TALITA LANCHA MOREIRA

DEVELOPMENT OF A MANAGERIAL SYSTEM BASED ON WCM'S PEOPLE DEVELOPMENT PILLAR PROCESSES AND STANDARDS

Trabalho de Formatura apresentado à Escola Politécnica da Universidade de São Paulo para obtenção do Diploma de Engenheira de Produção.

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Orientador:
Mauro de Mesquita Spinola

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RESUMO

Este estudo tem o objetivo de estabelecer melhorias para o pilar de desenvolvimento de pessoas da área de *World Class Manufacturing* (WCM) e foi desenvolvido durante um estágio na empresa CNH Industrial. O estudo focou na análise de ferramentas e indicadores usados por este pilar para identificar *gaps* da área e, para eliminá-los, desenvolver um sistema global de desenvolvimento de pessoas que padronize os processos envolvidos e melhore os resultados das plantas de todo o mundo. O método utilizado foi a análise da estrutura atual do modelo de competência, *radar chart* e treinamentos utilizados pela empresa, juntamente à análise da literatura como comparativo, e discussões e reuniões com membros da área para alinhamento do projeto durante o seu desenvolvimento. Foi definida uma lista de requisitos que o sistema de desenvolvimento de pessoas deveria ter para dar suporte à área e eliminar os *gaps* identificados para depois, junto ao time de tecnologia da informação, construir cada página e funcionalidade do Sistema. Os principais tópicos considerados foram o modelo de competências, o qual foi o foco de atividade do estágio da autora (com a criação de uma lista completa de competências e suas descrições), o *radar chart* e o modelo de treinamentos. Em relação ao *radar chart,* o objetivo foi garantir a correta inserção dos dados para identificar as diferenças entre o nível de conhecimento atual de cada competência e a sua meta definida. Para os treinamentos, o foco foi na melhoria da organização das aulas visando eliminar os *gaps* entre os níveis de conhecimento atuais e suas respectivas metas. Como resultado do desenvolvimento do sistema está a geração de análises e relatórios para melhorar a medição e acompanhamento dos indicadores medidos pela área e ter uma melhor e mais eficaz visualização desses dados. Para garantir a correta implementação do sistema em escala mundial, foi estruturado um plano de ação com as principais atividades voltadas ao treinamento dos funcionários no novo sistema e a correção de eventuais erros, além do mapeamento dos principais riscos envolvidos e a definição de ações para mitiga-los. Como conclusão, esse estudo trouxe a inclusão de novas análises à área da empresa, como o monitoramento de competências técnicas e a garantia da adoção do processo de validação do incremento do nível de conhecimento de cada competência, aumentando a confiabilidade dos dados registrados.

Palavras chave: WCM. Desenvolvimento de Pessoas. Sistema de Informação. Competências. *Radar chart*. Treinamentos.

ABSTRACT

This study aims to improve the people development pillar in the World Class Manufacturing (WCM) area, and was developed during an internship in the CNH Industrial Company. The focus was on the analysis of the tools and performance indicators used in the pillar to identify the current gaps and, in order to eliminate them, develop a people development global system that will standardize the processes and improve the results in all the plants worldwide. The method utilized was the analysis of the current structure of the competence model, radar chart and trainings inside the company, comparison with the literature and discussions with members of the area. It was defined a set of requirements that a people development global system should have to support the area and cover the identified gaps, and later, during the system development, together with the information technology area, build the pages and system functionalities. The main points considered were the competence model, focus of the author internship activity (create a well-defined set of competences and its description), the radar chart and the trainings. Regarding the radar chart, the objective was to guarantee the correct input of data in this instrument utilized to identify the differences between the competence actual knowledge level and its target. For the trainings, the focus was on improving the organization of the lessons organized with the objective to eliminate the gaps between the actual and target knowledge gaps. As a result of the system development there is the generation and analysis of the outputs to improve the measurement and monitoring of the performance indicators of the area, and in having an effective and visual representation of the data. To guarantee the correct implementation of the system worldwide, an action plan was developed including the main activities to teach the workers the new system functionalities and correct possible errors, besides the identification of the main risks and the definition of mitigation actions. As conclusion, this study included new analysis to the company WCM area, as the monitoring of technical competences and the guarantee of the adoption of a validation process to each competence knowledge level improvement, improving the accuracy of the data registered.

Key Words: WCM. People Development. Information system. Competences. Radar chart. Trainings.

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LIST OF ACCRONYMS AND ABBREVIATIONS

CD – Cost Deployment

FI – Focused Improvement

HERCA – Human Error Root Cause Analysis

IDP – Individual Development Plan

IT – Information Technology

KPI – Key Performance Indicator

LUTI – Learn, Use, Teach, Inspect

OPL – One Point Lesson

PD – People Development

PL – Pillar Leader

PM – Plant Manager

SOP – Standard Operating Procedure

TL – Team Leader

TWTTP – The Way To Teach People

WCM – World Class Manufacturing

CONTENTS

1 INTRODUCTION

Nowadays the companies are fighting for competitive advantage in order to gain market share through increasing the efficiency and the flexibility of the operations in a continuous improvement approach (Palucha 2012).

There are several managerial models focused on the automotive industry performance improvement, since the Fordism until the more recent Toyota Production System. The central idea of this is the attention in the quality level, reduction of defects, wastes and costs (Ohno 1988).

In this scenario, the World Class Manufacturing (WCM) concept appears as a modern model to structure the companies to achieve their goals, mainly in the automotive industry (which is the case of the company in study), in which there's a high pressure to do improvements and reduce waste, losses and consequently, costs (De Felice and Petrillo 2012).

The WCM concept is becoming more known and the number of companies adopting and implementing this model is increasing (Freitas and De barros Filho 2016). One of the reasons is the WCM principle of production processes optimization through continuous improvement and reduction of the wastes (M. Dudek 2014). Moreover, the model emphasizes the integration between the different areas of the company and the involvement off all the company structure, from the operators to the plant managers.

Inside the WCM model, there are thirteen specialized areas, and the focus of this study will be on the one responsible for the people management and development. According to Ohno (1988), the best approach to guarantee competitiveness to the companies is the development of a managerial system based on the knowledge development of the employees, to reduce errors and wastes. This area includes the definition of each employee competences and its targets and the organization of trainings.

This competence management is important to measure each employee performance, focusing on the competences that are more relevant and the ones that need to be developed, besides the usefulness of the convergence of the employee performance and the company goals (USOPM, 1999 apud Dorn & Pichlmair, 2007). The mapping of the competences that don't have the requested level enables the scheduling of actions and trainings to tackle the gaps and lead not only to an employee improvement but consequently to the company improvement.

Given the relevance of the people development in general, the companies should have a well-structured tool to manage these information, but the size of the company in study (acting worldwide with more than 60 plants) creates many difficult and obstacles to implement a standard competence and training management model. Until now there were no global tool in the company analyzed, and the management of the people development area was done through excel files and papers standardized only at a certain point, and that contained a lot of errors and subjectivity.

The idea of the creation of a system appeared as a way to solve these problems and offer instantaneous graphical analysis and more efficient and dynamic data storage and evaluation. According to Batista (2004), the information systems are developed with the objective of having trusted information, which can be spread to the whole organization and, as a managerial tool, they become strategic to the company decision making and help to improve and optimize the results.

Therefore, the necessity of a people development global system to create standards and offer a better organization and visualization of the data showed up.

1.1 PROJECT JUSTIFICATION AND INDIVIDUAL CONTRIBUTION

During the four months of internship in the WCM area of CNHI company, in Turin (Italy), the lack of standardization in the people development (PD) pillar was noticed, as well as the consequences of it in the area (time-consuming activities not relevant to the area and difficulty in the coordination). In discussions with the members of the office, it was possible to confirm some of the current problems and their motivation of looking for new actions for improving the PD management

Due to the detection of the problem and the increasing relevance of WCM in the companies, it was considered relevant to do a deeper study in the area, trying to develop a solution to cover the major part of the current gaps, together with the information systems to support the solution.

During the internship period, it was a responsibility of the author to gather and organize all the data existent related to the employees' competences (from technical to soft skills) and its description and to add new competences and descriptions in the cases of lack of information or non-consistent information. It was done dividing the competences according to the radar chart typology, pillars and job position to guarantee the correct insertion of this data in the system during the implementation phase.

Moreover, the author participated, together with the PD central team, in the weekly meetings with the information technology (IT) area to discuss the system pages layout and functionalities, and was responsible to check the meetings minutes and documents generated to certify the areas alignment and that the project would be completed according to the established objectives.

In this way, this study was an opportunity to the author to understand deeper the concepts and principles of WCM and, mainly, the management of competences in the PD pillar, and how these actions would impact the company results not only in the focused pillar but in the WCM as a whole.

1.2 PROJECT OBJECTIVES

The project has the objective of developing a managerial system based on the PD pillar to improve the individual’s performance analysis using objective tools and facilitate the management of the data, creation of reports and organization and controlling of improvement actions. With the implementation of this system, the expected output is the automated linkage between the employees, competences and knowledge level and a higher control of the process.

This approach considers all the employees of the company, covering from the managers to the operators, in order to evaluate their technical and behavioral skills and knowledge according to their job position, pillar in which participate, and project assigned. This analysis will provide a standardization of the minimum competences and knowledge levels required for each role and project and also an evaluation of synergies between employee competences and project requirements in the personnel assignment in the projects. Another benefit of the system creation is the possibility of providing training sessions in an automated way, to improve the knowledge level of the employees until achieve the target level requested for an activity.

The system will be implemented in the World Class Manufacturing (WCM) area of all the plants worldwide, with mid and long-term plans of implementation.

1.3 PROJECT STRUCTURE

This project is divided in six chapters, being the first one the introduction in the studied area, the trends and the objectives of the research.

The second chapter is the literature review, in which it was studied some articles and relevant books about the Word Class Manufacturing, people management and performance indicators. Based on all the articles analyzed, the main contributions of them were aggregated and compared in order to structure the analysis presented in this study. This chapter is divided in two parts:

- WCM overview: includes the history, characteristics and tools. Compares the WCM model with precedent models to understand the differences and improvements;
- PD pillar: includes the specificities of the pillar, which is the center of this study, its tools and performance indicators.

The third chapter includes general information about the company in which the study was developed (structure, size and areas of expertise) and how the PD pillar is structured and managed inside the company, including the company particularities. It presents the characteristics of the current scenario concerning the performance indicators cited in the earlier chapters, in order to understand how the processes are conducted and evaluated nowadays and the consequences of it in the company results.

In the fourth chapter the PD system that is being developed to solve the gaps between the analyzed literature and the current processes of the company, is detailed. The method utilized to structure the system development was established, as well as the definition of its requirements, based on the current problems, which were listed in the chapter before.

The chapter presents the system functionalities created to reduce the current problems and to automate some processes to improve the effectiveness of the PD pillar analysis, as well as implementation steps, considering the expansion of the system to all the plants worldwide, and the human and technical risks associated to the implementation process.

The last chapter presents a summary of the main conclusions of the study, based on all the analysis done in the other chapters. It shows the outputs and new analysis available after the system implementation and the impact the outputs to the company results.

2 LITERATURE REVIEW

In order to have an overview of the context of the study, this chapter presents the emergence of the World Class Manufacturing concept and the comparison with the previous Toyota Production System, presenting its main changes and advantages. Also, the WCM principles and pillars and described, with a deeper analysis of the People Development pillar (the methodologies, tools and indicators used to manage the area), to map its characteristics and objectives. In the end, as the study involves the development of a system to fill the detected gaps in the PD area, it is presented the most important concepts to be considered during the development and implementation of an information system.

2.1 WCM OVERVIEW

The WCM model should be analyzed considering its history and origin, principles, pillars and the tools used to support the model. The pillars, technical and managerial, were evaluated considering its importance in the model and, for each one of them, one or more tools were described as a support to achieve its objective.

2.1.1 Manufacturing history and development

The first industrial revolution, in the end of XVIII, introduced the machines power, reducing the production time. After that, the concern about high performance and cost reduction increased, due to the competitive pressure (De Felice and Petrillo 2012), leading to the constant development of new tools and techniques.

In 1950 a new methodology concerning the production system in the automotive sector was developed by Taiichi Ohno, Toyota Motor Corporation engineer, with the name of Toyota Production System (TPS), including a focus on the customer requirements (products with different colors, models, etc.)(CNHI 2015). The attention was on quality aspects (Total Quality Control), lead time and waste reduction, having the basis of Just in Time (JIT - continuous flow) and Jidoka (autonomy to detect abnormalities in the processes and stop the machines when it occurs, in order to fix the problem, with the objective of reducing defects) (Ohno 1988).

Evolving from the TPS, there's the lean manufacturing, which focus on the reduction of waste and of activities that don´t add value. The term was used in a study from MIT (Massachusetts Institute of Technology) in 1980 (Womack 1990) and has similar principles as TPS, but with the difference of not having a long-term approach neither a high concern on the teaching processes about the job activities (Kochnev 2007).

Although some few authors believe that are some differences between them, the term lean is usually used as an equivalent of TPS (Chiarini and Vagnoni 2014).

After that, Hayes and Wheelwright proposed the concept of World Class Manufacturing (WCM) in 1984 (which was changed and reinterpreted by Schonberger in 1986), based on the TPS principles, connecting the techniques of JIT and Total Quality Control (TQC) (Chiarini and Vagnoni 2014). It is defined by him as a "faster, higher and stronger" improvement that join many techniques and is used by the companies to gain competitive advantage and achieve excellent performance (Schonberger 1986) focusing on the continuous improvement.

This WCM model was redesigned by Fiat Group Automobiles (FGA) in 2005 and became based mainly on the concepts of JIT, Total Quality Control (TQC), Total Productive Maintenance (TPM) and Total Industrial Engineering (TIE) and is represented on figure 1 (De Felice, Petrillo and Monfreda 2013). According to Dudek (2016) the idea of natural evolution and sharing the best practices defended by Schonberger was changed to become more a flexible management model adapted to the changeable environment that the companies are involved.

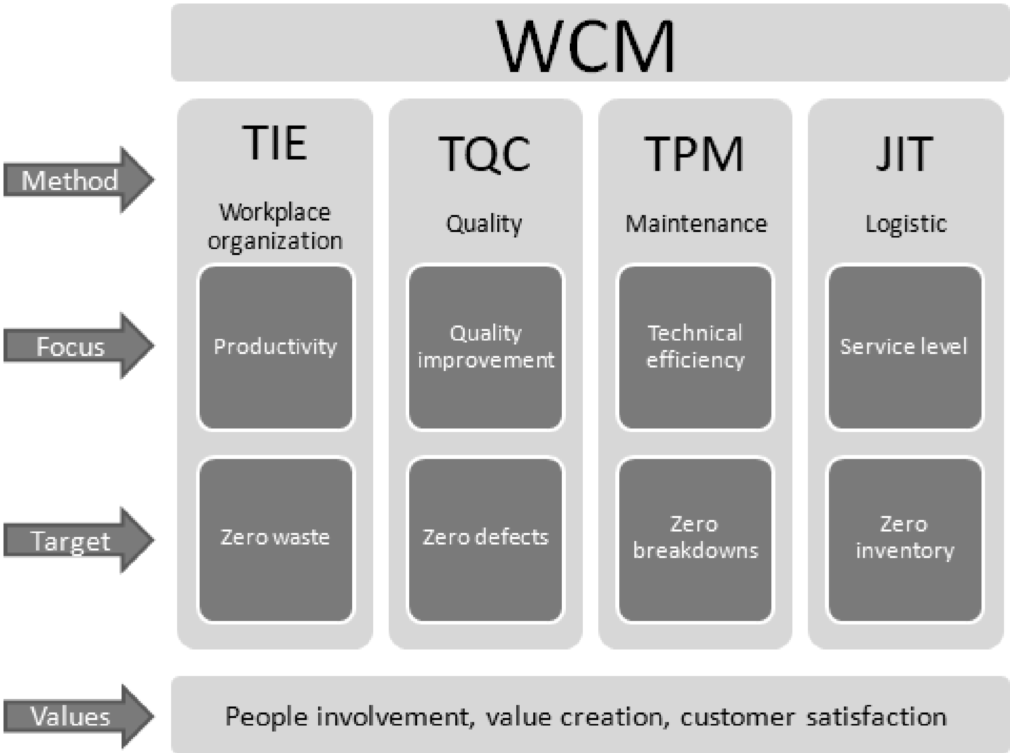
The JIT has a focus on the reduction of stocks, with the production aligned to the demand. As defined by Yasuhiro (2012), the JIT refers to a production only of the required units and quantities (utilizing the smallest amount of time required) through a continuous flow of production.

The TQC involves the control and improvement of the quality not only of the product (focus and satisfaction of the client) but also of the process, including all the employees (Feigenbaum 1983). To make these improvements, all the processes are analyzed, the cause of problems is identified, and actions are set to solve the situation. In addition to that, all the departments should work together and with extreme high communication because the quality couldn't be achieved working only on one department (Feigenbaum 1983).

The TPM focus on the overall equipment's effectiveness (OOE), maintenance efficiency and prevention and periodical maintenance by the employees (including training programs to improve their skills and, consequently, the success of the maintenance actions) (Wireman 2004).

Rao (2012) points that the TIE is identified by Yamashina as total employee involvement with a focus on the productivity and the looking for zero waste.

Figure 1 – WCM Structure



Source: adapted from De Felice, Petrillo and Monfreda (2013) and CNHI (2015).

According to Chiarini and Vagnoni (2014), although the tools similarities between the lean manufacturing and the WCM, there are differences between them. Some of these, described by the authors are:

- The WCM has a higher concern on safety and environment (which affects the quality and costs analysis), while in the lean manufacturing these two concepts are less correlated and less relevant in the company strategy and management;
- The WCM focus not only on finding and reducing the losses as lean, but also to measure it;

- Although their similar KPI, the WCM has a more automated management of the data to evaluate the employees work;
- The communication and sharing of knowledge and best practices is more spread between all workers levels and tools;
- WCM, differently from lean, has auditing system to evaluate the plants levels, compare (benchmarking) and measure the improvements.

2.1.2 WCM definition and principles

Although there is no agreed worldwide definition of the WCM (Santos Silva et al., 2013; Okhovat et al., 2012), it will be defined in this study as a mechanism to achieve the excellence through production improvements, as set by Massone (2007).

According to CNHI (2018), the WCM is considered as an integrated management model to improve and standardize the production systems in which the objectives are to reduce waste and losses by defining standards and methods in an approach to involve and coordinate all employees and with results concerning quality and customer satisfaction.

De Felice and Petrillo (2015) describe the main principles of WCM as: concern about quality aspects (attending customer requirements), relation between employees during their activities, measurement (well-defined tools), continuous improvement and effort in innovations as a way to become the first to introduce new products and services in the market.

However, for CNHI (2015), these principles could be simplified as three: continuity (continuous improvement), consistency (correct use of the methods and tools) and commitment (involvement of the whole company, motivating employees to work with focus on the company objectives). The role of quality is inserted on the continuity principle: the improvement should be done in all the areas, including the quality one.

The WCM outputs are the knowledge development (map the current situation and improvements for each pillar on their different requested knowledges) and the auditing system (track each plant evolution and improvement) (CNHI 2015).

The knowledge development is measured and controlled by radar charts, while the audits (internal and external) are done periodically to evaluate the WCM implementation level achieved by the companies and to motivate the employees to improve constantly, focusing on reaching the higher levels. Other audit benefit is the possibility of learning and copying some activity or process from one plant with high level in order to improve all the plants level, since the main goal is to reach the company improvement (CNHI 2015).

During the audits, each plant receives a score calculated by the sum of the scores of each plant pillar. The pillars are evaluated in a score from 0 (no action) to 5 (implementation and proactive expansion to other areas) and the plant total score gives a classification in four levels, with scores from 0 to 100 (Chiarini and Vagnoni 2014):

- Bronze: if receives 50 points or more;
- Silver: 60 points or more;
- Gold: 70 points or more;
- World Class: 85 points or more.

