&quot;B&quot;, &quot;C&quot; defects (data from DCS)</td>
<td>Quality Process;</td>
<td>Unsolicited verification process; problem prevention (e.g.epidemic problems)</td>
<td>FOR + DEFP</td>
<td>High</td>
<td></td>
</tr>
</tbody>
</table>

User training

The users has been trained on the use of the system: the training on BP2 and BP4 related to users and event administrator

And a further training on use of mobile device to interact with Notification Manager.
**Final instantiation**

Once the fine tune and the training has been carried out, the system has been officially released to be used by the users in Naples Factory.

**Extension**

The extension of BP to include new SE is a realistic representation of what should happen in the real factory. The objective of the extended BP is to demonstrate how a gauge system typically used in metrology laboratory could be used online as a source of real-time data.

For reasons linked to limited resource along the project, the experimentation has been carried out using a physical resource owned by Datapixel and installed in Bilbao. Whirlpool selected a set of parts whose gauging is currently difficult for geometrical complexity and sent those parts do Datapixel for initial analysis. The part that has been selected for further experimentation is a small plastic fan used to force air circulation inside microwave ovens: its combined properties of overall envelope, complexity and material composition, provided the best choice to maximise the experimentation scope.

The overall scope of experimentation is to demonstrate how a 3D scan system can be used as a real time event generator and the events be treated in the WHR FITMAN platform.

The first challenge is to transform the output of the 3D system into a set of reliable information onto which a condition based alarm system is generable. The solution adopted has been to elaborate the point cloud output from 3D system as differential quote from the expected model represented by a CAD model of the part.
As one can see from the picture above there are red parts which are representing +1mm deviation in the z axis. Human elaboration could be easily trained to identify important deviations from the expected and take decision. The second challenge is to transfer this function to a system that, through complex data elaboration, will identify those deviations and generate events consequently.

3.3. Data Gathering and Analysis

FITMAN system is mainly acting on people and its objective is to improve the way people take decision both from the point of view of effectiveness and speed. Of course there is no direct business advantage on speed and effectiveness on decision unless these decision are the reflected into real BPI. That’s why WHR decided not to track how people is changing behavior but, more consistently, on how main BPI linked to Quality and productivity will change in the medium / long term.

The following schema is representing the analysis conducted, station by station, on how the production line is influencing factory BPI, which are normally and continuously monitored.

A brief explanation on selected BPI:

- **DEFP and FOR**: Defective parts and Fall Off Rate are two ways to measure how the factory is able to detect failure in its processing. FOR is the ratio between defective parts detected in a specified timeframe and the overall production in the same timeframe. FOR can be computed at station, line, department and factory level.
- **SIR**, Service Incidence Rate is the measure of defect revealed in the market, i.e. at consumer home. Is always related to production rate and can be measured at 1st month in service or at 12th month. The latter representing a more robust statistical basis. The capacity of FITMAN to influence this BPI is limited by the time: actions conducted on process or product has latency of 4 months for 1M SIR and more than 1 year for 12M SIR.
- **OEE** is the classical Overall Equipment Efficiency: FITMAN should have a positive influence on it however its measure on the stations selected is not in place.
- **CCPU** is the conversion cost per unit. WHR has an Actual costing in place and it is updated every month.
The improved capability of sharing detection of severe defect can lead in the long period (1 year) a reduction of 5% of present Service Incidence Rate measure on 12 months on service.

In the long run the improvement of efficiency in decision making can lead to a reduction of variable conversion cost from 9.67% to 9%. This will be mainly driven by better utilization of resources.

Target is to reduce the number of peaks (i.e. Weekly rates exceeding 2sigma of the normal distribution).
The BPI measured at M18 are the following:

