Improving Operations Performance with World Class Manufacturing Technique: A Case in Automotive Industry

Fabio De Felice, Antonella Petrillo and Stanislao Monfreda

Additional information is available at the end of the chapter

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1. Introduction

Global competition has caused fundamental changes in the competitive environment of manufacturing industries. Firms must develop strategic objectives which, upon achievement, result in a competitive advantage in the market place. However, for almost all manufacturing industries, an increased productivity and better overall efficiency of the production line are the most important goals. Most industries would like to find the formula for the ultimate productivity improvement strategy. Industries often suffer from the lack of a systematic and consistent methodology. In particular the manufacturing world has faced many changes throughout the years and as a result, the manufacturing industry is constantly evolving in order to stay ahead of competition [1]. Innovation is a necessary process for the continuous changes in order to contribute to the economic growth in the manufacturing industry, especially to compete in the global market. In addition to innovation as a mode for continued growth and change, there are many other vehicles for growth in the manufacturing industry [2], [3]. One in particular that has been gaining momentum is the idea of World Class Manufacturing (WCM) developed by Richard J. Schonberger (in the 80s) who collected several cases, experiences and testimonies of companies that had embarked on the path of continuous "Kaizen" improvement for excellence in production, trying to give a systematic conception to the various practices and methodologies examined. Some of the benefits of integrating WCM include increased competitiveness, development of new and improved technology and innovation, increased flexibility, increased communication between management and production employees, and an increase in work quality and workforce empowerment. This work takes you to the journey of World Class Manufacturing System (WCMS) adopted by the most important automotive Company located in Italy, the Fiat Group Automobiles. World class can be defined as a tool used to search and allow a company to perform at a best-on-class level.

The aim of this work is to present establishments of the basic model of World Class Manufacturing (WCM) quality management for the production system in the automotive industry in order to make products of the highest quality eliminating losses in all the factory fields an improvement of work standards.

The chapter is organized as follows: Section 2 introduces World Class Manufacturing and illustrates literature review, mission and principles of WCM, Section 3 describes Tools for WCM with particular attention on their features and on Key Performance and Key Activities Indicators and Section 4 describes the research methodology through a real case study in the largest Italian automotive company. To conclude, results and conclusions are provided.

2. Literature review

Manufacturers in many industries face worldwide competitive pressures. These manufacturers must provide high-quality products with leading-edge performance capabilities to survive, much less prosper. The automotive industry is no exception. There is intense pressure to produce high-performance at minimum-costs [4]. Companies attempting to adopt WCM have developed a statement of corporate philosophy or mission to which operating objectives are closely tied. A general perception is that when an organization is considered as world-class, it is also considered as the best in the world. But recently, many organizations claim that they are world-class manufacturers. Indeed we can define world class manufacturing as a different production processes and organizational strategies which all have flexibility as their primary concern [5]. For example Womack et al. [6] defined a lead for quantifying world class. Instead Oliver et al. [7] observed that to qualify as world class, a plant had to demonstrate outstanding performance on both productivity and quality measures. Summing up we can state that the term World-Class Manufacturing (WCM) means the pursuance of best practices in manufacturing. On the other hand we would like to note that one of the most important definition is due to Schonberger. He coined the term "World Class Manufacturing" to cover the many techniques and technologies designed to enable a company to match its best competitors [8].

When Schonberger first introduced the concept of "World Class Manufacturing", the term was seen to embrace the techniques and factors as listed in Figure 1. The substantial increase in techniques can be related in part to the growing influence of the manufacturing philosophies and economic success of Japanese manufacturers from the 1960s onwards. What is particularly interesting from a review of the literature is that while there is a degree of overlap in some of the techniques, it is clear that relative to the elements that were seen as constituting WCM in 1986, the term has evolved considerably.