To reach these levels, there's minimum requirement levels for each pillar, which means that the development of each pillar is important for the plant improvements, which is reflected in the plant total score.

2.1.3 WCM pillars

The WCM is composed by 10 technical and 10 managerial pillars, forming the "temple of WCM" which requires the work on each pillar and its interaction to reach the global excellence level (De Felice, Petrillo and Monfreda 2013).

According to Felice, Petrillo and Monfreda (2013), and considering the material of CNHI (CNHI 2015), the 10 technical pillars can be described in table 1.

Table 1 – Description of the 10 WCM technical pillars

PILLAR	DESCRIPTION	IMPORTANCE
Safety (SAF)	Responsible for the report and analysis of accidents and risks, and the reinforcement of a prevention culture	Reduction of accidents, workplace improvement (ergonomics, noise)

PILLAR		DESCRIPTION	IMPORTANCE
Cost Deployment (CD)		Responsible for analyzing the right balance between waste and losses and analyze economic benefits	Identification of the main losses, its causes and prioritization
Focused Improvement (FI)		Responsible for developing the necessary tools to reduce the losses in their priority order and train and monitor project groups	Reduction of losses by reduction/elimination of set-up time and activities with no value-added
Autonomous Activities and Workplace Organization	Autonomous Maintenance (AM)	Improve efficiency by reduction of maintenance activities time as cleaning and inspection	Improvement of overall equipment efficiency and useful life
	Workplace Organization (WO)	Redesign of workplace by eliminating unnecessary employee movements and considering the ergonomic aspect	Improvement of motivation and reduction of labor and material losses
Professional Maintenance (PM)		Responsible for improving the equipment efficiency by doing failure analysis	Improvement of overall equipment efficiency and elimination of machine breakdowns

<table>
<tr><th colspan="2">PILLAR</th><th>DESCRIPTION</th><th>IMPORTANCE</th></tr>
<tr><td colspan="2">Quality Control (QC)</td><td>Responsible for guaranteeing a high-quality level delivered to the customers by the production process improvement, reduction of nonconformities and preventive actions</td><td>Improve customer satisfaction through high quality and low cost and improvement of quality skills</td></tr>
<tr><td colspan="2">Logistics and Customer Service (LOG)</td><td>Responsible for analyzing KAI (Key Activities Indicators) and KPI (Key Performance Indicators) in order to measure the improvement of the results and reduce stock levels</td><td>Reduction of stocks and transit time inside the company</td></tr>
<tr><td rowspan="2">Early Equipment and Product Management</td><td>Early Equipment Management (EEM)</td><td>Identify and reduce the life cycle cost through design reviews and specifications aligned to the customer needs</td><td>Ensure fast set-up and start-up and an easy to inspect equipment</td></tr>
<tr><td>Early Product Management (EPM)</td><td>Responsible for the product development process, optimizing the processes and achieve a fast launch</td><td>Minimization of product lifecycle cost</td></tr>
<tr><td colspan="2">People Development (PD)</td><td>Responsible for mapping and providing knowledge and skills by organizing training sessions</td><td>Improvement of employees’ efficiency and reduction of human errors due to lack of knowledge</td></tr>
</table>

PILLAR		DESCRIPTION	IMPORTANCE
Environment and energy	Environment (ENV)	Work respecting the environmental standards	Reduction in the pollution and environment accidents
	Energy (ENE)	Measures energy levels of consumption and reduce losses	Reduction in energy consumption and losses

Source: adapted from (De Felice, Petrillo and Monfreda 2013) and (CNHI 2015)

For the managerial pillars, they act as a support to the technical pillars on the working conditions and organization.

Felice, Petrillo and Monfreda (2013) lists the 10 managerial pillars, which CNHI (2017) divide in four focus areas, as shown in table 2.

Table 2 – Description of the 10 WCM managerial pillars

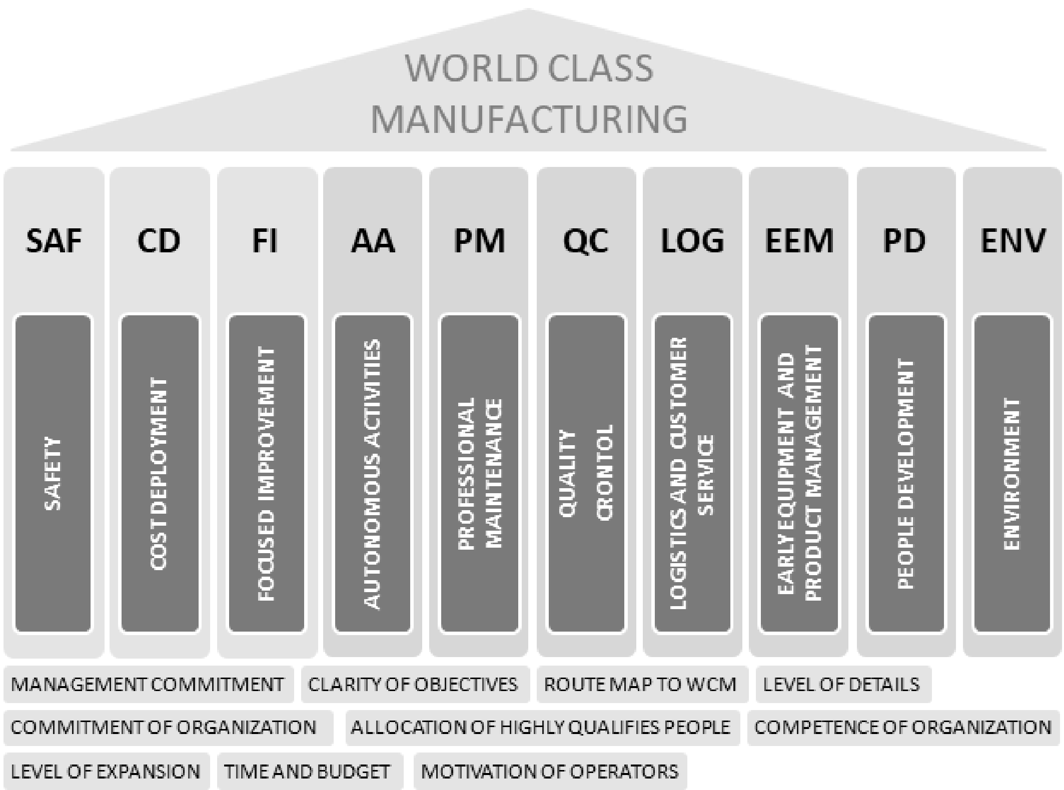
AREA	DESCRIPTION	PILLAR
Strategy	Focus on the main activities to achieve the objectives, affecting the KPIs and audits	Management commitment
		Clarity of objectives
		Route Map to WCM
		Commitment of Organization
Leadership	Problem solving oriented to the competence management	Allocation of Highly Qualified People
		Competence of Organization
		Level of details

AREA	DESCRIPTION	PILLAR
Resources and expansion	Related to the cost deployment	Level of Expansion
		Time and Budge
Motivation focused in improvements	Communication	Motivation of Operators

Source: adapted from (De Felice, Petrillo and Monfreda 2013) and (CNHI 2015)

Considering the twenty pillars described above, the temple of WCM is a visual way to represent all the WCM pillars, as shown figure 2.

Figure 2 - Representation of the temple of WCM



Source: adapted from CNHI (2018).

Although all the pillars are important to the company strategy and objectives, in this study the focus of the analysis will be on the technical pillars, mainly on the PD pillar.

2.1.4 WCM and the company strategy

A corporate strategy is the future expectations and goals of the company and it involves its type of product, customers, employees and financial situation in order to better utilize the resources to achieve competitive advantage (Foss 1997).

According to Keegan (2003), the WCM model acts on the operative strategy of a company, including the processes and resources management and contributes to create a flexible, competitive and customer-oriented company.

One of the basis of the strategy is the human resources, which, for the WCM model, is so complex that needs the employee’s integration and participation on the problems solutions (Keegan 2003). Therefore, the communication and alignment between the pillars is essential to a company strategy, and the role of PD pillar is to enable the participation of each employee (e.g. the suggestion box that incentives the employees to write suggestion for the production flow that he works).

2.1.5 WCM tools

The WCM model has some basic tools, which help the pillars in their management and improvement. According to Poor, Kociski, & Krehel (2016) and CNHI (2015), there are seven WCM basic tools, which are described as:

- **Prioritization:** definition of the main areas to be focused, basing on tools as Pareto diagram (decreasing rank of the errors frequency) and value stream maps;
- **Deployment of objectives:** systematic, logic and detailed analysis of the results compared to the objective, in order to identify the problem. Includes the PDCA (Plan, Do, Check and Act) and kaizen;
- **Problem description with sketches:** drawings to understand and better detail the problem, because visual information is considered easier in explanations;
- **5W1H (What, Where, When, Who, Which and How):** six questions to have the context and situation of the problem and manage losses as breakdowns and defects;
- **Root cause analysis (RCA):** find the main cause. Includes the 4M (Man, Machine, Material, Method) tool and 5 Why’s;

- **Phenomena description:** understand the context behind the problem through OPL (One Point Lesson) and SOP (Standard Operating Procedure);
- **The Way To Teach People (TWTTP):** find hidden issues through analyzing the knowledge of the employees in doing the processes correctly.

For the objective of this study, the focus will be on 5W1H, 5 why's, RCA, 4M, OPL, SOP and TWTTP. As the RCA and TWTTP are more deeply related to the PD pillar, it will be described on the PD pillar section.

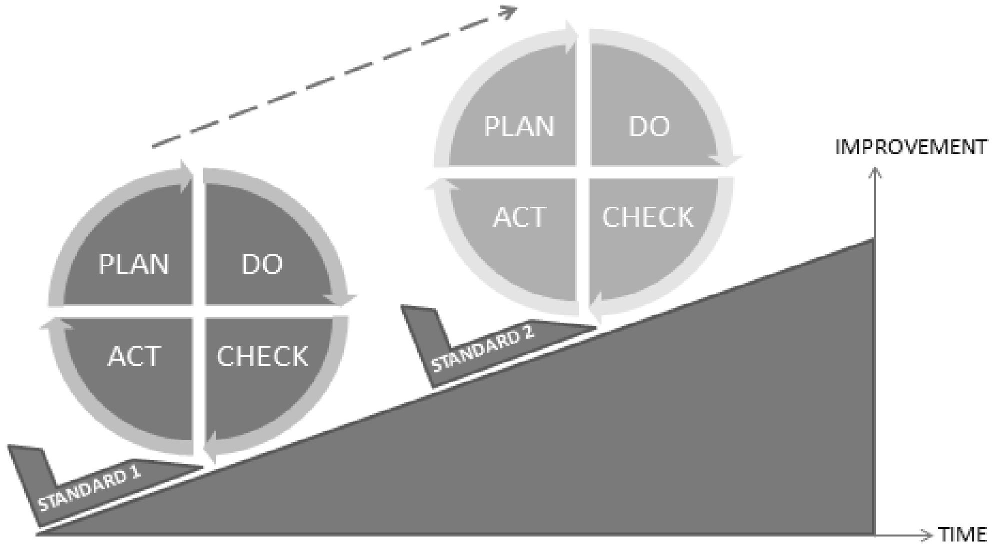
PDCA

The PDCA is a simple and structured method to be applied in order to establish the series of activities that must be performed focusing in the constant improvement (Slack et al 1996). When one PDCA cycle is finished, a next one can be started based on the previous results and standards defined, as represented in figure 3.

The cycle is divided in four phases, as described by Andrade (2003) and CNHI (2014):

- **Plan:** this phase starts with the definition of the problem and goals, search for more details, definition of the root cause and creation of an action plan (set the responsible, objective and deadline). It includes the 5W1H, 4M and 5 Why's tools;
- **Do:** application of the action plan, description of the solution to attack the root cause, and how it will solve the problem by comparing the past and actual situation;
- **Check:** calculate the benefits and costs relation and if the solution is generating the desired results (effectiveness);
- **Act:** apply the right procedure to guarantee the correction and not repetitiveness of the problem including documentation of the knowledge and procedures learned, and standardization by, for example, the creation of explanation sketches. It includes the OPL and SOP.

Figure 3 - PDCA Cycle as a continuous improvement



Source: adapted from CNHI (2014).

Kaizen

The term Kaizen is a tool focused in the continuous improvement in specific processes that impacts in the company results (Fonseca et al 2016) and, in the WCM, is used by the FI pillar to reduce wastes and losses. The advantage of the kaizen is the division of the problems in steps, making small improvements every day, what generates more effective projects (De Felice, Petrillo and Zomparelli 2018).

Fonseca et al (2016) affirm that the objectives of the kaizens are the elimination of wastes and losses, reduction of costs, improvement of quality and customer satisfaction by simple daily actions that involve and consider the suggestion of all the employees, including the operators.

It is based on the PDCA logic and is divided in four types of projects according to the difficult of the problem, and they are focused on the daily orientation of the employees. The division is (CNH 2015):

- Quick kaizen (QK): applied for sporadic and simple problems, with low focus on monitoring the causes;
- Standard kaizen (SK): applied for chronic problems containing causes related to each other. It searches the root cause and, because of that, includes tools as 5W1H and 4M;

- Major kaizen (MK): applied for chronic and complex problems in an approach to make changes in the product and process. It contains a more detailed documentation of the action plan and results;
- Advanced kaizen (AK): similar to the MK, but more complex, requiring specialists to help the team.

5W1H

According to CNHI (2016), this tool helps the FI pillar to have the details of the problem by asking:

- "Who" was involved (individual or group problem) and if it is a lack of knowledge problem. It is important to understand who has detected the problem;
- "What" has happened, in which process, and if it is possible to reproduce the problem;
- "Why" it has happened and what have influenced it;
- "Where" it occurred during the process;
- "When" it occurred (data, hour and shift) and the frequency;
- "How" the problem has started and developed (sequence of events).

By applying this tool, it is possible to have an initial perspective of the real cause of the problem, by restricting the possible causes and creating hypothesis for the root cause. It can also be used as a tool to define an action plan focused on eliminating the problem through the root cause, by describing the actions to be done, responsible and methods (Shingo 1996).

5 Why's

The 5 why's are important in the definition of the real root cause and the correct countermeasure, by a consecutive set of questions "why" (Andersen and Fagerhaug 2006). The idea is to have the details and precise information in order to attack the root cause and not just the first cause discovered.

According to Andersen and Fagerhaug (2006) the steps of the 5 why's tool, until the root cause identification, are:

- Definition of the problem to be investigated;
- Start identifying the causes of this problem through methods as brainstorming;
- For each cause detected, the question "why" should be done to understand the reason why the cause affects the problem;

- For each answer obtained, ask one more time "why" until it is not possible to obtain an answer/cause different from the already detected ones;
- The root cause is the last answer/cause identified.

This tool is important for safety incidents, breakdowns, sporadic defects and chronic losses analysis (CNHI 2008).

4M

The 4M tool, also known as cause and effect diagram, is used by the FI pillar to identify if the problem has causes in a machine, man, material or method.

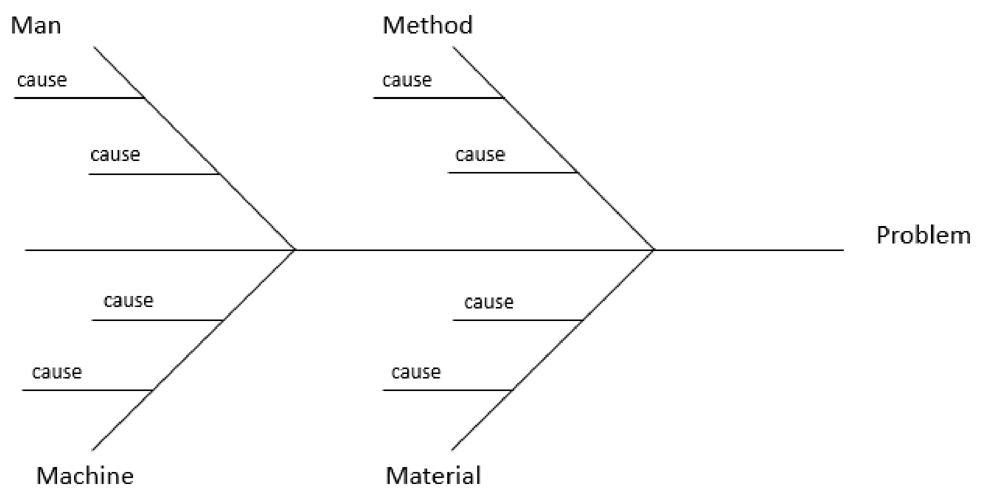
This tool contributes to the process of finding the primary and secondary causes of a problem and it is divided in the four categories cited before, to create a clear representation and investigation of the problem (Behr, Moro and Estabel 2008).

According to CNHI (2017), the four possible causes are:

- Machine: performance problem or some broken piece;
- Man: human error (not adequately following the methods);
- Material: nonconforming material;
- Method: the defined process is not guarantying the good activity results.

A common visual representation is shown in figure 4, including the relation between causes and effects.

Figure 4 – Ishikawa diagram



Source: adapted from CNHI (2017).

After the definition of the cause category, it is possible to do a deeper analysis and find causes and sub causes. If the problem is due to a man, an RCA should be applied, and the PD pillar must be notified to establish the countermeasures.

One Point Lesson (OPL) and Standard Operating Procedure (SOP)

The OPL and SOP are used by the QC and WO pillars to give clear instructions to the employees and help on the reduction of human errors and on fixing the necessary skills.

The OPL is based on teaching about a specific point (e.g. instructions for the use of a specific machine) in a simple and fast way by using easy and visual explanations, which will be posted on the workplace (CNHI 2017).

Instead, the SOP acts on the standardization of the work processes by a written instructions manual giving the operations steps (CNHI 2017).

2.2 PD PILLAR

To Yamashina (Freitas, I. S., 2016 apud Yamashina, 2007) the PD pillar is important in the employee’s development and motivation and works on the reduction of human errors by, for example, the organization of training sessions.

The relevance of this pillar is also shown in the need of PD level 3 (in the scale 1 to 5, in which 5 is the maximum) to achieve a silver level in the audits, and level 4 for a golden level. In other words, if the plant doesn’t improve the PD pillar it will never achieve a good classification in the audits and will be impossible to become a World Class plant (CNHI 2014).

The PD pillar has as main objectives (Saengchamnong and Chokechaiworarut 2015):

- Organize and offer trainings according to the company needs and objectives;
- Support the other pillars to work focusing on the same objectives;
- Help in the minimization (until achieve level zero) of losses due to lack of skills;
- Continuously improve the company learning and background.

To efficiently reach these objectives, the CNHI (2017) divide the PD pillar in four phases. The first one manages the human error, identifying the causes and developing actions to solve and prevent errors occurred due to man cause. The second phase is based on the analysis of the losses which, by applying the PDCA cycle, are reduced through evaluation and development of skills.

In the context of analyzing the losses and developing trainings to attack it, the PDCA cycle is based on the following steps (CNHI 2017):

- **P:** Based on the losses tracked by the CD pillar (divided by process, area or workstation), it is selected the project members that are related to these losses and the competences that they need to improve;
- **D:** Definition and organization of the trainings that should be given to cover the knowledge gaps identified;
- **C:** Evaluation of the effectiveness of the trainings in covering the knowledge gaps;
- **A:** Update of the knowledge levels of the employees that have proven the knowledge improvement in the step before. This new information will be used to define new project members and leaders.

After that, there's the 5YCD (5 Years Cost Deployment) which evaluates past data and forecast data related to projects losses. The losses attacked by this pillar are human errors due to lack of knowledge, absenteeism, turnover (number of employees that have left the company) and light duty (working hour losses due to employees with a high age or healthy problems) (CNHI 2017).