<table>
<thead>
<tr>
<th>Biz Scenario</th>
<th>Biz Indic</th>
<th>Value</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 WUBI_FOR Current</td>
<td>0.24</td>
<td>ASPT, FOR and ASNT, FOR are referring to two station whose contribute are not separable and the value is computed as for one station FT (Functional Test). FITMAN system will take some time to impact in a significant way the BI proposed. 16/3/2015 - WUSI, FOR changed from 0.2 to 0.1 to reflect improved capacity demonstrated in initial period</td>
<td></td>
</tr>
<tr>
<td>1 WUBI FOR 1</td>
<td>0.121</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 WUBI FOR 2</td>
<td>0.216</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 WUBI FOR 3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 WUBI FOR Target</td>
<td>0.22</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 WUSI FOR Current</td>
<td>0.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 WUSI FOR 1</td>
<td>0.118</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 WUSI FOR 2</td>
<td>0.115</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 WUSI FOR 3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 WUSI FOR Target</td>
<td>0.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 ASPT FOR Current</td>
<td>4.49</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 ASPT FOR 1</td>
<td>2.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 ASPT FOR 2</td>
<td>2.85</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 ASPT FOR 3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 ASPT FOR Target</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 ASNT FOR Current</td>
<td>4.49</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 ASNT FOR 1</td>
<td>2.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 ASNT FOR 2</td>
<td>2.85</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 ASNT FOR 3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 ASNT FOR Target</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 CCPU Current</td>
<td>9.67</td>
<td>CCPU is the percentage of Conversion Cost over Total Product cost. FITMAN system will take some time to impact in a significant way the BI proposed. CCPU1 has no statistical significance and will not be computed. CCPU2 is related to JAN 2015.</td>
<td></td>
</tr>
<tr>
<td>1 CCPU 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 CCPU 2</td>
<td>9.47</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 CCPU 3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 CCPU Target</td>
<td>9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 ASFT DEFP Current</td>
<td>31181</td>
<td>Defective parts onto 1 year. The current value is the 2013 value. DEFP1 is the linear projection of September values. FITMAN system will take some time to impact in a significant way the BI proposed, 5/3/2015: DEFP target changed from 28000 to 14000 to reflect improved factory capacity.</td>
<td></td>
</tr>
<tr>
<td>1 ASFT DEFP 1</td>
<td>16764</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 ASFT DEFP 2</td>
<td>13872</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 ASFT DEFP 3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 ASFT DEFP Target</td>
<td>28000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 ASNT DEFP Current</td>
<td>31181</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 ASNT DEFP 1</td>
<td>16764</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 ASNT DEFP 2</td>
<td>13872</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 ASNT DEFP 3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 ASNT DEFP Target</td>
<td>28000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 WUBR FOR Current</td>
<td>0.03</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 WUBR FOR 1</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 WUBR FOR 2</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 WUBR FOR 3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 WUBR FOR Target</td>
<td>0.02</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 ASZHBC_DeFP Current</td>
<td>4.49</td>
<td>WUBR, FOR target changed from 0.03 to 0.02 to reflect improved factory capacity</td>
<td></td>
</tr>
<tr>
<td>2 ASZHBC_DeFP 1</td>
<td>2.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 ASZHBC_DeFP 2</td>
<td>2.85</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 ASZHBC_DeFP 3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 ASZHBC_DeFP Target</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 ASZH_SIR Current</td>
<td>50000</td>
<td>FITMAN system will take some time to impact in a significant way the BI proposed. SIR will be computed only at 3rd stage</td>
<td></td>
</tr>
<tr>
<td>2 ASZH_SIR 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 ASZH_SIR 2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 ASZH_SIR 3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 ASZH_SIR Target</td>
<td>47500</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 ASZHBC_DeFP Current</td>
<td>31181</td>
<td>FITMAN system will take some time to impact in a significant way the BI proposed. DEFP1 is the linear projection of SEP 2014 value. DEFP2 is the linear projection of OCT14 to JAN15 values. DEFP2 value is influenced by the production stop during month of December. 5/3/2015 DEFP target changed to 14000 to reflect improve capacity of the factory.</td>
<td></td>
</tr>
<tr>
<td>2 ASZHBC_DeFP 1</td>
<td>16764</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 ASZHBC_DeFP 2</td>
<td>13872</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 ASZHBC_DeFP 3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 ASZHBC_DeFP Target</td>
<td>14000</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## Final Business Processes

<table>
<thead>
<tr>
<th>PIACENZA</th>
<th>Production capacity seller</th>
<th>Production capacity purchaser</th>
</tr>
</thead>
<tbody>
<tr>
<td>Textile/Clothing</td>
<td>Enhanced production floor monitoring</td>
<td>Share production capacity</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Handle orders from purchaser</td>
</tr>
<tr>
<td></td>
<td>Search for resources</td>
<td>Set-up and order</td>
</tr>
<tr>
<td></td>
<td>Monitor virtual capacity</td>
<td></td>
</tr>
</tbody>
</table>

### BP1 - Enhanced production floor monitoring Business Process

Production floor monitoring and supervision of production will be done using smart tags. In this way the monitoring of an order status will be automated as long as each order in production will be connected with the right machinery. Currently, operators have to input data regarding the process phase of an order in production, and the information declaring which machinery is processing an order is not automatically collected by the system. This information is mandatory to implement cloud production.

### BP2 - Share production capacity

It is focused on those companies which show an overcapacity of production and want to sell it. The first step to be performed by the end user is the subscription to the portal that manages the marketplace of the orders and resources. The main activity is the estimation of the availability of the machines and resources to offer:

- Creation of the model of the Plant of the company, the list of machines and processes that may be shared per department.
- Model each tangible asset of the plant
- View the list of all tangible assets
- Select a tangible asset and view profile and availability data
- Select a time frame and set the tangible asset available for cloud production in the time frame. This allows potential purchasers to ask for a quotation of a certain machinery in the time frame they are interested in.
- Availability data keeps being updated by business process 1.

### BP3 - Handle Orders from Purchaser

Main activities per each participant are:

- **Listing the orders that can be produced for third parties** and **Listing the unexploited production capacity.** Because of the discontinuous and seasonal market of textile products, the internal production of the company can exploit different departments for periods and years. The target is to be able to know if some orders can be carried on for external production and whether unexploited capacity can be offered on the marketplace. In this case, the company can become supplier of production capacity.

- **Management of the new incoming type of orders.** A new request of production capacity has been received from an external customer. The production manager acquires this information and looks for a possible delivery or for a free slot of production. This job requires a more precise scheduling of the work, supported by the previous task (at present to be improved).

- **In the production floor, a more precise localization of the item** is necessary for a faster and more efficient monitoring of the production process. To achieve this target, the use of...
the RFID technology is advisable. In the first case it can be applied on the machine to monitor the execution and timing of the orders of production. In the second case, it can support the definition of the item location in the production floor.

**BP3 - Search for Resources**

It is focused on those companies which need external production capacity supplied by third parts and want to purchase it. The first step to be performed by the End User is the subscription to the portal that manages the marketplace of the orders and resources. The main activity is the estimation of the availability of the machineries and resources to purchase:

- The purchaser logs in the cloud manufacturing portal
- He can set up a query for manufacturing resources specifying the type of resources he needs, the production object and the desired time frame.
- The cloud manufacturing system matches the search filter with the availability data of all the shared resources and submits the list of potential offers
- The purchaser selects the best matching offer, and then the system sends a request for a quotation to the seller(s).

**BP 5- 5 Set-up and Order**

Main activities per each participants are:

- **List of orders that can’t be produced inside and/or List of needed production capacity.** Because of the discontinuous and seasonal market of textile products, the internal production of the company can exploit different departments for periods and years. The production manager should be able to know if some orders must be produced by external production capacity offered in the marketplace. In this case the company can become customer of production capacity.

- **Management of the external production.** A new offer of production capacity has been received from an external supplier. The production manager acquires this information and updates possible delivery timing on the basis of the increased production supported by external resources. This job requires a more precise scheduling of the work, supported by the previous task (at present to be improved).

**BP 6 - Monitor virtual capacity**

At virtual level the status of the shared resources has to be kept up-to-date. The same must happen for the status of the production orders managed by the trial system. The status of production orders has to be kept in sync in the purchaser ERP as well. The real time monitoring of orders and items is a key point for the efficiency of all the system.
4.2. Experimentation Plan

*Foreseen tasks in order to complete the experimentation*

A part from the technical implementation, that requires its times and workflow, the trial requires also a preparation in terms of resources, tasks, organization and, particularly in these business cases, a collaboration with the external company not directly involved in the project.