The design approach is the last phase and involves the EEM and EPM pillars. It is related to the management of the necessary knowledge to the design, manufacture, installation and optimization of the product and equipment (CNHI 2017).

2.2.1 Seven steps approach

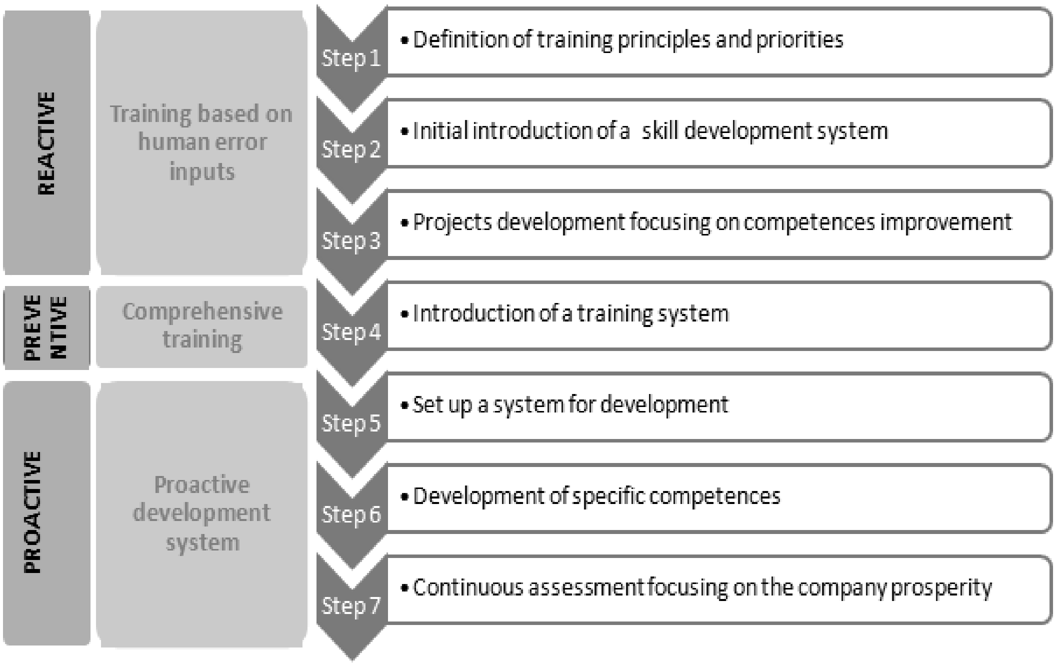
The implementation of WCM is based on seven steps, used for each technical pillar to reach the expected results. These seven steps are divided in three phases: reactive (correct a detected problem), preventive (use inductive thinking to avoid the recurrence of a problem) and proactive (use deductive thinking to create actions and standards to reduce the change of surging new problems) and the length of each phase varies according to the pillar analyzed (De Felice, Petrillo and Monfreda 2013). The approach goes from the model area to an expansion area until reach the whole plant after the conclusion of all the steps.

According to CNHI (2017), for the PD pillar the seven steps cover from the trainings development until the consolidation of the competences and the definition of a system to constantly evaluate the skills level. In this case, the three phases have the following roles: reactive (definition of losses priorities and initial trainings to solve those losses and human errors that occurred), preventive (introduction of trainings to develop competences to reduce losses and errors) and proactive (definition of a system to develop competences based on a long-term objective).

The figure 5 represents all these steps. In more details, the seven steps for PD are:

- STEP 1: Definition and prioritization of trainings according to other pillars inputs, as cost deployment, human error and skill gap analysis;
- STEP 2: Spread of education based of WCM principles and basic tools;
- STEP 3: Use of different development methods to improve competences based on radar charts;
- STEP 4: Optimize knowledge and define the critical ones to develop a specific job;
- STEP 5: Develop trainers capable to teach the competences required;
- STEP 6: Training plans based on 5YCD and on sharing good behaviors;
- STEP 7: Refinement by adding original competences to gain competitive advantage

Figure 5 – Seven steps approach for PD pillar



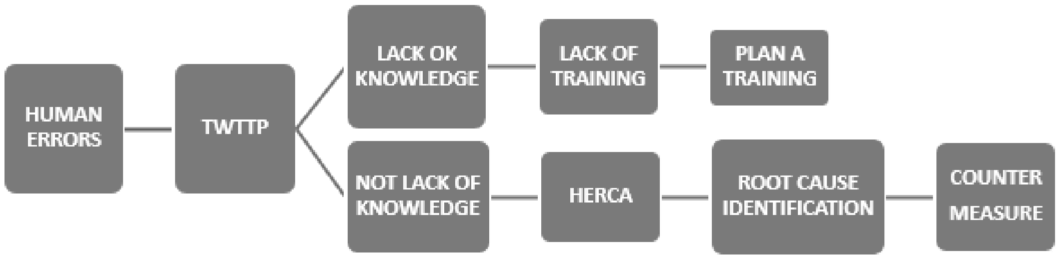
Source: adapted from CNHI (2017).

2.2.2 PD methodologies and tools

Based on the tools outputs of the other pillars, the PD pillar selects the causes related to human error to attack. When the 5W1H and 4M determines that the cause of a problem is a human error, the TWTTP and HERCA (Human Error Root Cause Analysis) are applied to understand if there's a lack of knowledge that should be improved.

The figure 6 represents the possible paths to solve a problem after detected that the cause is a human error.

Figure 6 - Sequence of procedures for the human errors problems



Source: adapted from CNHI (2018, p. 6).

TWTTP

The TWTTP is a method to analyze human errors and identify if the error is due to a lack of knowledge or a lack of skill.

De Felice, Petrillo and Monfreda (2013) defined the TWTTP as a set of four questions utilized to verify the employee ability to conduct a specific operation and is applied by the TL together with the employee related to the error. The questions are about his job in order to understand the employee view about the processes that he is doing and them search for lack of knowledge that he may have. The questions are "How do you do this work; How do you know you are doing this work correctly; How do you know that the outcome is free of defects; What do you do if you have a problem" (CNHI 2018, p. 6).

In most cases, the lack of knowledge is the cause of error if it is related to a repetitive human error (because if the employee doesn't know how to do an activity, it will make the same mistake all the times that the activity is done). It could also be due to a sporadic human error, if the activity is related to a product produced only once in a semester, for example. If it is a sporadic error the approach is different, and it should be construct a Pareto for each employee, to understand the main points to be improved and apply a countermeasure.

HERCA

For the cases that the human errors are not due to lack of knowledge the HERCA must be applied.

The HERCA, as pointed by De Felice, Petrillo and Monfreda (2013), is a technique used to find the root cause of an accident/defect by asking the reason of each action from the accident fact to the root cause. The possible human errors causes are procedures problems (e.g. need of more described operation), technical problems (e.g. not adequate tools), workplace (e.g. disorganization), behavior (e.g. lack of motivation), forgetfulness (e.g. extremely repetitive work) and team work (e.g. low team involvement) (CNHI 2018, p. 6).

Once defined the root cause, a countermeasure should be created and, if possible, a visual control to facilitate the management and tracking.

This approach is usually the first step to the PD pillar actions, because by applying this method the pillar can have the list of employees and knowledges that must be improved in order to reduce these losses. After provided with this list, it is possible to organize the data and define the best action for each situation.

Competence management

First, it is important to define the term competence. Mulder (2001) describes competence as a group of knowledge, skills and attitudes that support the company accomplishments and results. So, competence includes the behavioral capacity at the same time that the knowledge and the skills are used.

According to Dorn and Pichlmair (2007), knowledge is the theoretical information acquired, while skill is more related to the manifestation of some ability (learned capacity).

In order to manage these competences, it should have a constant development of human resources, involving the definition of the competences needed by a company, recognition of gaps in those competences, and trainings to eliminate the gaps and improve the competence levels (Baladi, 1999 apud Lindgren, Henfridsson, & Schultze, 2004).

According to Agha et al. (Agha et al., 2002 apud Söderqvist, J. B., 2016; Kööhler, O., 2016) the competitive advantage is becoming more related to competence leadership (employees knowledge) and not only related to the set of products developed by the company and offered to the customers. So, the competence management become very important for a company strategy and excellence.

The management of the competences in a company gain importance a strategical approach that offers learning processes for each employee, contributing to the improvement of the company activities effectiveness (Mulder 2001).

Lawler and Ledford (Lawler and Ledford, 1992 apud Söderqvist, J. B, 2016.; Kööhler, O., 2016) emphasize the importance of having a skill-based view instead of a job-based view, meaning that the skills of the individuals should not be improved considering only the job roles requirements because this does not train the employee to future challenges.

To objectively manage the employee’s competence, a competence model may be used. CNHI (2018) define competence model as a description of the competences required for each role and pyramid position. For each competence, there’s a 1 to 5 scale classification to define the actual and target value required (competence level required to develop the role or project that is in analysis), considering the level of knowledge and demonstration of that competence. The definition of the competence level is based on a document with the description of the evidences that each employee should have demonstrated to achieve each level. The idea is to reduce the subjectivity of the definition of the actual levels.

2.2.3 Performance Indicators

In order to continuously check the improvement of the different pillars in WCM and guarantee that improvements are being accomplished, each company should base its analysis on performance indicators.

To define an efficient performance indicator, the framework SMART was created (Cross and Lynch, 1988 apud Kibira, Morris, & Kumaraguru, 2015). This framework states that each indicator should be:

- **S:** specific
- **M:** measurable
- **A:** achievable
- **R:** relevant
- **T:** time bound

To control the processes and track and evaluate the results of each pillar there are Key Performance Indicators (KPI). According to Saengchamnong and Chokechaiworarut (2015) the performance indicators for PD are: absenteeism, turnover, people development ratio (related to the skills and knowledge management) and training hours.

In the other hand, CNHI (2017) uses as the standards KPI: absenteeism, number of suggestions per employee, number of human errors due to lack of knowledge, percentage of knowledge growth and gap closure.

For the objectives of this study, it will be only considered the people development ratio (number of human errors due to lack of knowledge and percentage of knowledge growth) and training hours (related to the percentage of gap closure due to the trainings function of reducing the knowledge gaps), as expressed in the table 3.

Table 3 – PD pillar main KPI description.

KPI	Objective
Number of human errors due to lack of knowledge	Evaluate if an employee needs an improvement in some competence and, sometimes, a training course
Percentage of knowledge growth	Evaluate the employee's improvement on each competence and change their actual level in each one of the competences
Percentage of Gap closure	Measure the ability to reach the target set

Source: adapted from CNHI (2017)

2.2.4 Radar Chart

The radar chart is a graphical data representation used when it is necessary to represent simultaneously different information about the object analyzed. Mosley and Mayer (1999) describe a radar chart as different axes combined by lines forming one figure, in which each line represents the level of performance of one axe (one information analyzed).

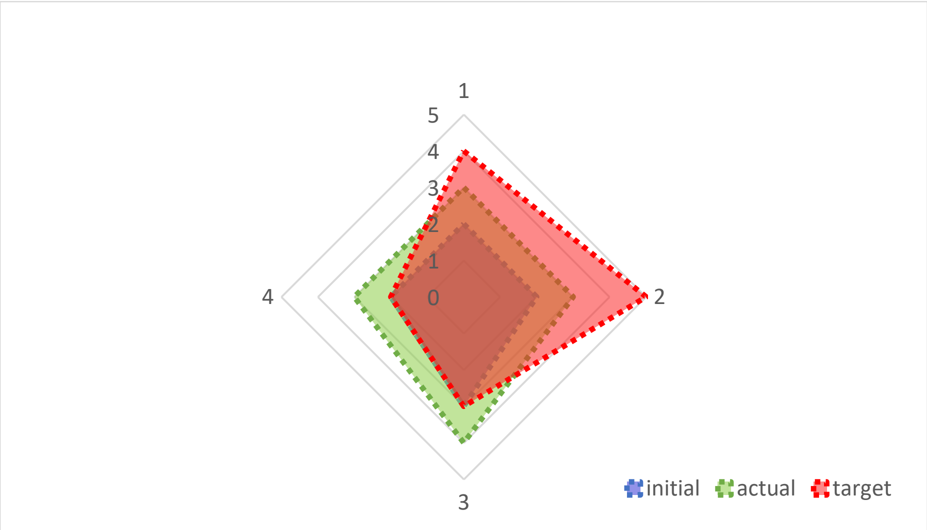
In people development and human resources areas, this tool is frequently used to analyze the individual knowledge level of the employees in different areas (for example social and technical skills) according to the competence level and compare that with the target level set. The authors

Hecklau, Galeitzke Flachs and Kohl (2016) consider this an important way to have a visual representation of the competence models and to establish the gap analysis between required and measured levels.

To construct the radar chart first a set of competences are listed based on the competence model elaborated previously, and for each one of them a target is defined, changing according to the employee analyzed. A radar chart is created for each employee and an analysis of the gap between actual and target level is done. For each gap showed, a strategy should be created to eliminate it through the definition of the method that best close the gap (Hecklau, et al. 2016).

The model representation is shown in figure 7.

Figure 7 - Radar chart with the initial, actual and target situation, considering four competences



Source: adapted from Hecklau, Galeitzke, Sebastian, & Kohl (2016).

2.2.5 Trainings

Chiavenato (1999) define training as a teaching process to capacitate the employees for their specific work (selecting, from a set of skills, the ones related to their job activities) and, as a result, improve their productivity. In the case of WCM, the trainings are generated through the gap analysis evaluation for each employee.

In order to be able to use the WCM tools, it is important to improve the competences of the employees frequently, which is one of the main objectives of WCM (Górska, J., 2008 apud Midor, 2012).

The trainings are important to improve individual performance in their job and consequently the productivity improvement and should be done continuously (Ávila and Stecca 2015). In addition to that, the right choice of the necessity of a training and the choice of the training method is essential to achieve the objectives and improve the competence level of each employee (Rocha, 1998 apud De Paula Santos, 2016).

There are different instruments to train the employees such as coaching (one support other in the execution of an activity based on the competences that already have), internal training school (more complex teaching with the aim to give the employees career developments) and courses (used to spread new knowledge) (Ávila and Stecca 2015). To choose the best instrument for each case, the improvement requirements (what are the objectives of the training), the workload (the total amount of work assigned to an employee) and the number of employees that must be trained are considered. This evaluation is relevant because if only one employee needs to develop some competence, it doesn't make sense to organize a course class, for example.

After the definition of the correct training to be applied for each case, it should start to plan and organize the training sessions. Ávila and Stecca (2015) defines four steps to establish a training:

- Context: verify the necessity of it and the objectives;
- Draft: development of the training that best fit these requirements;
- Implementation: apply and monitor the training;
- Evaluation: check if the training was effective and have achieved the expected results.

This evaluation, according to Lee-Kelley and Blackman (2012), should consider the participants feedback about the training, its effectiveness (increase in the knowledge) and the efficiency of the outcomes according to the strategical intended results.

The training evaluation is important because after the confirmation that the knowledge was acquired, the competence actual knowledge level should be updated in the radar chart.

2.2.6 Integration of CD and FI pillars with PD pillar

As all the ten WCM technical pillars are integrated, the activities managed in the PD pillar have impact in the other pillars. This integration increases the importance of working on the PD pillar improvements.

The two pillars that are more correlated to the PD are the CD and FI pillars, which give important inputs to the PD analysis and, because of that, their integration should be studied.

Starting from the CD perspective, the seven matrixes of this pillar work from the identification of the losses until the definition of actions focused on the causes of these tracked losses. Two of them (C-matrix and D-matrix) are more relevant to this study, because they generate essential information to PD pillar.

The A-matrix gives the list of losses and costs, the loss category (equipment, labor, material, energy or environment) and the classification of a causal loss (caused by a process problem or a resultant one, which is indirect and derives from a loss in other process) (CNHI 2016).

After that, the B-matrix reallocates the resultant losses to their real causes, considering the process and machine to which is related. The objective is to have a matrix with only causal losses (generated by the sum of the resultant losses related to them) because the results will be effectives only if tackling the real causal (CNHI 2016).

The C-matrix aggregates all the causal losses and divide them by processes. With this approach is possible to identify the most impactful losses and define prioritizations according to their impact, cost and easiness to reduce the loss through a feasibility analysis (CNHI 2016).

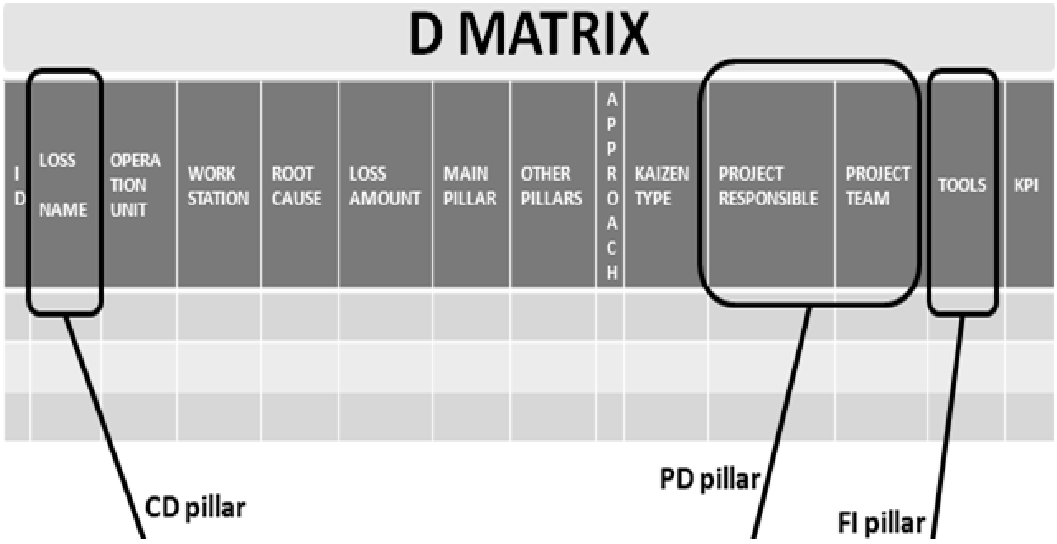
After this losses list, the D-matrix identifies the methods and tools to reduce each loss considering their prioritization, as shown in figure 8.

Based on the D-matrix, the FI pillar select and creates a pool with the necessary tools and methods for each project and assign the project leader of each loss that will be tackled. Also, establishes the level of knowledge needed to attack the losses (CNHI 2016).

Finally, the PD pillar is responsible to guarantee that the project team has the necessary knowledge level (comparing the individual radar charts with the level established by FI) for each tool in their assigned project and that there will not be an overload of project leaders (CNHI 2016). If the level required is higher than the actual team level, a training plan will be drafted to eliminate the gap or other person that already has the skill will be allocated in the project.

After that this information is taken, it is divided by projects, creating the E matrix, which presents the amount of losses attacked and the possible savings for each project. Then, the F matrix establishes the implementation plan and monitoring, and the G matrix focus on guaranteeing the productivity level and the budget constraint for the following year (CNHI 2016).