Thus, the task definition and planning should be re-visited for each business process by the supplier's project manager in agreement with the production manager. Here the task guidelines as follows:

- **Trial definition.** The internal project manager of Piacenza defines the subtasks and the timings that are typical of the pilot company infrastructure. In order to do this, he should define a document in which the pilot company infrastructure is designed and analysed carefully. The number and type of textile machines, the setup timings, the system used for the connection to the machineries, the hardware availability, security issues, the internal staff and their skills: everything in this list should be collected in order to calculate the foreseen timings and deadlines so to propose a project schedule. The schedule has to be agreed between the parts and, as a task results, the project will move to its operative stage.

- **Sensors, infrastructure and technical phase.** This task has to be performed by the technological supplier partner, with the support of the pilot company IT staff and the textile experts. It consists on physically connecting the hardware to the textile machineries, installing and verifying the software.

- **Staff training.** This process, involving the supplier professional service as well as the pilot company planning and department manager, consists on a training session in which all the software aspects will be shown to the end users. The following subtask will be a set of training on the job sessions, in which the manager will learn the new operations, always followed by the professional services.

**Documents**

This preparation will deliver a set of documents that will show the progress of the project and may be used as documentation for both parts to support the maintenance and possible customisations.

- **Company layout.** It is a collection of information coming directly from the pilot company project manager and the observations from the supplier project manager. It will contain the list and the characteristics of the computers involved in the installation, IT security issues, the list of textile machines, the departments involved, names, phone numbers and email of the involved staff and their availability.

- **Installation manual.** This should be developed before the pilot starts up and it will be a summary of the tools. It will have to be personalized for each customer, adding information from the company layout and enriching it by the performed customisations. It contains information on how to manage the software components, connect to other components and call the support.

- **The last interesting point is the procedure of managing the unexpected events:** if it is not properly managed, it will produce an unusable result.
Roadmap

In order to organize the preparation of the trial, a simple roadmap based on the list of business processes has been produced.

<table>
<thead>
<tr>
<th>BP</th>
<th>Task Description</th>
<th>Months of implementation since pilot start</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Enhanced production floor monitoring</td>
<td>123456789</td>
</tr>
<tr>
<td></td>
<td>Map sensors to machines and process steps</td>
<td>12222</td>
</tr>
<tr>
<td>2</td>
<td>Tests and data collection</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Share production capacity</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Define a possible market and an offer for the customers</td>
<td></td>
</tr>
<tr>
<td></td>
<td>List of possible customers and contacts</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Technical implementation of estimation of the publication of capacity</td>
<td>22</td>
</tr>
<tr>
<td>3</td>
<td>Training of staff on the use of tools</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Handle orders from purchaser</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Technical integration of the FITMAN tools</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Training of staff in third parties production orders</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Retrieve and analysis data for BPI</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Search for resources</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Technical implementation of forecasting</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Training on queries external capacity</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Set-up and order</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Training on comparison of offers and internal business rule</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Confirmation and set-up of the orders</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Monitor the virtual capacity</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Integration of data from the new orders and capability estimations</td>
<td>22</td>
</tr>
</tbody>
</table>

1=preparation, 2=technical implementations, 3=training and trial execution

Human resources

The following roles are needed for the proper functioning and execution of the trial:

The user is responsible for using and monitoring the system, and makes the proper evaluations and validations. He can have one or more of the provided system roles (Floor manager, Machine Supervisor, Production Manager), with each role giving him access to specific services and service functionalities.

<table>
<thead>
<tr>
<th>User</th>
<th>Roles</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Floor Manager</strong></td>
<td>The floor manager will be responsible for and able to monitor the machines production, handle machine alerts, viewing and understanding the aggregated reports. He will also be responsible for the correct estimation of the capabilities.</td>
</tr>
<tr>
<td>User</td>
<td>Roles</td>
</tr>
<tr>
<td>--------------</td>
<td>----------------------------------------------------------------------</td>
</tr>
<tr>
<td>Production Manager</td>
<td>The production manager will be responsible for and able to schedule the entire production, viewing the capabilities and share them or part of them to the cloud in according with the business rules.</td>
</tr>
<tr>
<td>IT Expert</td>
<td>The IT Expert will be responsible for implementing and integrating the solution inside the company, with respect of the current workflow and limits due to the current production scheduling.</td>
</tr>
</tbody>
</table>

**Trial scenario**

Defined the key persons and the tasks, the chosen method was to group the tasks in three main groups and run them in parallel.