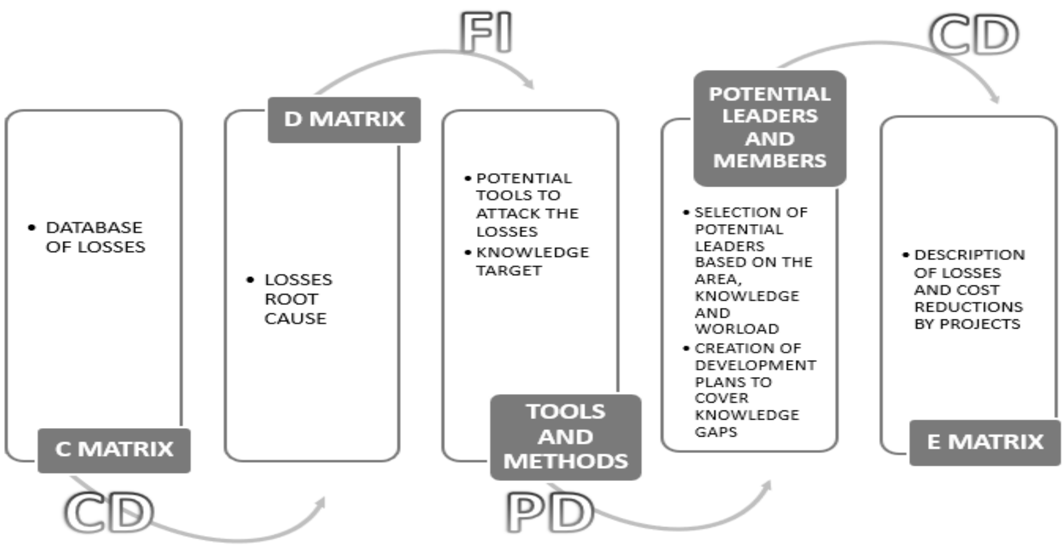
Figure 8 - Representation of D matrix and the different pillars inputs



Source: adapted from CNHI (2016).

This integration between the three pillars is synthetized in figure 9.

Figure 9 - Representation of the integration between CD, FI and PD pillars



Source: adapted from CNHI (2017).

2.3 INFORMATION TECHNOLOGY

The information technology (IT) is becoming more relevant to the companies' strategy considering the high competitive scenario and the speed and easiness in spreading and providing rapid access to the information, even for large amount of data (Santiago 2004).

Terra (2000) identify some IT tools to manage knowledge:

- Knowledge library accessible, without restriction, by all the employees;
- Knowledge maps containing the employees' data including the competences related to each one of them;
- Just-in-time knowledge: data storage created to facilitate the access to the information and knowledge.

In this study, the focus will be on the knowledge maps, by classifying the employees by their competences and level in each competence listed and, then, manage this data. The knowledge maps facilitate the localization of the employees that can teach others some competences, the analysis of the knowledge gaps that must be filled and the definition and improvement of project groups knowledge according to their requirements (Santiago 2002).

For the knowledge map to be effective, it is necessary to have a clear motivation and objective to apply it; a detailed description of the knowledge; a relation of the knowledge with an employee, project or group; a visualization tool to present the information (Ebener et al 2006).

2.3.1 Information system

Based on Alter (2008) studies, an information system can be defined as a system that collect, organize and share information and other resources to be visualized and managed by the workers. Its functions are to support the employees in the internal processes and decisions and, consequently, being an instrument to the company achieve its goals and objectives (Balloni, A. J., 2005 apud Oliveira, J. F., 2016).

Therefore, the implementation of an information system occurs when there is a need to storage and analyze a large amount of data in an efficient way, as occurs in the case of competence management, which includes the competences of all the employees of a company and their knowledge levels. According to the size of the company, the importance of an information system to manage these data is even higher.

In the competence management system implementation, it should be well defined the content (type and quantity of information needed inside the system), technical aspects (manage and update of the data) and organizational aspects (who will have access to use the system) (Dorn, J. et al. 2008).

Despite the importance of an information system in the people management, it must be seen as a support to further analysis and knowledge development. The systems must be used as the base for the managers decisions and development of action plans, to create more agile processes and let the managers focus their work time in the more important and impactful activities for the company results.

To develop an information system, it is necessary to define the functional and non-functionals requirements based on the organization objectives and the system stakeholders (the persons which will be directly or indirectly involved with the system, including the system users, and which will influence the requirements) (Pohl and Rupp 2015).

Functional requirements represent the functions and operations that the system must have, while the non-functional ones are not related to the functions, but to the system performance and confidentiality (Koscianski and Soares 2006).

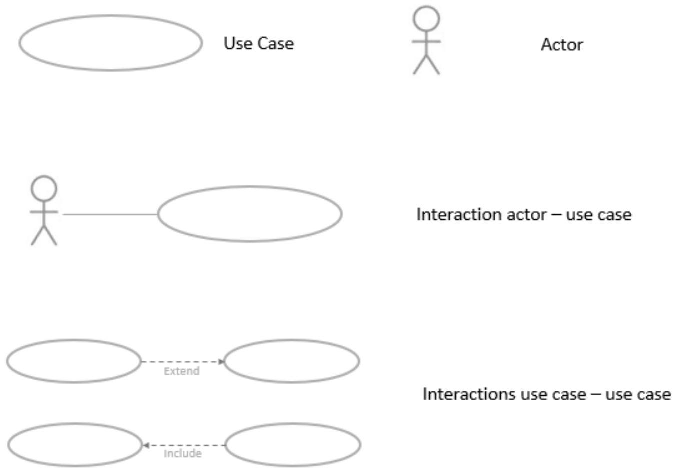
To represent the critical functionalities of the system and their relations and interactions it is used the use case model (composed by a few use case diagrams for each function), which presents it through the system main processes linked with the users' actions (Li and Liu 2008).

Each use case diagram is composed by the following elements (Li and Liu, 2008; Pohl and Rupp, 2015):

- Actors (person/system which calls a system operation);
- Operations (the system functionalities);
- Interactions between actors and use cases, when the activity of the actor directly affects the use case;
- Interactions between use cases, which can be:
    - Extend relation: means that the operation x directly influences and generates an operation y;
    - Include relation: means that the operation x is a general operation which includes the operation y;

To understand how these elements are represented in the use case, they were illustrated in figure 10.

Figure 10 - Representation of one use case elements



Source: adapted from Pohl and Rupp (2015).

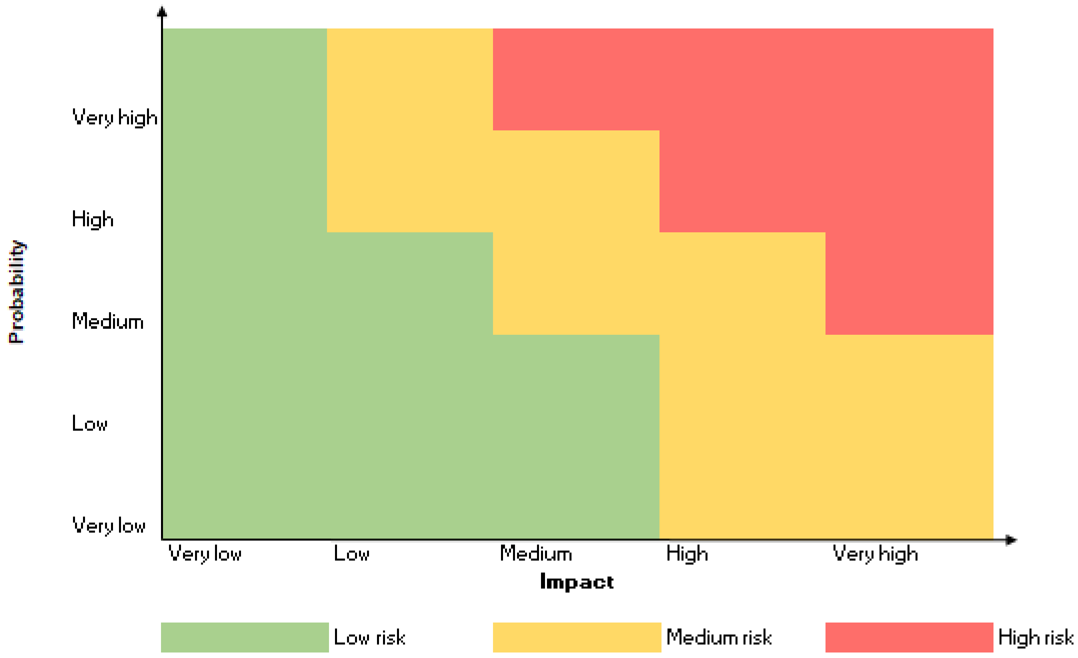
2.3.2 Risk Management

After the definition of the system requirements and use case, it is important to structure a risk analysis and try to apply mitigation actions.

According to Stoneburner, Goguen and Feringa (2002), as the risks are related to the threats to the information system which could generate negative effects in the company, it is important to define the potential risks associated (risk assessment), create mitigation actions and monitor it to guarantee the maintainability of the mitigation actions in the company future.

During the risk assessment, it should be considered the system characteristics, vulnerability and the risk matrix (probability and impact analysis). The risk probability-impact matrix is composed by the axes probability and impact, each one divided in a three or five levels scale: very high, high, medium, low and very low. According to the position of the risk (combination of probability and impact levels) in this matrix, a different action should be defined. As illustrated in figure 11, the risks positioned in the green area are classified in a low risk level in the scale, requiring corrective actions in some cases, or just accepting the risk; the risks in the yellow area are classified as having medium risk, when the corrective actions are required; the risks in the red area are classified as having high risk, requiring not only corrective actions but with a fast action plan (Stoneburner, Goguen and Feringa 2002).

Figure 11 - Risk management matrix



Source: adapted from Stoneburner, Goguen and Feringa (2002).

3 ANALYSIS OF THE COMPANY

After understanding the main aspects of the WCM, this chapter presents how this area is organized in the company, including its general organizational structure and the hierarchy of the PD area in the different plants.

Moreover, it shows the current scenario of the area in the company, describing how the processes occurs, the functions of each activity, the responsibilities and gaps detected, with the objective of mapping the critical points.

3.1 CNHI STRUCTURE

The CNH Industrial was formed from the merger of Fiat Industrial (created in 2011) and CNH Global (created in 1999 from the merger of Case Corporation and New Holland) in 2013 and is now a leader in capital goods in the world, with 64 manufacturing plants in 180 countries and 63000 people employed.

The company has 12 brands acting in three divisions:

- **Agricultural (AG&CE):** CASE IH, NEW HOLLAND AGRICULTURE, STEYR, CASE CONSTRUCTION, NEW HOLLAND CONSTRUCTION;
- **Bus and trucks (B&T):** IVECO BUS, IVECO, IVECO ASTRA, HEULIEZBUS, MAGIRUS, IVECO DEFENCE VEHICLES;
- **Powertrain (PWT):** FTP.

It operates worldwide and can be divided in four regional groups: NAFTA (USA, Canada and Mexico), LATAM (Latin America), EMEA (Europe, Middle East, Africa) and APAC (Asia Pacific).

3.2 WCM ORGANIZATIONAL STRUCTURE

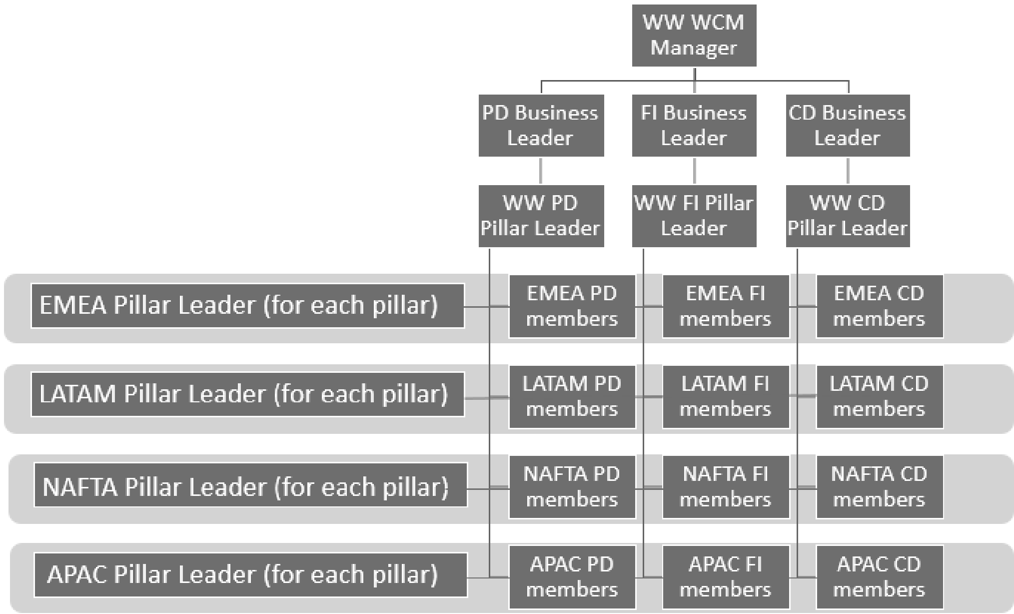
In 2007 the World Class Manufacturing (WCM) was implemented in all Fiat companies and nowadays the CNH Industrial company has 1 plant with gold aware, 17 silver awards and 26 bronze awards (the WCM is not yet implemented in all plants).

The WCM structure is composed by a WCM central team, divided in the ten pillars, in each region (NAFTA, LATAM; EMEA and APAC) to manage the plants and support and guide the pillars' responsible.

The EMEA WCM central team, located in Turin, is composed by 16 persons divided in the pillars, a worldwide (WW) pillar leader and a business leader per pillar, an EMEA WCM manager and a worldwide manager. The EMEA PD pillar is composed by two members, one pillar leader and one business leader.

The hierarchy of the different levels inside the WCM area is shown in figure 12 through an organizational structure.

Figure 12 - WCM central team organizational structure (simplified)



Source: developed by the author.

The WCM organizational structure in the plants follows the WCM pillars and, for each pillar, there is plant level structure, which will be described in chapter 3.3.

3.3 PLANT LEVEL STRUCTURE

For each pillar, each plant has the following pyramid level structure: Plant Manager (PM), Pillar Leader (PL), Specialists (including engineers, analysts, technician and supervisor), Team

Leader (TL) and Operators. This division represents the hierarchy relation inside the plants considering the job roles.

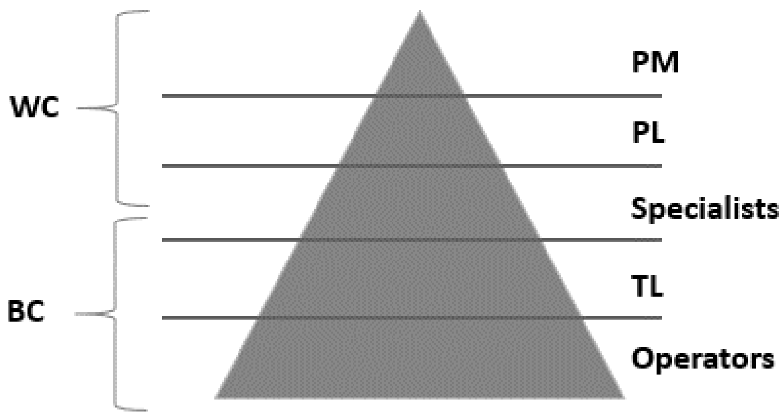
The functions of each pyramid level are (CNHI 2013):

- PM: Decision makers based on the plant strategy and cost deployment, defining goals and targets to the plant;
- PL: Definition of the correct tools and methods to be utilized to solve the problems. On the PD pillar, the role consists in reduce the knowledge gaps and offer trainings and education to enable the employees to reach specific knowledge level according to the objective set and future needs;
- Specialist/supervisor: Responsible for the projects organization, monitoring and results;
- TL: Acting in the projects by using their technical and behavioral competences;
- Operators: Day by day activities.

There is another division related to the wages payment. For the employees payed according to their hours worked, it is given the classification “Blue Collar” (BC) - includes the technician, TL and operators, while for the ones with fixed monthly wage it is considered “White Collar” (WC) - PM, PL, supervisors, engineers and analysts.

These divisions are represented in figure 13.

Figure 13 - Representation of the pyramid level structure



Source: adapted from CNHI (2013).

3.4 CURRENT SITUATION

As the PD pillar is responsible for supporting the other pillars by certifying each person knowledge improvement (responsibility of the plants PD Pillar Leaders) and the overall plant improvement (responsibility of the WW PD Pillar Leaders), the organization of the data becomes extremely important.

Nowadays, this organization is done by using excel files for each analysis and performance indicator (competence model, radar chart, KPI, etc.). Each plant must fill each excel file with the updated data of their employees, which will be controlled by the central team of the respective area monthly. As there is one excel file for each month, it is difficult to have an historical analysis of the data and some information are missed during the months.

Besides the analysis of each performance indicator, there is a scorecard done monthly to group the information about the PD room (will be detailed on chapter 3.5.5) and the coverage and effectiveness of the projects.

After conversations with the EMEA PD central team in Turin, some issues were detected. One of them is the difficulty of the plant pillar leaders to understand in which cell they should put each information, which causes the necessity of rework. The rework is done by the PD central team that checks and compares each information to validate it, what is a time-consuming activity.

During the period of internship in the company, there was the possibility of participating in some of these scorecard monthly meetings, exposing the time waste due to this validation and rework (it took almost one day of work per month, about 6 hours).

Even with workshops and calls organized by the PD central team to the plant pillar leaders and years doing this procedure, they remain doing these errors and the validation phase couldn’t be eliminated.

Another point highlighted by the PD central team was the lack of some analysis because of the difficulty to organize the required data in excel files. For example, some competences are very specific of each plant and grouping it in excel files to create a standard becomes difficult to manage without an automation.

It is important to emphasize that although the data storage is done by using a global online platform, is very common that one information in some folder is not updated in its last version and only one worker has the final version on its own computer. This creates a problem on finding the correct information and sometimes the use of a wrong value and, consequently, affecting the final results of some analysis.

Another point regard the trainings management. Nowadays there is no worldwide standard to manage it, and each region uses a different software to gather and analyze the trainings data. This eliminates the possibility of sharing information between regions and difficult the comparison of training session results.

Regarding the WCM organizational structure, the lack of standards in the trainings definition and competence analysis to define project groups hinders the evaluation and management of the plants, done by the PD central team. Consequently, the hierarchical relation between the employees becomes weak because the PD central team of one region can't correctly support the PD pillar leader of each plant to improve the results, as there is no standard to be followed and each plant works in a particular way.

Therefore, the waste of work time, confusion, lack of some analysis and a non-accurate data generated the necessity to develop a solution for this problem and a standardization for the processes.

The focus of this study is on the analysis of the competence model, radar chart and trainings, described in chapter 2.2.

3.5 PD PILLAR IN THE COMPANY

Considering the company scenario, the PD pillar was analyzed in order to understand the current gaps and improvement points. In this analysis was included the classification projects, competence model, radar chart and trainings.

3.5.1 Classification projects

For some levels of the pyramid there are specific projects to evaluate and classify the employees of the same level. By applying these classifications, it is easier to measure the results and manage the knowledge levels.

The output of these projects is the current number of employees per level, which will be confronted with the target value. When there is a gap, these classifications also contribute to the evaluation of which employee should be improved, to which level and the creation of an action plan to solve the gap.

Staff Classification

For PL, the company compares the knowledge (technical and project competences), involvement (number of projects that has participated) and result (savings) and for each one there is a pre-established weight to arrive in the final classification category (basic, intermediate, high qualified and exceptional) (CNHI 2018). The standards for the weights and classification criteria are presented in table 4.

To define the final classification, each weight is multiplied by the correspondent score of the category, according to the classification criteria. For example, if an employee presents a level 4 in the technical knowledge, the first factor of the multiplication will be the weight 10% multiplied by the score 2. Doing this process for each column and summing all the results will give a value that matches one of the four final evaluation categories. According to this value, the final classification will be defined.

The technical and WCM knowledge information are taken from the employee’s radar chart, while the project involvement, project leadership and the savings are given by the D matrix construct by the CD pillar.

The evaluation considers the 5YCD and, by this classification, the PM can manage the number of PL in the highest categories and if there’s a need to develop others based on future needs (define the targets to support the plant future results).