**Preparation:**

The preparation includes some tasks of business rules definition, as the price of the capability offer or the amount of hours to keep as lifebelt in order to cover an urgent or an unforeseen event (i.e. machine break). About the price, the production manager together with the administrative office, makes an evaluation of the current market as for the efficiency in the delivery; in fact, whether on one side Piacenza could sell its capability under normal price as incentive, it couldn’t have the same delivery timing of a normal third part supplier, because Piacenza needs to harmonize the existing production and find the perfect free frame to share.

In the same way, the production manager in cooperation with the floor manager makes an estimation of the hours to keep as lifebelt: they consider the average production per different periods for each season and what is unforeseen. The result are described in WP7.

In addition to this the production manager started to contact the possible customer or supplier (weaving case) of capability, in order to propose a commercial opportunity due to this new platform, in order to create a value-chain. A list of companies has been selected and contacted, some with similar other with different production, in order to have a more flexible combination of possibilities.

The last operation was to choose the departments and the machineries for the trial scenario. In particular the weaving department was selected in order to try the second business scenario (a capability purchaser) and the stenter machine and raising machineries were selected as target for the RFID monitoring system. The raw control was selected as the moment during the workflow production in which it can be installed the RFID Tag on the single production batch.

**Technical implementations:**

This was the major part of the work of the trial and was divided in different tasks. A first technical one is made by the IT partner and the internal IT staff to implement the solution. They start on installing the RFID Sensors on the machines and make some physical test of connection and reading; these operations needed many time in order to have a reliable system, on one side for the testing of different tags, and on another side on finding the correct position of the reader and the tags on the batch; after that, connecting the existing software with the FITMAN tools and testing the specified components for capability estimations. Having a good monitoring and all the software installed in the company, they started to connect the internal layer to the external one, where the capability is collected, managed and shared.
Training and trial execution:
Last group of tasks regards the staff training and the execution. The training started on a test platform in order to save time, the production manager, the floor managers and the external companies that participate to the project started the training sessions in order to use the tools of capability sharing. This part was very important because gave an important feedback on the usability and the new improvements that it were needed to be able to make this instrument more effective.

Once the system was installed and the first tests were made, the operators could start the execution of it in a real production environment. The execution returns a set of data from the monitoring and the estimations of capability that were collected and analyzed in order to have a new vision of production and the computations of BPI.

4.3. Data Gathering and Analysis

The Piacenza trial belongs to two different domains, SMART and VIRTUAL. This division is reflected not only on the location (inside, outside the company), but also on the managed data, on the output BPI and on two different periods; in fact the smart domain is mandatory in order to startup the virtual domain, so information about the first one started before.

In particular on the SMART domain, we focus on improving the monitoring, thus the data strict connected to the machines and the production workflow, this in Piacenza is grouped in three main parts, the yarn production and dyeing, the fabric production from warping, weaving to raw control and the last one the finishing. The trial acquires information of the textile batches processing in the second on the weaving department and third group on the stenter machine and raising machine.

The weaving process is characterized by a production of an order that could be start from 3 to 20 days, depend on the type and the length. The type of batch is divided in three groups:

- **TRIALS** the new articles, longest management in the production.
- **SAMPLES** a short size of fabrics sold to the customer, middle timing management in the production.
- **PRODUCTIONS** are a normal size of fabrics, standard time of production.

For the previous reasons the data collected on the loom are very different from the finishing phase, in particular these have the characteristic to include in the monitoring not only a **START** and an **END** of the production but also the **STOPS**.

In order to have a more precise forecast in fact the machines **STOPs** of this departments is very important because it could enlarge the production timing up to 35% of the time. A set summary of data were:

```
<name>MachineID</name><type>sx:string</type>
<name>OrderID</name><type>sx:string</type>
<name>MachineStatus</name><type>sx:string</type>
<name>EventDate</name><type>sx:dateTime</type>
```

In the machine status is stated the condition of the machine, if it runs or is stopped, the OrderID that represents the batch number the date of monitoring and the loom (MachineID).