Table 4 – Criteria for staff classification

	Technical knowledge	WCM knowledge	Project involvement	Project leadership	One year saving certified	Final evaluation	Final classification
Weight / Score	**10%**	**15%**	**10%**	**30%**	**35%**		
0	< 3	< 3	Member SK.	Not applicable	Not applicable	< 1	Basic
1	3 to 3,5	3 to 3,5	Member SK and MK	Leader SK	2x yearly salary	1	Intermediate
2	3,6 to 4	3,6 to 4	Member of several SK and MK or member of AK	Leader MK	3x to 5x yearly salary	2	High Qualified
3	4,1 to 5	4,1 to 5	Member of several AK	Leader AK	> 6x yearly salary	3	Exceptional

Source: Adapted from CNHI (2018)

Team Leader project

For specialists and TL, there is a project validation checklist that measures the projects implementation (based on a standardized and structured process) and results.

The checklist is composed by a few questions covering all the steps of a project and, in base of the answers, a score of 1, 3 or 5 is given. The areas covered by the questions include communication, TL knowledge gap analysis, WCM, soft and technical skills and performance. For each question, after the evaluation of gaps, action plans must be created and tracked by the PL with precise deadlines.

To evaluate the results of the projects, a monthly scorecard is applied, including five standard KPI (CNHI 2018):

- Number of suggestions/kaizen per team;
- Number of projects (kaizen) lead by TL;
- Reworking hours;
- Projects and processes savings;
- Number of human errors per team.

Each month the plants must fill this information and the PD team evaluates if the target set was or not reached. Based on the gaps, an implementation percentage is calculated and used to define the plants level and classify them.

Operators 5 level classification and job cover matrix

For operators, there is a classification in five levels, with a list of the competences and target needed for each level, based on the AM and WO implementation, and a list of activities (called gates) that should be performed and that measure involvement and team work (CNHI 2018). By filling this classification, it is possible to evaluate the number of operators required per level and if there's a need to train others.

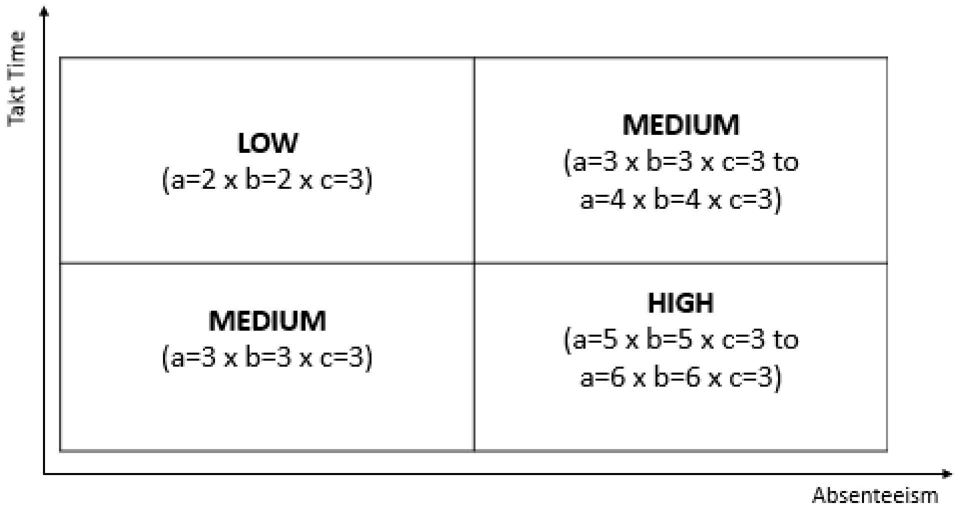
The actual and target knowledge levels for each competence are defined by the radar chart, while the gates are related to the KPIs (the number of suggestions, number of projects involved and absenteeism). The main output is the operator's autonomous growth, which leads to a reduction of losses because they understand their knowledge, gaps and how to improve it.

To a more detailed information about the operations knowledge and absenteeism there's the job cover matrix tool, which lists the macro operations for each workplace and, for each operation, the operators actual and target levels are added.

This tool is based on the relation between the absenteeism level and the takt time (pace of production calculated by the production time divided by the production requirement) and is expressed by a matrix (expressed in figure 14), which gives:

(a) the number of operations that each operator knows;
(b) the number of operators that know each operation;
(c) the number of employees that knows all the operations.

Figure 14 - Takt time and absenteeism evaluation matrix



Source: adapted from CNHI (2018).

From this matrix, each competence target and current status of the operators may be established and added to the job cover matrix (figure 15). After that, there is a prioritization of the improvements needed, based on the gap impact and the value of the gap, because it is not possible to remove all the operators from the fabric flow at the same time to receive a training. There is also the identification of trainers for each gap. With all the data, the trainings are organized focusing on the employee's improvement through operator's development plans.

The matrix is utilized also to manage the employees that can occupy the position of other employee in the case of absenteeism, considering their knowledge in the required processes, which reduces the impact of the absenteeism in the production flow.

Figure 15 - Example of a part of the job cover matrix

		EMPLOYEE					
	% GAP CLOSURE	76%		88%		100%	
WORK STATIONS	OPERATIONS DESCRIPTION	Employee 1		Employee 2		Employee 3	
		ACTUAL	TARGET	ACTUAL	TARGET	ACTUAL	TARGET
Engine Line 01	PUT ENGINE ON THE AGV	1	1	1	1	4	4
	ASSEMBLE THE ENGINE ON THE CHASSIS	1	1	1	1	4	4
	ASSEMBLE OF PTO ON THE ENGINE	1	1	1	1	4	4
	ASSEMBLE HYDRAULIC PUMPS ON PTO	1	1	1	1	4	4
	ASSEMBLE THE COMPRESSOR	1	1	1	1	4	4
	ASSEMBLE THE VALVE ON THE PTO	1	1	1	1	4	4
Engine Line 02	ASSEMBLE THE COMPRESSOR	3	4	1	1	4	4
	ASSEMBLE THE ALTERNATOR ON THE ENGINE	1	4	1	1	4	4
	ASSEMBLE THE ELECTRIC CABLE	2	4	1	1	4	4
	ASSEMBLE OF ELECTRIC TUBES	1	4	1	1	4	4
	ASSEMBLE OF THE BLOW OFF	2	4	1	1	4	4
Engine Line 03	ASSEMBLE OF HIDRAULIC TANK	3	4	1	4	4	4
	ASSEMBLE OF HIDRAULIC TUBES	2	4	2	4	4	4
	ASSEMBLE OF AIR CONDITIONING TUBES	4	4	4	4	4	4
	ASSEMBLE THE PROPULSOR	4	4	4	4	4	4
Engine Line 04	ASSEMBLE OF COOLER BOX	4	4	4	4	4	4
	ASSEMBLE OF COOLING HOSE	4	4	4	4	4	4
	ASSEMBLE OF FUEL SYSTEM	4	4	4	4	4	4
	ASSEMBLE OF THE SCREEN SHAFT	4	4	4	4	4	4

Source: adapted from CNHI (2018).

3.5.2 Competence model

As set before the importance of having a skill-based view, the company analysis considers the competences of each employee regarding not only the project that are assigned but also their role in the company, the pillar in which is inserted and general technical and soft skills. In that way, the competences improvement considers these five variables in order to better construct the individual's competence.

The competences are divided in three categories:

- WCM:
  - Role: applicable to PM, Specialists, TL and operators. Refers to the necessary competences for the execution of the job;
  - Pillar: applicable only to the PL. Refers to the necessary competences to participate in the specific pillar;

  - Project: applicable only to the specialist. Refers to the necessary competences to participate in a specific project, as a leader or a member. All these competences are already existent in the other groups of competences and are just grouped by project;
- Technical skills: applicable to all the pyramid levels. Refers to the necessary technical competences for the execution of the job, including knowledge of different machines handling;
- Soft skills: applicable to all the pyramid levels. Refers to personal skills needed as the ones related to communication with other person and adaptability in different job situations.

To evaluate the level on each category, there is a scale from 1 to 5 to support it, as descripted in table 5. For WCM and technical competences the scale focus on the ability to use the correct tools without any help, while the soft skills scale focus on the frequency of demonstration of that competence.

Table 5 - Competence model scale description

Scale	**WCM and Technical Skills**	**Soft Skills**
1	Doesn’t know	No evidence
2	Knows the theory	Weak demonstration
3	Can apply the tool with support	Medium demonstration
4	Can apply the tool without support	High demonstration
5	Can teach others	Very high demonstration

Source: adapted from CNHI (2017)

The competences and scale definition are important as an objective tool to define the level that each person have and create a more accurate evaluation of the individual’s performance.

Considering the company complete set of competences, 100% of the basic competences are applied in all the plants, while for the intermediate and advanced competences, the percentage varies according to the plant specificities and requirements.

The set of pillar competences related to each employee depend on the plant level hierarchy, because the type of ability required is different: the operators and TL should demonstrate comprehension and application of the concepts learned; the specialists should have an additional ability of analyzing the situations; the PL and PM should not only analyze but evaluate the situation.

The operators and specialists are required to have a good knowledge level in the reactive competences; the PL needs reactive and preventive competences to reach this level; the PM set of competences include reactive, preventive and proactive, with the last one being the major part of them.

In the end, to achieve the world class level, the objective is to have all the pillar competences being utilized in all the plants, because all these competences are standardized requirements.

Despite that, nowadays the company doesn’t have the percentage evaluation of the competences utilized per pillar and per plant, creating an obstacle to the management and improvement of the competences utilization. Moreover, there is not a database of the competences description to help the pillar leaders to classify the employees according to their actual and target knowledge level. The scale is used to set the level of the employees, but there is not a specific description for each competence per knowledge level, it is only considered the basic idea of what represents being a level 1, 2, 3, 4 and 5 in the scale. Due to the lack of specific descriptions, the definition of the employee´s actual and target levels is subjective and it created difficulties to establish an accurate comparison between employees inside the company.

The PD central team started the creation of the competences description per knowledge level in different excel files, but this information was not shared to the plants pillar leaders because there are still some inconsistences in the definitions, some competences missing, and it was not validated.

3.5.3 Radar chart structure

The company considers five types of radar chart, according to the five categories of competences:

- WCM
    - Role radar chart: the competences are grouped in reactive, preventive and proactive phases;
    - Pillar radar chart: the competences are grouped in reactive, preventive and proactive phases;

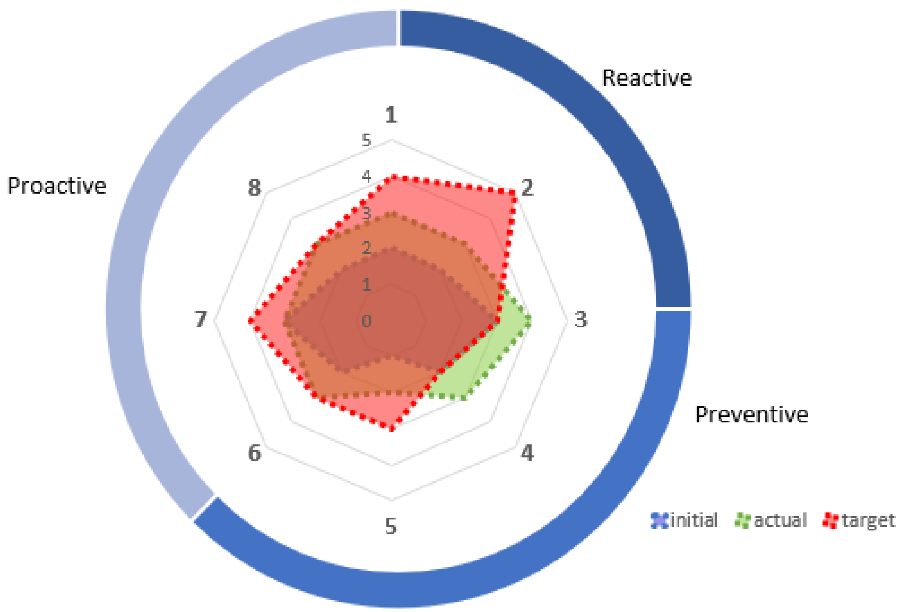
  - Project radar chart: the competences are grouped in basic, intermediate and advanced categories;
- Soft skill radar chart: the competences are grouped in leading-change, problem solving and leading people (in the case of white collar) and engagement, team work and behavior (in the case of blue collar);
- Technical radar chart: the competences are grouped in reactive, preventive and proactive phases;

Despite these categories, due to the difficulty of aggregating the technical competences, the technical radar chart is not applied by the company and is only considered as an ideal analysis. The definition of the teams and the team knowledge level are not analyzed, what restrict the organization of the trainings for the project improvements.

The radar chart update is done annually for all the radar chart, except the project radar chart, which considers the projects time cycle.

For each part of the radar chart divisions (e.g. reactive, preventive and proactive) there are specific competences that must be evaluated, and the approach should be done by focusing on the current phase competences (CNHI 2017). An example of the WCM role radar chart used by the company, with the three phases division, is represented in figure 16.

Figure 16 – WCM Radar Chart



Source: adapted from CNHI (2017).

The target levels depend on the route map (for the cases of role, pillar and project competences), job position (for the cases of soft and technical skills) and integration of a person with other pillars. They are set by the plants considering their specifications, but for some of them there's a minimum set established by the PD pillar.

The gap analysis gives as output an Individual Deployment Plan (IDP) created to define the right actions applied to each employee to reach the target level, with the related deadlines. It is an action plan with a defined activity to cover the gap, the deadline and the name of the validator to confirm the knowledge improvement, as shown in figure 17. Examples of actions (activities) are self-study, become member in a project, lead a project and training people.

Figure 17 - Representation of the IDP structure

INDIVIDUAL DEVELOPMENT PLAN								
Plant				**Name**			**Function**	
Pillar				**Leader/ Manager**			**Date**	
Knowledge/ Skill	**Actual Level**	**Target Level**	**Activity**	**Planned conclusion date**	**Actual Concusion date**	**Validator name**	**Signature**	**Validation date**

Source: Adapted from CNHI (2018).

To measure the ability of each pillar to reach the targets, the company uses the indicator percentage of knowledge grow, to measure each employee knowledge level improvement.

3.5.4 Trainings

For each jump between the competence model levels, the company has a training approach to achieve the next level. For the first levels are used online trainings and courses while for the higher levels the knowledge improvement is reach by internal trainer's sections, as presented in table 6.

The internal trainers are employees that are at level 5 in one competence and are responsible to give the trainings about that specific competence (from knowledge level 1 to 2). To find an internal trainer, it is necessary to analyze each radar chart to find the employees with level 5 in the needed competence. Nowadays, if there is no internal trainer available in the plant, some plants choose employees with knowledge level 3 or 4 to fill this gap and the results of the trainings is, consequently, not the best possible.

After the training, a checklist certification is applied to confirm or not the effectiveness of the training. The checklist varies according to the competence level improvement. For example, knowledge level improvement from 1 to 2 in a competence requires courses to teach the theory but there is no need to apply it.

Table 6 – Relation between the knowledge gap, training method and validation tool to be applied

GAP	**LACK OF KNOWLEDGE**	**TRAINING METHOD**	**VALIDATION TOOL**
Level 1 to 2	Theory	Training, self-study	Knowledge test
Level 2 to 3	Practices	Project participation, benchmarking, training	Checklist
Level 3 to 4	Practices (more detailed)	Project participation/leader, best practices application	Checklist
Level 4 to 5	Teach	Trainer certification	Internal trainer certification

Source: Adapted from CNHI (2017)

The checklists are completed by the participant and checked by the validators, including questions about application of the tools, difficult and autonomous use of the competence.

The validation process is an important step to guarantee the knowledge improvement of the employees. This process is done by the validators, who are employees with knowledge level 4 or 5 in the evaluated competence. Despite that rule, the company can’t assure and control that all the plants utilize only employee’s knowledge level 4 and 5 to validate and, it becomes a problem because if someone doesn’t know very well a competence, the evaluation of other employee knowledge level can’t be correctly done.

The knowledge improvement is updated in the radar chart once the certification is completed and prove the knowledge level achieved. If there is no knowledge improvement, the level remains the same.

Despite the checklist validation process, some plants change the knowledge level of some employees in the excel files without applying the checklists or without the signature of the validator, which compromises the veracity of the knowledge improvement and all the activities related to these employees.

The internal trainer certification occurs only when there is a requirement for a trainer in the specific competence, and is completed in five steps:

- Identification of potential internal trainers (must have level 4 in the competence);
- Training the trainer course, to develop the ability of managing a group course (this training must be done only on the internal trainer certification cycle of the employee, because doesn’t present differences according to the competence that is being improved);
- Practical training section trial (pilot), which will be evaluated by the PD team through a checklist;
- Practical training section, which will be evaluated by the PD team through a checklist;
- Certification, after passing in the checklists listed before.

Furthermore, for the cases when the need of an internal trainer is focused in a specific and new tool and the process must be fast, it is used the LUTI process (Learn, Use, Teach, Inspect). It is an accelerated learning process composed by four phases (at the end, cover the improvements from level 1 to 5):

- Learn: development of theoretical knowledge;
- Use: application of the knowledge;
- Teach: development of training materials and conduct trainings;
- Inspect: analysis of the results and the knowledge growth acquired.

To analyze the effectiveness of the trainings, there’s the KPI percentage of gap closure which divides the solved gaps by the total number of gaps at the beginning.

3.5.5 Management of the results

To expose the employee’s knowledge levels and indicators, there is a place in each plant floor called “PD room” where there are printed papers showing the competence model, radar charts and classifications for each level of the pyramid. This information is updated every month, as well as the KPI analyzed.

The objective is to have a graphical visualization of the data in a wall that is visible to everyone working in the plant floor, remembering and stimulating the effort to increase knowledge by seeing the impact of it.

The information available includes the 5YCD (to set the needs of that specific plant), IDP (to guarantee the completion of the actions and the alignment with the PD strategy), LUTI (list of the employees that are being developed), internal trainers (overview of the existent internal trainers and gaps), operator’s classification and KPI (including action plans to the non-achieved KPIs) (CNHI 2017).

It is important to have clear legends to distinguish between the positive and negative marks, as smile faces or well-known colors. Each plant can organize and adapt the PD room in the way that best fits the plant specific characteristics.

4. PD GLOBAL SYSTEM

After comparing the literature researched (chapter 2) with the current situation of the company (chapter 3) and jointing the view of WCM specialists (through conversations done), it was detected the necessity of organizing a system to automate the PD processes and better control the flow of information and the accuracy of the data.

In this chapter, it will be presented the steps of the system development, from the requirements defined by the PD central team to the description of the main processes and mockups to illustrate the functionalities added in each page. To reduce the possibility of errors in the system and during its usage, it was defined an action plan setting the trainings to be organized and implementation phases, and a risk analysis.

Therefore, this chapter lists the phases and results of the work done by the author (whose main deliveries were the documents setting the requirements and the monitoring of the alignment between the IT team progresses and the PD central team objectives), and include the future steps structured to guarantee its effectiveness.

4.1 METHOD UTILIZED TO DEFINE THE SYSTEM AND ITS REQUIREMENTS

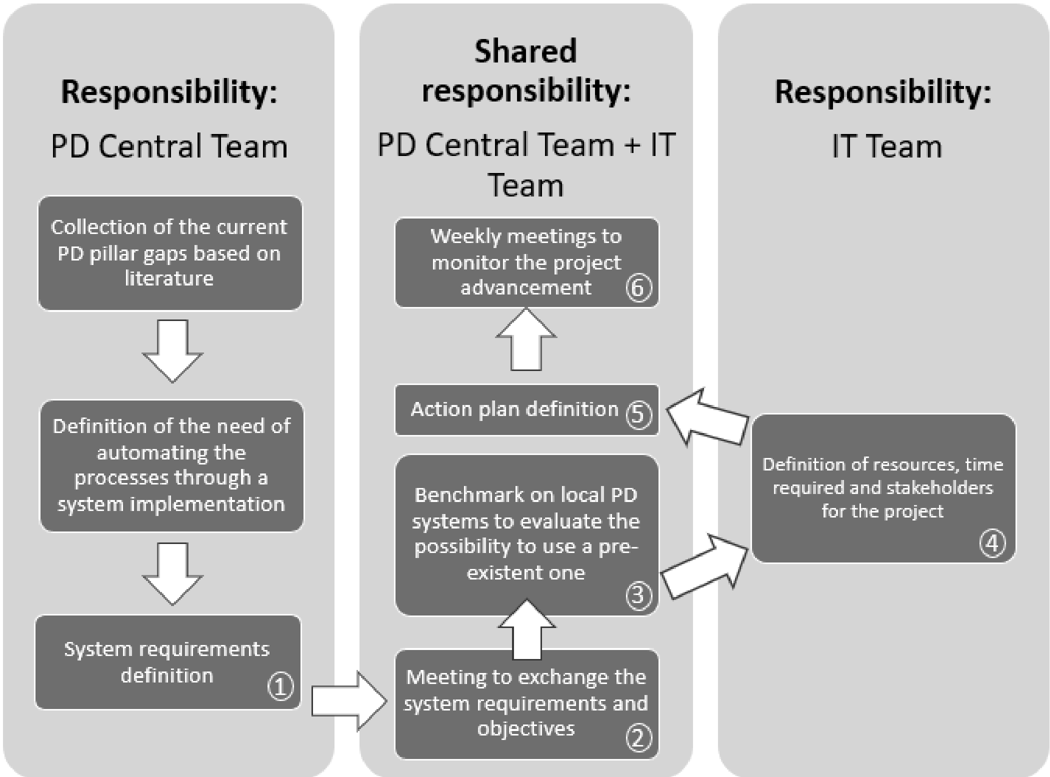
The first step of the system development was the mapping of the PD area processes and the record of the gaps in each phase, in order to confirm the necessity of automating the processes inside the PD pillar and creating a database with all the information. As the PD central team is responsible to manage all the plants PD areas, the EMEA PD central team was responsible to work on this project.

After that, focusing on the next steps, the method utilized to solve the identified problem was divided in six steps, with activities involving the WCM central team and the IT (Information Technology) team, represented in the flow in figure 18. The steps were:

- Step 1: meeting of the EMEA PD central team to define the requirements needed and the objectives;
- Step 2: meeting between the EMEA PD central team and the IT team to exchange the system requirements and objectives;

- Step 3: benchmark on other existent local PD systems to understand if it would be possible to expand one of them, and, if not, to gather ideas of outputs visualization;
- Step 4: TI team work on defining the resources needed, time required and stakeholders;
- Step 5: meeting between the EMEA PD central team and the IT team to define an action plan for the PD system development;
- Step 6: weekly meetings between the EMEA PD central team and the IT team to align the requirements and the system screams.

Figure 18 - Flow of the system development method



Source: developed by the author.

The first step was set to define the system requirements and objectives based on the PD area deficiencies. This process was done through meetings involving the PD central team following the activities:

- Brainstorm to enable the members to talk at will about the current problems and which charts/reports/information were important to have and which were not considered until now;

- Grouping the similar information listed on the previous meeting, order them by priority and eliminate the less prioritized information;
- Validate the information selected within the PD central team and transform it in requirements. The decision criteria to define a requirement was the relevance of that in the KPIs and plants analysis, impacting in these results;
- Meeting with the PD business leader and the WCM manager to validate the defined requirements of the PD system and to guarantee that the system would cover the main current gaps of the pillar.

The second step was to schedule a meeting with the IT team to show the system functional requirements and explain the project to the IT team.

After identified that some plants utilized local PD systems developed by them to manage the PD pillar information, it become important to track and analyze each one. The third step included the members of the PD central team, together with the IT team, who were responsible to schedule calls or visit the plants in order to understand the processes which were included in each system, the logic behind these processes (more related to the IT tools), the outputs and the general layout.

After aggregating all this information and evaluating the coverage of the important processes of the systems, the result was that none of the systems was sufficiently widespread to cover all the gaps identified during the analysis of the company. Even with this lack of some processes and analysis inside the system, it was considered the possibility to expand one preexistent PD system (use it as base and include other functionalities), but after the cost benefit analysis considering the functionalities and the security, it was noticed that the cost would be higher if compared with the creation of a new one and, also, there was no system with a user-friendly screen.

Besides that, some ideas and visualization types from the preexistent system were collected to guide the new PD global system layout development, gathering the best practices from each plant.

The step four involved only the IT team with the objective to discuss and define the time required to structure the functionalities, the layout, the implementation phase and the expansion to all the plants; the required resources to the development and implementation; and the stakeholders to conduct the project.

The fifth step was a meeting between the PD central team and the IT team to establish an action plan to the system development. The action plan included a division of the project in phases: system design (2 months), development (3 months), first implementation (2 months).

The development phase included a first document called "blueprint" with all the functionalities, outputs and structure of the system; a series of presentations and documents containing each functionality of the system. For each phase, it was defined the frequency of meetings, the milestones and the key user (including the different types of access in the system according to the plant pyramid level).

The sixth step was the weekly monitoring of the advancement of the system development, to align the system requirements pre-defined with its design and functionality shown on the mockups produced by the IT team (iterative process until the definition of the final version of each functionality scream).

4.2 SYSTEM REQUIREMENTS

The system requirements were divided in two categories: functional and nonfunctional requirements.

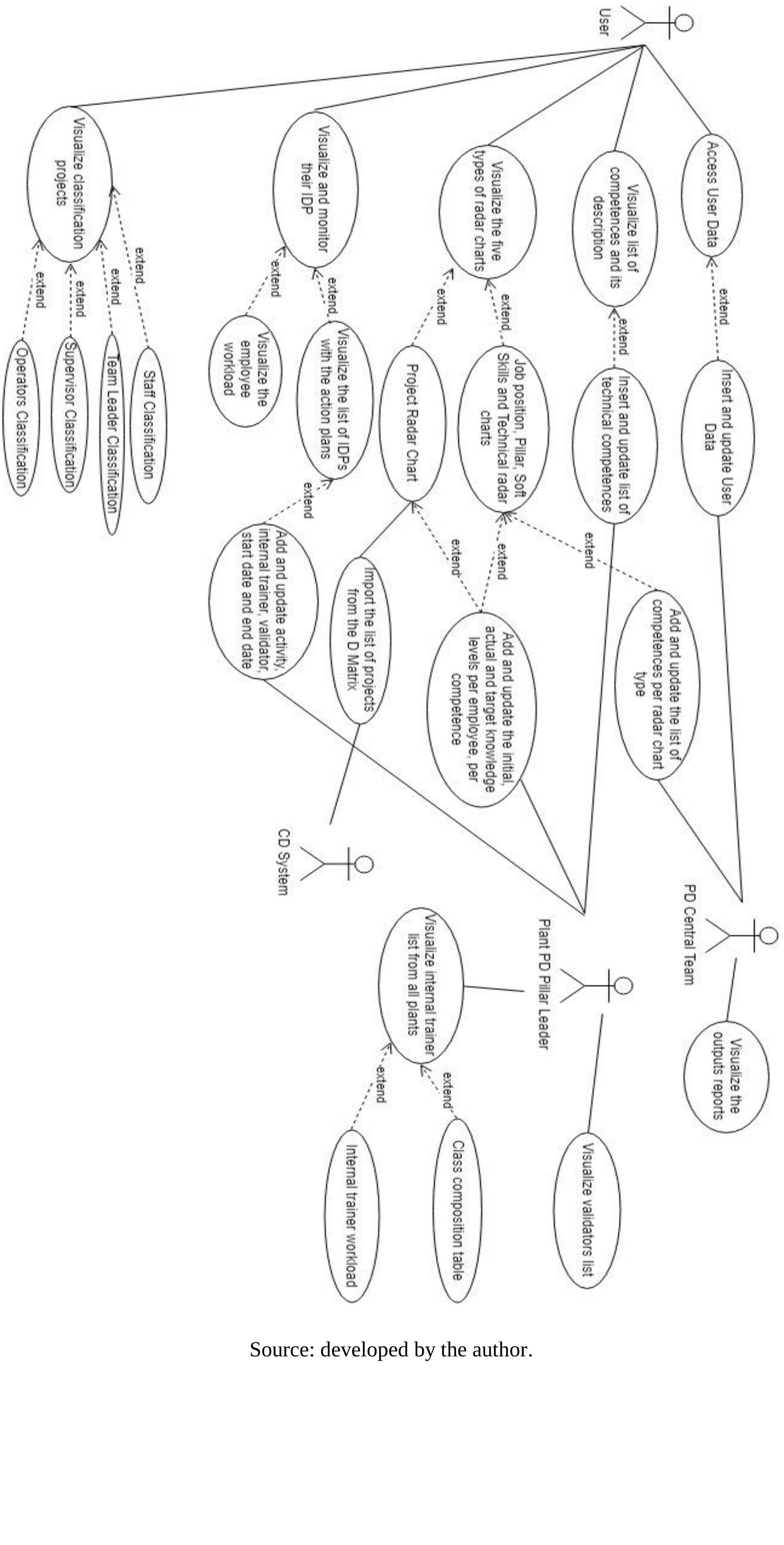
The functional requirements of the system are:

- Include and allow the visualization of data from all the plants worldwide;
- Create filters in the pages to analyze specific plant, person, group of persons, pillar or job position;
- Show personal information of all employees and allow the additional of new employees or change in one role;
- Show a standard of competences description to be used by all plants worldwide;
- Enable the plants to add technical competences specific to their context;
- Enable to add the values of initial, actual and target knowledge levels for each employee in each competence, and change only the values of target (all the others should be blocked);
- Automatically generate one IDP for each knowledge gap detected;
- Fill the checklists for the validation process;

- Enable to add information about the training, internal trainer, validator and dates for each knowledge level improvement;
- Show the list of internal trainers available;
- Enable the development of a new internal trainer and automatically add its name in the list of internal trainers;
- Enable the selection of an internal trainer from an external plant;
- Manage the information of number of students to attend a training, name of internal trainer, data and status
- Show the list of validators;
- Automatically update the actual knowledge level of a competence if the improvement level is validated and confirmed;
- Automatically generate the different types of projects with the classification of the employees according to the radar charts information;
- Generate reports consolidating the information, by years, competences, employee hierarchy;
- Enable to export the information in excel and pdf files.

In order to meet these requirements, the functionalities of the system were created. To present in a visual way the system functionalities and its integration with the user actions, it was drawn simplified use cases diagrams of the system, as shown in figure 19. It shows a scenario of how the system responds (through which functionalities) to the user actions.

Figure 19 - Use Case Diagram of the PD system



Source: developed by the author.

Each actor and use case are described in table 7, showing the responsibility of each actor and how each use case is decomposed and detailed.

Table 7 - List of actors, use cases and its description

Use case/actors	Description
Actor: User	All levels of the PD pillar employee's hierarchy
Actor: PD Central Team	All members of each region central team, which are responsible for the input of managerial information in the system
Actor: Plant PD Pillar Leader	Responsible for the input of information specific from their plants and each employee knowledge level
Actor: CD System	Other system utilized in the company, which is responsible for transferring the information of the list of projects from one system to the other (PD system)
Access User Data	By selecting one employee from a list of employees (added and updated by the PD Central Team), show their information
Visualize list of competences and its description	Show all the competences divided in the categories and their description per knowledge level
Visualize the five types of radar chart	Each user will access their role/job position, pillar, project, soft skills and technical skills radar charts (with the initial, actual and target values of each competence in each type of radar chart) and from the ones who report to them
Visualize and monitor their IDP	Each user will visualize their own IDP (competence to be developed, training) and from the ones who report to them (to manage the trainings and monitor their status)
Visualize internal trainer list from all plants	The Plant PD Pillar Leader will visualize the list of internal trainers per competence in order to understand if there is a lack of internal trainer for some competence and create IDPs to develop a new one
Visualize validators list	The Plant PD Pillar Leader will visualize the list of available validators and each validator will be assigned to a training session.

Use case/actors	Description
Visualize classification projects	The user will visualize the classification project related to his position in the hierarchy. According to this classification, the user can understand the points which should be focused and developed by him in order to increase his level in the classification
Visualize the outputs reports	The PD Central Team will be able to generate the different types of reports to visualize and analyze historical and grouped data
Add and update the list of competences per radar chart type	The PD Central Team will have the possibility to change the list of competences when necessary (updating process to occur occasionally)
Add and update the initial, actual and target knowledge levels per employee per competence	The Plant PD Pillar Leader will add the initial, actual and target knowledge levels of their employees when the user is inserted in the system. Them, they are allowed to change only the target values when necessary. The other values will be changed automatically according to the conclusion of the IDPs
Import the list of projects from the D Matrix	The CD system will be automatically integrate with the PD system to send the list of projects from the D matrix and update this information frequently
Add and update activity, internal trainer, validator, start date and end date	The Plant PD Pillar Leader will add these information to compose the IDP of their employees, according to

Source: developed by the author

The nonfunctional requirements are:

- Multiple language availability;
- Integration with the already existent CD system (get information from the CD system automatically and update every day);
- Control and limit the access and modification of some data and pages according to the user hierarchy (plant level structure);
- Guarantee the security of the data inside the system, allowing only authorized persons to have access;

- Be available and works full day, in all days during the year;
- Be compatible and works in all the countries;
- The system should support the access of many people at the same time maintaining its performance;
- User friendly (usability): visual representation of the information to facilitate the interpretation (e.g. colors to show the actual status of some activity).

4.3 SYSTEM USERS

The access in the system will be different according to the position of the employees in the plant hierarchy.

The PM will have access of the information from all the employees of his plant, because he is responsible to define the plant strategy and actions to improve it level.

For the other levels of the pyramid (PL, Specialist, TL and Operator), the visualization of the data will be allowed to the employees who report to them.

In the case of the PD central team, the access will be done according to the region in which the PD member is responsible for (e.g. the EMEA PD central team members will visualize the information of all the employees of all the plants inside the EMEA region).

The WW PD pillar leader, due to the fact that acts worldwide, will have the possibility to access the employees' information from all the four regions.

4.4 SYSTEM PROCESSES

The system is composed of twelve menus, according to the necessity of the PD pillar, and each menu has different visualization and edition authorization according to the employee job position and the need of protection of the data. The available menus are:

- **Home**: contain buttons to go to the other pages and present an overview of the percentage of competences utilized worldwide and percentage of gap closure;
- **Process**: created to facilitate the upload of data to the system (e.g. when a new employee is hired the master data and current competences must be inserted) and the download of

user master data, the list of competences and the relationship showing which competences are considered in which radar chart type;

- **Employee master data**: list of all the employees including basic information of each one, as name, job position and plant. It is possible to apply filters and have a visualization of the employees per pillar, job position and plant and all the relations between these three classifications;
- **Competence**: list of all the competences and its description, according to each knowledge level;
- **Radar chart**: graphical visualization of the five radar chart types;
- **IDP**: visualization of the actions and deadlines to cover knowledge gaps;
- **Validator:** information about the available validators and all the validation process;
- **Internal Trainer**: information about all the plants internal trainers and the development of new ones;
- **Staff classification**: visualization of the staff classification;
- **Team Leader classification**: visualization of the team leader classification;
- **Supervisor classification**: visualization of the supervisor classification;
- **Operator's classification**: visualization of the operator's classification.

Considering the PD pillar and its KPI, the main menus will be explained in the next chapters.

4.4.1 Competences

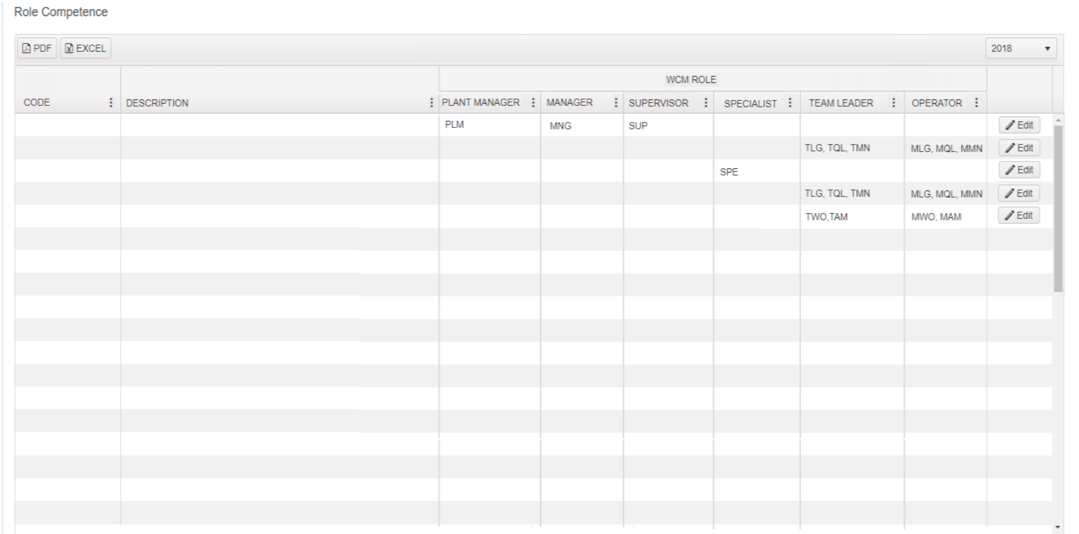
After analyzing the competence model of the company and compare with the literature background, the lack of a central competences database to be used by the pillar leaders to understand what is expected from each employee in each knowledge level, became clear.

To the company achieve a competitive advantage in the competence model and improve the current employee´s individual learning process, the competences tab was developed inside the system. The objective is to have a reference source of all the existent competences and their descriptions, to support the management of each employee knowledge.

The system has the complete list and description of competences per job position, pillar, soft skills and technical skills. The description includes the requirements for reach each knowledge level from 1 to 5.

The system also allows the link between each competence and the respective job position/pillar that needs this knowledge, as shown in the mockup of the respective page, in figure 20.

Figure 20 - Mockup of the role competence page in the system



Source: CNHI (2018).

Each plant PD pillar leader will have the authorization to add new technical competences specific to the activities of their plants, in a way to adapt the system to the plants specificities while following the minimum set of standards defined by the system for all the plants.

The description of the technical competences was created during the system development, because the technical competences had not been analyzed before. The reason for this is the high variety of competences according to each plant production line specificities, which make it hard to define standard competences and manage it.

With this information, each pillar leader from each plant has the possibility to understand and analyze which is the correct knowledge level for each employee in each competence. The evaluation of the employees becomes more objective and pragmatic, enabling the plants to schedule correct actions and trainings and form the project group with the employees that are more suitable to the specific work. Moreover, the quantity of trainings is optimized because only the employees that really need an improvement in their knowledge will receive the trainings (more accurate definition of the trainings).

Another benefit is the reduction of employees' time-consuming activities and consequently reduction of expenditure, because of the reduction of support from the PD central team in order to understand how to insert the data.

4.4.2 Radar Chart

The technical radar chart is going to be applied in the company for the first time only in the system, because of the difficulties to group the different competences of the plants in an excel file. Consequently, neither the gap analysis nor the action plan to eliminate the gap were done. The management of which technical competences to improve was not considered and, during audits, it was reported a bottleneck in the operator's human errors due to lack of knowledge.

Before the system, the project radar chart was considered to analyze the members' knowledge gap, but the information from the other radar charts was not considered to compose the project groups. This lack of confronting between the different radar charts is due to the difficult to consult different excel files and search for the competences needed. Until the implementation of the system, the project groups were selected without an objective methodology.