The finishing process instead is more different. The fabrics of this part of production doesn’t remain more than 4 hours in a machine, in particular for the stenter machine, that is a dryer machine, the timing could start from 3 to 8 minutes for a production order, so different orders are chained and processed together. Also for the raising machine the duration time is very
different and depends on the type of fabric and the final effect that is needed; it could start from 15 to 45 minutes and it could process up to 4 batches together.

For the previous reasons the machine stops were not so important in the finishing phase, instead the focus was made on the timing of setup of the machine (for example the stenter machine need a long time of warm up) or the waiting time from a set of orders to another.

During the trial pilot we acquire sufficient data to compute the unused capability inside the company; information that is under Virtual domain. Leaving the Smart domain, we connect the FITMAN components to the internal ERP and thanks to this connection we were able to make a forecast of the incoming production for the next two months, starting from a particular, date with daily precision. The effort will fill the machines availability and arise the unused capability, which will be publish to the external management.

A typical trace of the capability is:

```xml
  <WAbody>
    <WAitem>
      <lineN>1</lineN>
      <fabMnfrOperation>
        <texJobTech>56</texJobTech>
        <texMachine>01</texMachine>
      </fabMnfrOperation>
      <calendar>
        <capability>
          <data>15/10/2013</data>
          <availability>
            <um>KBat/g</um>
            <value>350.0</value>
          </availability>
        </capability>
      </calendar>
    </WAitem>
  </WAbody>
  ....
</WeavingAsset>
```

The last important used data was the reservation for a machine time of production, based on the same map “capability.xsd” and the standard Moda-ML, so the capability was exploited to the competitors or suppliers through the Fitman platform. During this phase were elaborated about 4 quantity for every day of 6 months for 64 machines.

With the previous acquisition we were able to define and compute the BPIs that belong to the both domains:

**SMART DOMAIN**

- **NUMBER OF PRODUCTION RECORDS (PROD.REC.):** that represent the number of parameters collected by FITMAN implementation and where there wasn’t any particular elaboration, we have been 100% of the expected ones.

- **PERCENTAGE OF FORECAST ERROR (FOR.ERR.):** that is measured on the basis of the difference between standard expected working time and the effective one, the first is a historical data inside the company, instead the second is obtained from the
new monitoring that are able to return us not a estimation but a real timing of production per article type.

- **AVERAGE PRODUCTION LT PER METER (AV.LT):** this is the index of the benefit of the second scenario, external suppliers. The standard production lead-time is partially cover by an external supplier, in parallel to the internal one, so the percentage of buy capability represent a shorter average production timing.

**VIRTUAL DOMAIN**

- **MACHINE FIXED COSTS PER PRODUCED UNIT (MFC):** that index represents from one side the exploitable capability, this was compute by the elaboration of the running machine status (working hours) over the maximum working time and on the other from the exploited capability data that came out from the publication and selling of them.

- **ENERGY SPENT PER METER PRODUCED (EPM):** unlike the previous here the monitor of the not working hours represent not only an under exploitation, but also the fixed unused energy that increase the total amount per meter.
5. CONCLUSIONS

Deliverable D4.3 has focused on the description of the pilots, of the related business cases, of the technical implementation and of the general results, while the quantitative results of the pilots are detailed in deliverable D7.1.

Some general conclusions are common to all three Smart Factory business cases:

- The 3 Smart factory pilots TRW, Whirpool and Piacenza have carried out the expected activities, e.g. they have progressively defined their objectives, the operators involved, the architecture and the use of GEs and SEs and finally they have defined the architecture and proceed with its instantiation. The activities of TRW, Whirpool and Piacenza have been successfully carried out and the pilots have been implemented in the end user environment.
- The definition of the BPIs per each one has been provided per each pilot and business case, and is used for the quantitative definition of the use case results of D7.1 and D8.1
- The collection of technical and qualitative evidences as regards the GEs and SEs in use have been carried out and the evaluation of their potential application has been evaluated in the real business environment of the pilots and is still ongoing.
- All pilots have reached the running stage and are collecting increasing amounts of data and evidences to proceed to further and progressive evaluations of FITMAN outcomes.