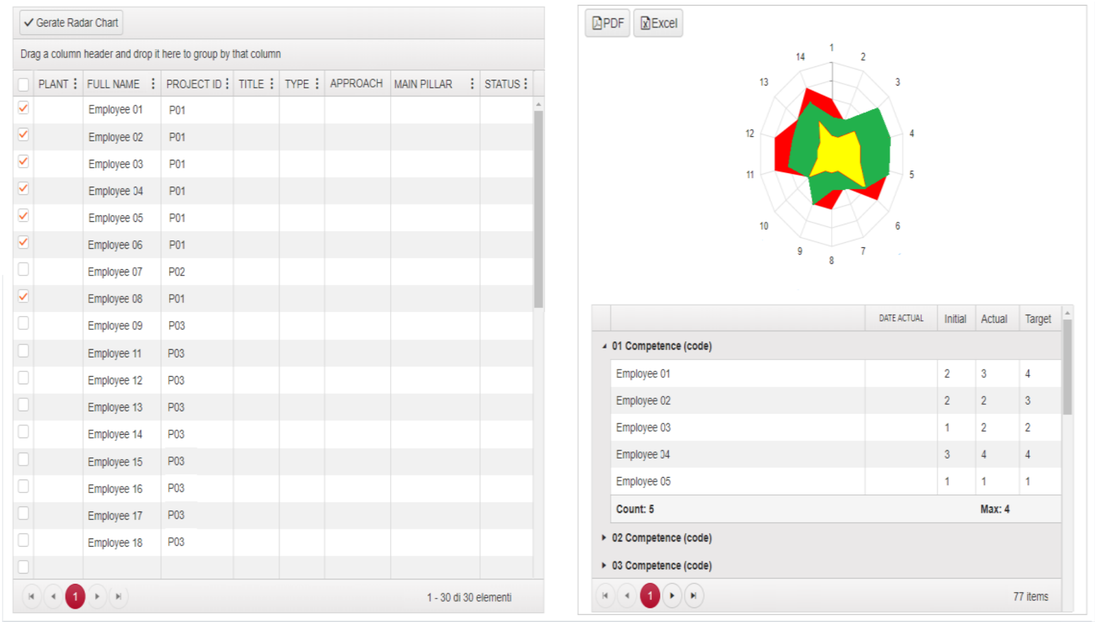
To reduce these problems, the system was created with five tabs to show the five types of radar chart: job position (role), pillar, project, soft skills and technical skills.

For each radar chart, it is possible to visualize the colorful graphical images according to the filters selected by the logged user and have a quick visualization of the gaps (figure 21). There is also the possibility to filter the results according to the plant, employee name, pillar, area and actual and target levels.

Now, the information about all the current projects and its teams is automatically collected from the CD system (D matrix), while for the others radar charts, is inserted by the PD central team and plants pillar leaders.

For the projects analysis, the composition of the graphical radar chart considers the highest knowledge level among all the project members for each competence. It is also possible to select just some members to generate a radar chart of them in order to analyze how a sub group of the project is developing.

Figure 21 - Mockup of the radar chart page in the system



Source: CNHI (2018).

The system will enable the evaluation and selection of the people for each project according to the alignment between their and the project competences knowledge level (considering all the existent radar charts). Their workload will also be considered, to understand if the employee has the time to develop the project. With this analysis is possible to improve the team performance and results and, consequently, the KPI percentage of knowledge growth.

For the technical radar chart, the system helps the improvement of the plants floor performance and reduction of human errors. After the analysis of this radar chart, it is possible to define actions and tools to the specific gaps detected, as the OPL and SOP. Consequently, it is expected that, after the system implementation, the score obtained by the plants in the audits will increase because the process will become more controlled and focalized to the real bottlenecks.

Another benefit of the system implementation is the guarantee that the data in all the radar charts are not inconsistent. In other words, the system automatically inserts the actual and target levels of employee competences in a project radar chart considering the levels presented in the other radar charts. With this process, it is impossible to the same employee to have two different knowledge levels for the same competence, as occurred in the excel files management.

4.4.3 Individual development plan (IDP)

As the IDPs are currently created in excel files after the evaluation of each radar charts file (and inside it, it is necessary to analyze each competence that has a gap), the inclusion of the IDP in the system is required to become a more automated process and eliminate the risk of the team members forgetting to input some essential data as knowledge gaps (as the insert of each IDP is done manually by a member of the team by looking at the excel file and searching for gaps).

The system has an IDP menu where is possible to see the list of employees who have a knowledge gap (the visualization permits filters by plants, job position and pillar), which comes automatically from the radar charts. The only information that should be added by the PD pillar leaders are the activity, internal trainer (only for improvement from knowledge level 1 to 2), validator, start date and end date.

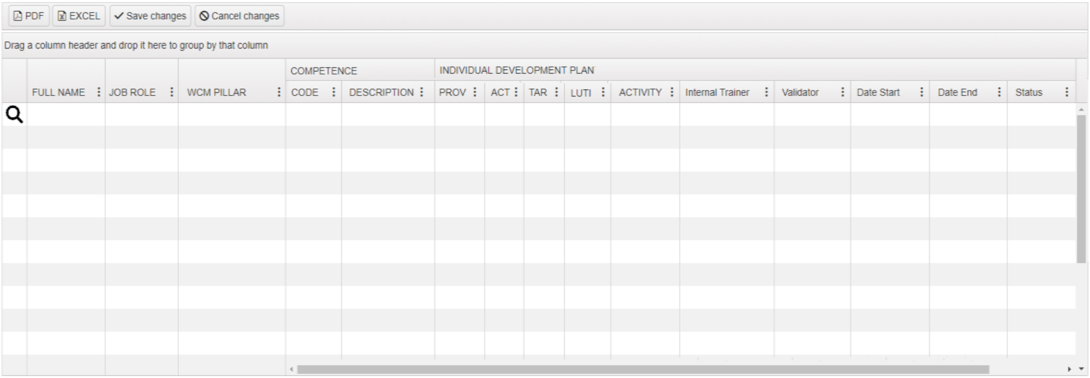
When the knowledge improvement is from level 1 to 2, the activities are chosen according to a pre-defined set of possible activities: training on the job, self-learning, benchmarking and others.

When the knowledge improvement is from level 4 to 5, there is no need of a validator, and this column is empty.

The additional information that the IDP table has in the system are represented in the mockup (figure 22) as additional columns, which are:

- The status of the activity, by automatically comparing the scheduled and actual date of the activity start. The status includes the options: planned, ongoing, delayed, done, failed and cancelled. An IDP will be considered cancelled when the employees that needed the knowledge improvement change the position inside the company, what changes the competences related to the respective job position or pillar;
- The relation between each action and the internal trainer who will be responsible to train that employee in the specific competence (in the case of improvement from knowledge level 1 to 2);
- The checklist model to be filled by the validator. The checklist is shown for knowledge level from 2 to 3 and from3 to 4, and includes different questions according to the knowledge level;
- The LUTI column, which express if the action in the IDP refers to a LUTI or not. If yes, the checklist that will appear is the specific for a LUTI:

Figure 22 - Mockup of the IDP page in the system



Source: CNHI (2018).

It is also possible to choose the logged user own IDP to visualize the actions that he needs to do and the scheduled dates, facilitating the organization of the employee's calendar.

The system enables the visualization of each employee workload (through a calendar visualization) when the logged user clicks in the action row.

After the system implementation, the IDPs are automatically generated, allowing the visualization of the assigned/to be assigned trainings filtering by group of employees, competences or activity type. It also reduces the time spend in the creation of the IDPs in excel files.

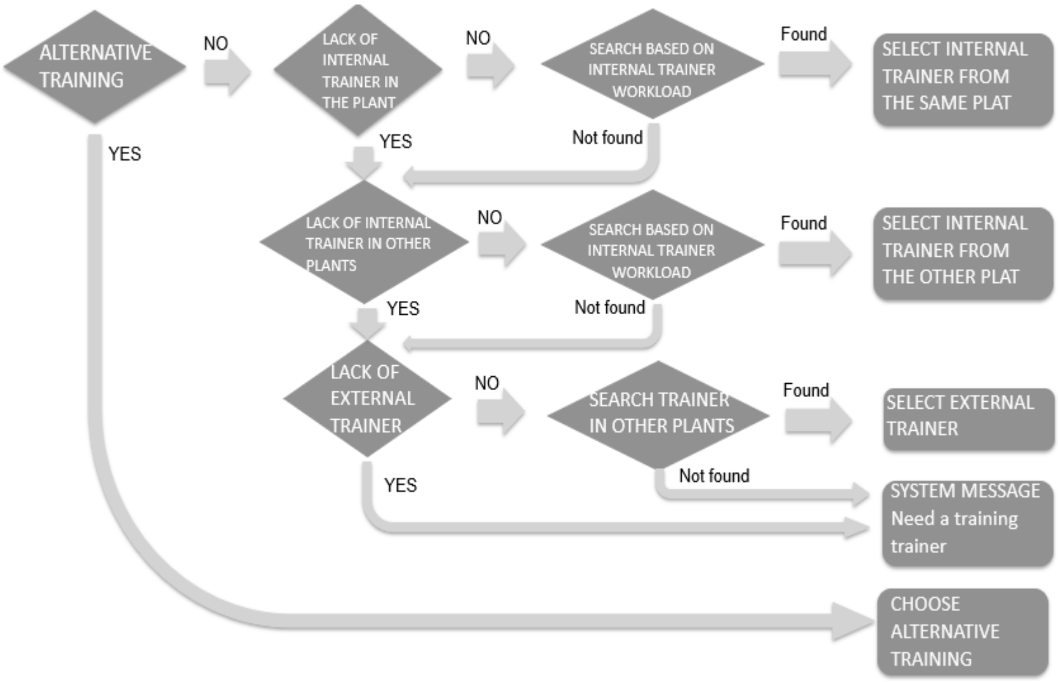
In addition, the trainings and other activities will be better managed, by following the status column and guaranteeing that all the activities set will be completed. Without the system, there was no fast visualization of the delayed and failed activities and the control wasn't done due to the difficulty to analyze each employee IDP. Now, the quantity of knowledge improvements will increase, due to the better management of the IDPs and workloads, reducing the KPI human errors due to lack of knowledge and improving the KPI percentage of gap closure.

4.4.4 Internal trainers

The internal trainers (employees with knowledge level 5) are important to give the trainings to other employees to improve their knowledge level from 1 to 2. The lack of internal trainer in some plants is now a problem to the company, because the utilization of employees with lower knowledge level to conduct the trainings compromises the results and the activities inside the company.

Due to this problem, the system was created including a complete database of all the internal trainers available in all the plants worldwide. By accessing this list of internal trainers, it is possible to filter the information by plant and competence. It also allows that, if there is no internal trainer in the plant and there is no need or time to develop a new one, the plants can choose internal trainers from other plants nearby, according to the flow expressed in figure 23.

Figure 23 - Flow of the internal trainers' selection



Search: adapted from CNHI (2018).

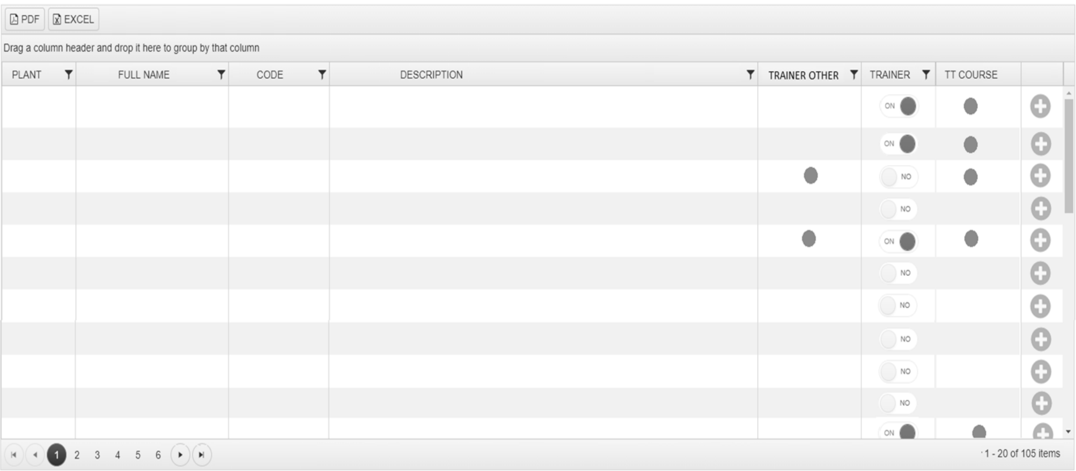
The internal trainers are linked to the IDP from the employees that need a training section. The objective is that all the trainings scheduled in the IDPs are developed within the planned deadline and, as a way to manage this information, there are two indicators available: the total number of required trainings relate to an IDP and the number of scheduled trainings. If there are delays or lack of available trainers, the comparison between the two indicators will immediately show an alert to the necessity to correct this problem.

To manage the employees that must attend the trainings and the number of students per course, a class composition table is created containing the number of students, the related competence and IDP, the trainer and the start and end dates. For the trainer, the system will show two columns: the first related to the type of internal trainer (from the same plant, from other plant or an external consultant) and, according to the information selected, the list of available trainers will appear to be chosen by the internal trainer. The system will also allow the division of a training in two classes, according to the comparison between the number of students and the maximum number of students per class.

There is also a calendar page containing the internal trainers' workload, to manage their activities and time spent and distribute the internal trainers between the employees that need the trainings, tool that was not available before the system implementation.

The development of internal trainers can also be managed by the system, where is storage all the data from employees with knowledge level 4 or 5 in at least one competence. Presents also the information if it is already an internal trainer in that competence, if is an internal trainer in other competence and if has already attended the training the trainer course. The representation of the system view regarding this information is shown in figure 24.

Figure 24 - Mockup of the internal trainer page in the system



Source: CNHI (2018).

Therefore, by enabling the search of internal trainers from other plants and the visualization of all the available internal trainers for each competence, the system speeds up the training process and reduces the number of trainings applied by employees that haven't the required knowledge level. As the knowledge level is important for the plant flow activities, receiving a high-level training is extremely necessary to guarantee the company performance and help to achieve its objectives.

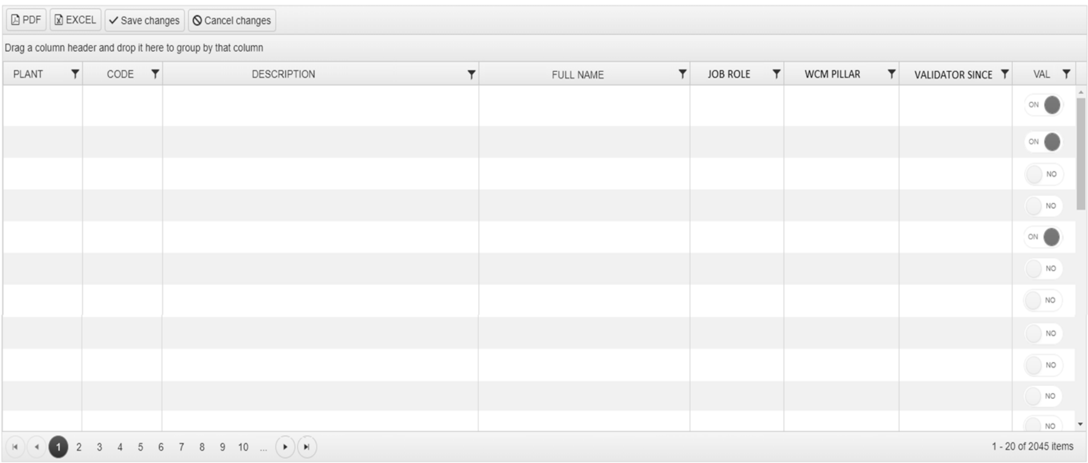
4.4.5 Validation

From the conversations with the PD central team to understand the current situation of the company regarding the validation process, it was noticed that the checklists and validation of the knowledge improvement were more theoretical and only a few plants applied it correctly due to the lack of an instrument to analyze how each plant conducts the process.

To this extend, the inclusion of an automated process of showing the checklist and requiring the selection of the validator to validate the process was required. By this approach, the system only validates the improvement in the knowledge level of some competence after the checklist was filled and validated by a validator.

In the system, there is a specific menu to present the list of all the available validators, reporting the respective plant, competence, validator name, job position, pillar and if the person is already a validator or is in the process to become one. The mockup of this menu is show in figure 25.

Figure 25 - Mockup of the validation page in the system



Source: CNHI (2018).

As a result of attaching the validation process to the PD system, it is not possible that an employee with knowledge level 1, 2 or 3 validate a training because the list of validators only includes employees with knowledge level 4 and 5 to be selected for each competence training.

Moreover, the system only approves the knowledge improvement for a competence after filling the checklist and having the approval of the validator.

Consequently, the reliability of the knowledge improvements will be confirmed by the system and the accuracy of the KPI gap closure will be improved. Only with accurate KPIs is possible to manage the PD pillar focusing on the real gaps and creating actions to cover them, instead of creating wrong actions due to the wrong inputs given by the validation process.

It will directly affect the result of the audits and will contribute to improvements in the WCM implementation level focusing on achieving the world class level (the plants objective).

4.4.6 Classification Projects

For each classification project (staff classification, team leader classification, supervisor classification and operators' classification), it was created a menu to be accessible in the PD system with the objective of improving the management of these data and facilitating the access of the employees' classification. The two projects that, after the inclusion in the system, present the main improvements to the PD pillar results (team leader project and job cover matrix) will be detailed in this study, showing the most important contributions to the area.

The team leader project is implemented in the system to present an easier evaluation of the KPIs gaps (by adding colors to represent if the target was achieved or not, for each month). Also, enables to get the input of some of the KPIs from the D matrix in the CD system (e.g. number of suggestions and savings), without the necessity of inserting the information manually and increasing the chance of errors. The system will show a list of standard KPIs and each plant will be able to add others from a pre-defined list, according to their requirements.

For the job cover matrix, the relevance of the system is the automated integration between the operations knowledge gap and the development plans. The system will analyze all the operations and compare the actual and target levels, setting, for each knowledge gap, a development plan containing the name of the operations to be improved and the number of employees that need to be developed. Therefore, the time spent due to this check is reduced and also the quantity of forgetfulness of operations and employees to be developed.

4.5 SYSTEM REPORTS

Besides the possibility to export, in excel files, the data from the processes described above, the system will create reports and charts to analyze the data over time and by grouping in different categories. These reports are available on a separate menu bar called "reports", to fasten the search of this information.

The objective is to have an easily and more user-friendly view of the data to facilitate the analysis of the KPIs (percentage of knowledge growth and percentage of gap closure) and to have a historical visualization of the data to guarantee that the improvements in the PD pillar area in each plant are being done and to control the gaps.

The available reports and its types of visualization are defined in the table 8.

Table 8 – System outputs and visualization

Output	Description (visualization type)
Knowledge gap analysis per tool, person and competence knowledge level	Bar charts showing, in absolute number and percentage: • the competences applied during the year and the ones which achieved the knowledge level target • the sum of the employees with a specific competence knowledge, divided in their knowledge level • the visualization of all the gaps in the different competences, that each employee has
Validators (per tool or per person)	Bar charts showing the evolution in absolute number, year over year, of the: • total amount of validators per plant • the validators per competence of that plant • validators per pillar of that plant

Output	Description (visualization type)
Internal Trainers (per tool or per person)	Bar charts showing the evolution in absolute number, year over year, of the total amount of: • internal trainers per plant • internal trainers per competence of that plant • internal trainers per pillar of that plant A bar chart showing the percentage of competence coverage by internal trainers, year over year, including the competence coverage by level (reactive, preventive, proactive and/or basic, intermediate, advanced)
IDP status	A combined chart (bar and line chart) showing the monthly evolution of: original targets, closed gaps, cumulative target, cumulative closed gaps
LUTI	Report including the delay, duration, number of LUTI concluded and number of LUTI not concluded
Training Costs	A pie chart showing the internal and external training costs per pillar, competence and project A bar chart showing the total training costs year over year per pillar, competence and project
Staff classification (results)	A pie chart showing the percentage distribution of number of employee per level (total plant or per area) A bar chart showing the evolution in absolute number and/or percentage per category (basic, intermediate, high qualified and exceptional) year over year
Job cover matrix (results)	Report including the number of person who knows all the operation of one line Report including the number of gaps per workstation and per person

Output	Description (visualization type)
% of gap closure	A bar chart showing the evolution of % of gap closure per person, pillar, radar chart typology and area (group) - monthly and/or year over year
% of knowledge growth	A bar chart showing the evolution of % of knowledge growth per person, pillar, radar chart typology and area (group) - monthly and/or year over year

Source: adapted from CNHI (2018)

These reports will be a support for the PD Pillar Leader of each region in the management of the plants results, and to each plant PD Pillar Leader manage the results of their own plant to create actions focused on the gaps and areas identified as a gap area.

The reports will enable mainly the overview of each plant knowledge gaps and the percentage of coverage (to understand the type of trainings that should be organized), the total number of validators and internal trainers (if there is a lack of validators/internal trainers the central team can support the plant to develop more validators/internal trainers), the percentage of gap closure (if this percentage is low, it is important to track the problem and try to solve it) and the percentage of knowledge growth (to have a historical visualization of the improvements in the knowledge and identify outliers).

4.6 IMPLEMENTATION PLAN

An implementation action plan was created to guarantee the correct implementation of the system in all the plants, the correction of information technologies errors and the explanation of the system functionalities to all the plants employees that will use the system. The action plan was structured based on meetings between the PD central team and the IT area to align the requirements and the time and capacity required to conduct each activity.

The implementation of the PD system will be structured in three phases:

- Short-term plan: the system will be applied in one sample plant (pilot) to analyze the difficulties, errors and results, and adjust the system based on this information gathered.

The objective is to guarantee the fast and correct implementation in the other plants, as well as the effectiveness of the system in meeting the pillar requirements;

- Mid-term plan: thirteen plants will be selected to receive the system until six months after the first implementation period. In this phase, a second check of the system behavior will be analyzed, and new corrections will be done, if needed;
- Long-term plan: all the plants worldwide will receive the system until two years after the first implementation period. The objective is to have the data from all the plants worldwide after two years and that all the plants utilizes correctly the system as a support tool to the pillar management.

The schedule of activities for the two years of PD system implementation are expressed in the figure 26.

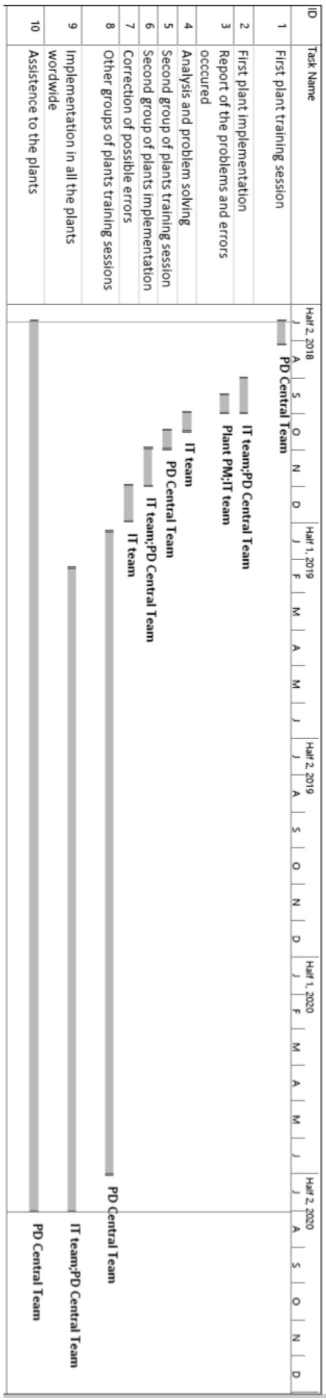
Before each implementation, training sessions are planned by the IT team (with support of the PD central team) to explain the main functionalities of the system to the plants. These training sessions will be organized by groups of plants according to the period when the implementation will be done in that plant (groups of four or five plants and considering their geographic localization), because a training attended months before the implementation is not efficiency.

For each implementation, an instruction manual will be sent to the plant to give orientations about the system processes and how to use it, in a simple, succinct and visual way. The objective is to have a reference material to the plants consult when doubts appears.

Moreover, given the importance of the PD system to the company results, the PD central team will organize periodical calls to clarify the plants doubts that are not covered by the instruction manual (more complex questions) during the two years of implementation, to eliminate misunderstandings and guarantee that the system will be managed correctly.

The IT team will be available to correct system errors during the first and second phases of implementation and to support the insert of data in the system by the plants (technical competences that each plant can add to the standard ones).

Figure 26 – Implementation Action Plan



Source: developed by the author.

The summary of these activities, its objective and the definition of the resources and time required for each one are important to guide each area in their internal organization before the activities (definition of the responsible members, their work hours and time to plan and execute each point of the activity). They are described in table 9.

Table 9 – List of responsible and resources per implementation activity

Activity	**Activity objective**	**Responsible area**	**Resources and responsibilities**	**Time required**
Training session	Train the users in all the pages of the system, showing: • Objectives of each page; • Functionalities of the buttons; • Frequency of data updates;	PD Central team	• One member of the PD Central team: to create the training material and conduct the training • Plant PD PL: to support the PD central team in jointing all the PD members of the plant, organizing their agenda • Plant PD members: learn the system functionalities • Support resource: presentation including the system objectives, print of the pages and system rules	3 weeks
Plant implementation	Do a usability test with the users to adapt the system inputs to the specificities of each plant	PD Central Team and IT Team	• One member of the PD Central team: to support the discussion between the plant and the IT team • Plant PD PL: to discuss the specificities of the data inputs • IT member: to support the implementation processes and give access to each user	1 month

Activity	Activity objective	Responsible area	Resources and responsibilities	Time required
Report of the problems and errors occurred	Exchange and alert the system errors to the responsible area	Plant PD PL and IT Team	• Plant PD PL: to list the errors found and notify the IT Team • IT member: to collect the errors and define the approach to solve them	2 weeks
Analysis and problem solving	Guarantee that the system will be effective in its objective	IT Team	• IT member: to correct the detected errors in the system considering their priority (impact in the users work) and correction time	2 weeks
Assistance to the plants	Guide the users, in the initial phase, to correctly use the system and generate the reports monthly	PD Central Team	• PD Central Team member: to schedule calls and visits in the plants PD PLs to solve user difficult and monitor its usage • Support resource: Instruction manual	2 years

Source: developed by the author

The selection of the plants for each step was done considering two aspects:

- Their actual PD system level: choose the higher ones because of the higher knowledge about all the PD pillar processes, reducing the difficulties in inserting and collecting the data from the system;
- The geographic proximity of the plant in respect to the PD and IT teams responsible to the system development, which are located in Turin (Italy).

This last requirement is due to the necessity of frequent interactions between the plant and the PD central team and IT team to understand where there are errors and have face-to-face meetings to improve the exchange of information.

4.7 RISKS

As in any project, there are risks involving the implementation and the conduct of the PD global system day to day.

The risks of the implementation involve the mismanagement of the plant data prior the upload in the system (causing the upload of only part of the data or uploading the information in the wrong locals) and the distrust in the effectiveness of the system by the plants that have already a local PD system and don't want to strive to change the current system.

The day to day use of the system includes some risks which can be divided in two categories: human and technical (IT) risks.

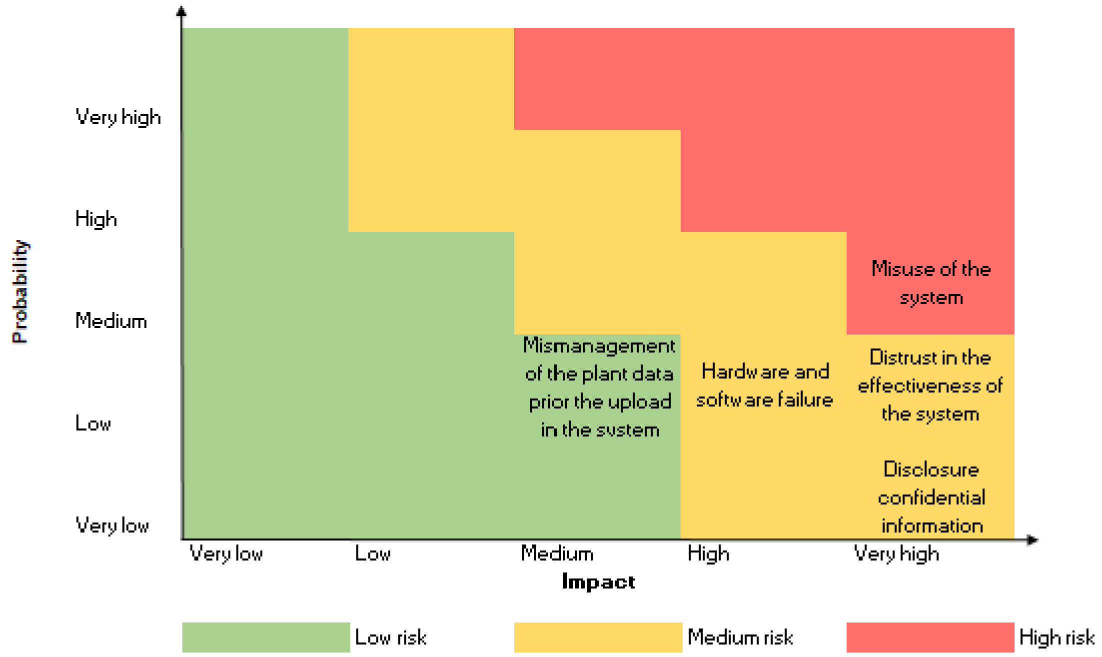
The human risks are related to the misuse of the system. A user can insert a wrong number or insert a number in the wrong column (for example insert the value of target knowledge level in the column "actual"). This error can be caused by a lack of training or attention.

The technical risks include hardware and software failure, compromising the storage of the data without any loss. A loss in parts of the database means the wrong list of competences per employee (if the system lost the relation between the employees and its competences or some competences are eliminated in the system list), or competences without the initial, actual and target knowledge levels (if the knowledge levels are lost due to the IT failures).

Another technical risk is the confidentiality of the data. The PD global system developed in this study includes information of all the employees of the company, its competences and knowledge levels. Because of that, if this information becomes public, the employees could prosecute the company, compromising the company image and its financial situation.

All these risks should be analyzed considering its probability to occur and impact in the company, in order to understand the priority of them and select the correct action to reduce them. Therefore, it was used the risk management matrix, in which each one of the five risks listed was positioned in the matrix (figure 27) and, according to their position, a different degree of mitigation actions was considered.

Figure 27 - Risk management matrix



Source: developed by the author.

To minimize the two implementation risks (located in the green and yellow areas of the matrix), the EMEA PD central team structured visits and calls to the plants during the first days of implementation of the system in the specific plant. The objective is to explain how the system works and its benefits, and have a member of the team responsible to support the upload of information. In the cases when the plant already have an old PD system, as it has a very high impact in the project results, this approach will be intensified, focusing in showing, with concrete data, the functionalities covered by the plant current system and the new one and the impact of it in the area reports and indicators.

The technical risks were all positioned in the yellow area of the matrix, and as mitigation actions, the IT team defined the frequency of equipment monitoring, updates and replacements and the guarantee in the security in the login and password data (including encrypted password).

As the misuse of the system is the only one detected in the matrix as a high risk, the mitigation action was planned to be more specific and effective, and was divided in two parts, according to the cause of the problem. To minimize the error in the cases of inattention, there is limited access to the pages in which there is upload of data, to guarantee that only selected and instructed people can add and delete information. For the lack of training, the minimizing action is the scheduled meetings and calls to the plants before the system implementation, and the implementation manual (created with short phrases and visual indications to facilitate the understanding) in virtual format to facilitate the search of frequent doubts. Moreover, to ensure fast response to the errors, the assistance of the PD central team to the plants was structured not only during the period of implementation but also, during the next years, it was set a responsible in the team to collect the problems and help the plants, and was established the monitoring of the systems usage during the scheduled audits in the plants.

The mitigation actions for each risk were summarized in table 10, including the responsible to these guarantee that these actions will be done. Besides the mitigation actions, all the listed risks must be frequently monitored to create corrective actions in case of occurrence of them.

Table 10 – List of risks and its minimizing actions and responsible

ID	Risk	Type of risk	Probability X Impact	Mitigation Action	Responsible
1	Mismanagement of the plant data prior the upload in the system	Implementation	Low	Nominate the PD PL of each plant to be responsible for the upload of information after meetings with the ID team to define the excel structure to be filled	PD Central Team
2	Distrust in the effectiveness of the system	Implementation	Medium	Visits and call to explain the functionalities and benefits of the system to the plants	PD Central Team

ID	Risk	Type of risk	Probability X Impact	Mitigation Action	Responsible
3	Misuse of the system	Human	High	Visits and calls to monitor the correct usage of the system	PD Central Team
				Limited access to some pages in the system	IT Team
4	Hardware and software failure	Technical	Medium	Equipment updated and replaced periodically	IT Team
5	Disclosure confidential information	Technical	Medium	Security in the login and password data	IT Team

Source: developed by the author

5. CONCLUSION

This study led to the comprehension of the importance of the WCM model for the reduction of wastes and costs and the increase in the results of the automotive industry, and its main contribution was the standardization of the people development pillar processes. Mainly, the PD area was focused and analyzed as the basis to collect and manage the data of the employees' competences, looking for improvements in each employee performance during the activities and projects.

To guarantee the effectiveness of the pillar in the company, this study analyzed the PD pillar situation in the company and highlighted some points that needed improvements. For that, a PD global system was developed to fill the gaps detected and support the advancement of the WCM area results, reducing also excessive costs.

The system was based on the main functionalities of the PD pillar and others that were missing before, focusing on improving the company competence model through the organization of all the competences and its description divided by category, pillar and job position, to facilitate the creation of consistent radar charts and the management of this data.

The development of this system enabled the automation of the PD pillar activities which allowed the standardization of the processes. By standardizing the PD pillar processes, the control and support of the PD area of the plants was intensified, because there is no need to understand the specificities and local systems utilized by the plants. It generates a more effective WCM organizational structure inside the company and an easier coordination of all the plants PD areas, by organizing standard actions and projects that can cover a higher number of plants.

Together with this organizational improvement, the system will enable the accountability of the utilized competences per plant, helping in the management of the effectiveness of the plant expansion level in the different competences and in understanding in which competences the plant should focus to achieve the world class level. Moreover, the system will show the percentage of utilized competences worldwide, with the objective of evaluating the competences efficiency and having a list of non-utilized competences in order to understand for which of them the company should search an external trainer to teach this competence and start its utilization in the plant. The advantage is the improvement of the WCM competences utilization and, consequently, the improvement of each plant performance, becoming closer to the world class level.

Furthermore, the system will increase each plant team leader's autonomy through the availability of all the operators' information and analysis needed to manage the operators' activities and define actions to improve its performance. The necessity of support from the PD central team of the plant region on the analysis and decision making will be reduced and, consequently, the actions will be set fasten.

Another benefit is the reduction of the time spend to search, organize and group all the information needed for some analysis and KPI evaluation. Moreover, it eliminated the difficulties experienced by team members when inserting and finding the specific data, contributing to a more accurate data and less central team work time spent on supporting calls and meetings. The accuracy allows the tackle of the correct gaps, focusing the effort on the activities that are more critical. Besides that, the automation achieved by the implementation of the system will guarantee that the initial, actual and target values of each competence in the radar charts will be the same in all types of radar chart, eliminating the data confrontation and avoiding the selection of a wrong value (present in one radar chart type, but different from the others) to start some analysis and arrive at a wrong result.

The additional analysis included in the system, which were not done before, enables a more complete and broad manage of the PD pillar, as shown in the table 11.

Table 11 – Main functionalities added in the system and how it improved the PD pillar management

Functionalities	**Contribution/new analysis done**
List of all competences and its description per knowledge level	Support the plant PD pillar leader to accurately define each employee knowledge level and establish a standard in all plant worldwide (enables the correct comparison between employees from different plants)

Functionalities	Contribution/new analysis done
Technical radar chart	Visualization of the list of technical competences of each employee and analyze in which there are gaps
Project radar chart created based on the other radar charts competence levels	Support the plant PD pillar leader to select the employees that best fit the project characteristic, and the selection of the project leader
Internal trainer from all the plants worldwide	Enables the selection of an internal trainer for some competence from other plant, if there is no one available in the plant searched
Internal trainer workload	Support the PD central team to organize the training sessions according to the number of people that need the training and the availability of the trainers during the weeks
Confirmation of validation checklist and signature	The system will not authorize the selection of a validator with knowledge level 1, 2 or 3 in the correspondent competence, and will only certify the improvement in the knowledge level after the completion of the checklist
System reports	Easy and graphical visualization of the main analysis and KPI utilized by the PD pillar

Source: developed by the author

In conclusion, the development of a managerial system in the company contributed to the improvement of the performance of the PD pillar, reduction of extra costs, increase the effectiveness of the coordination and, consequently, support the company in achieving a world class level in a large number of plants worldwide.

All these benefits can be shared and impact the whole automotive industry through the enrichment of the WCM model adopted by other companies (as the model should always be revised and improved), including the competences standardization perspective and utilization of information systems to have a faster and more accurate management of the employee's data.

The main contribution of this study to other companies is the establishment of a WCM PD standardization structure, setting the method and steps necessary to develop a competences management system. Depending on the specificities and size of the company, the system requirements, users, processes and implementation plan will change to better fit the company needs. Nevertheless, every company must follow the steps:

- Analysis of the company PD area: to understand how the area is structured, the classification projects used, the PD indicators, the trainings organization (who are the trainers and validators);
- Meetings with the IT team (from the same company or outsourcing, in the case the company don't have the capability to develop a system internally): to align the project definitions, objects, resources, development time and to set the project action plan and future meetings;
- Definition of the system requirements and users: according to the company specificities, the same user can act in two different actions or more users can be inserted to the use case diagram;
- Definition of the system processes: set the required pages in the system, depending on the complexity and size of this company area;
- Establishment of an implementation plan and risk analysis: to plan and monitor the system after its development.

For the author, this study contributed to increase his knowledge of the importance of the people management in a company and how the lack of standardization and management of the employees' competences data can affect a company results. Moreover, contributed to a deeper understanding of the WCM model, KPI, radar charts and trainings structure and monitoring, besides the application of industrial engineering tools learned during the university as PDCA, 5 Whys, 5W1H, and Root Cause Analysis.

Having the opportunity of analyzing an area of a company and helping in improving it, working together with the company employees, was one of the author's main professional achievements, because he could add to the project his experience (from the literature and university years) and opinion in the topic, becoming part of the project solution building.

As the next steps, the company should focus the attention in two aspects: ensuring the correct implementation of the system in all the plants and the understanding of its pages and functionalities by all the members, through face-to-face and virtual meetings. Moreover, the risks of the system should be constantly monitored to avoid its occurrence along the years.

Besides the monitoring of the PD system in the WCM area during the two years of implementation, the company could study and analyze the possibility of using the system in other areas, considering the changes to adapt to the area specificities.

As the company convinced its suppliers to apply the WCM model in their industries, the implementation of the PD system (and other systems related, as the CD system) could be considered not only internally, but exchange it, through a strategic plan, to its suppliers, in order to guarantee the quality of the products received by them. Consequently, the quality of the CNHI products would increase and the number of non-conformities and errors could decrease by acting in the whole supply chain and not focusing only in one area of the company.

This study presented the development of a system to improve the WCM area in automotive industries, but it could be extended to other industry segments. Some, for example, already uses this model in their industries nowadays, as Unilever, Ariston Group and Royal Mail (Chiarini and Vagnoni 2014), so they could focus on the development of a system to improve the effectiveness of the utilized model.

The motivation to these industries is the standardization of the employees' competences monitoring process (the main contribution of this study), which can be easily applied to other industry segments in order to improve its management and results.

In conclusion, although this study was focused on the WCM area of the CNHI company, the methodology and results achieved could become a basis to other projects internally and externally the company, and also a reference material to other industry segments to absorb it.

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