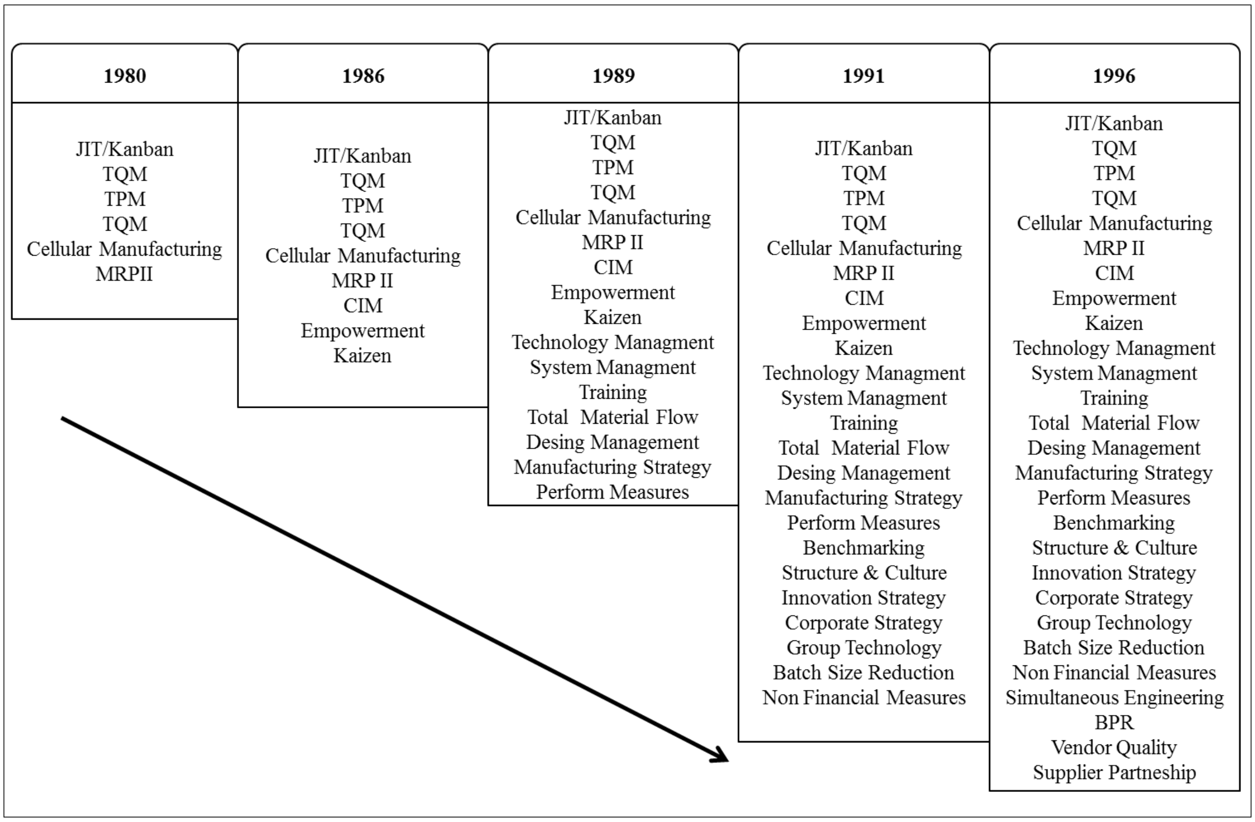

Figure 1. The growth of techniques associated with the WCM concept

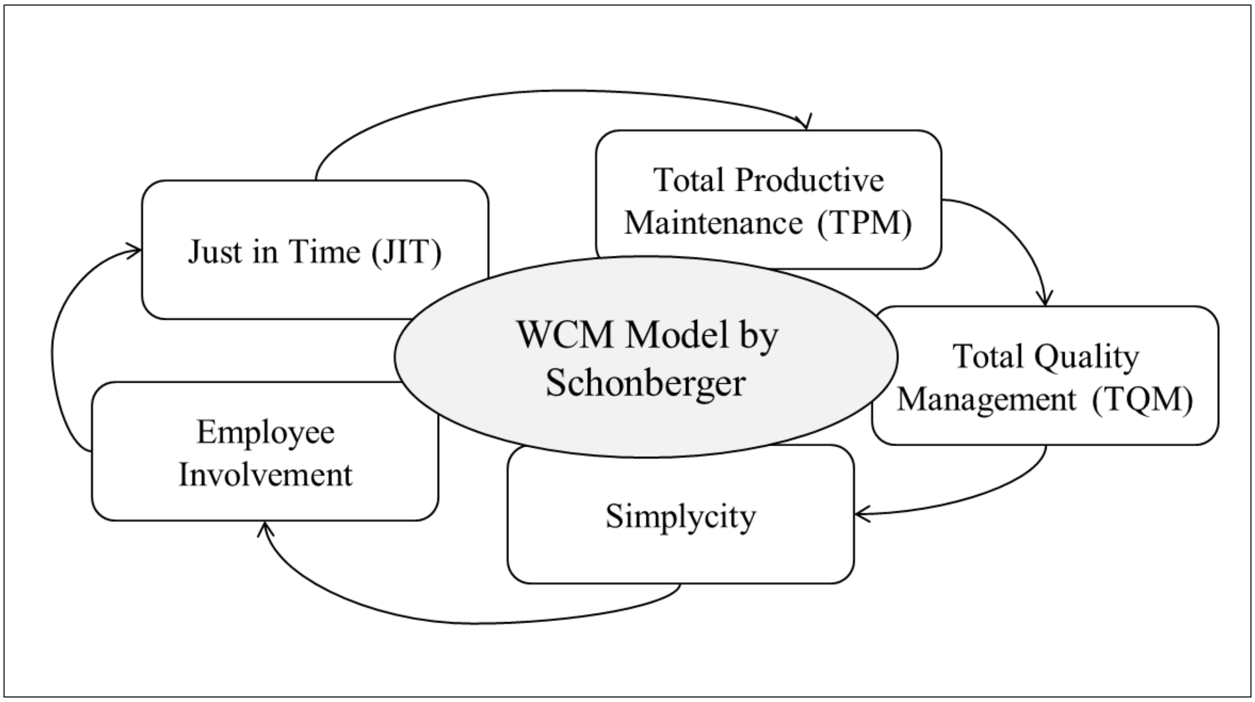

Figure 2. WCM Model by Schonberger

These techniques have been known for a long time, but with Schonberger, a perfectly integrated and flexible system was obtained, capable of achieving company competitiveness with products of high quality. The WCM model by Schonberger is illustrated here above in Figure 2.

According to Fiat Group Automobiles, "World Class Manufacturing (WCM)" is: a structured and integrated production system that encompasses all the processes of the plant, the security environment, from maintenance to logistics and quality. The goal is to continuously improve production performance, seeking a progressive elimination of waste, in order to ensure product quality and maximum flexibility in responding to customer requests, through the involvement and motivation of the people working in the establishment.

The WCM program has been made by Prof. Hajime Yamashina from 2005 at the Fiat Group Automobiles. The program is shown here below in Figure 3.

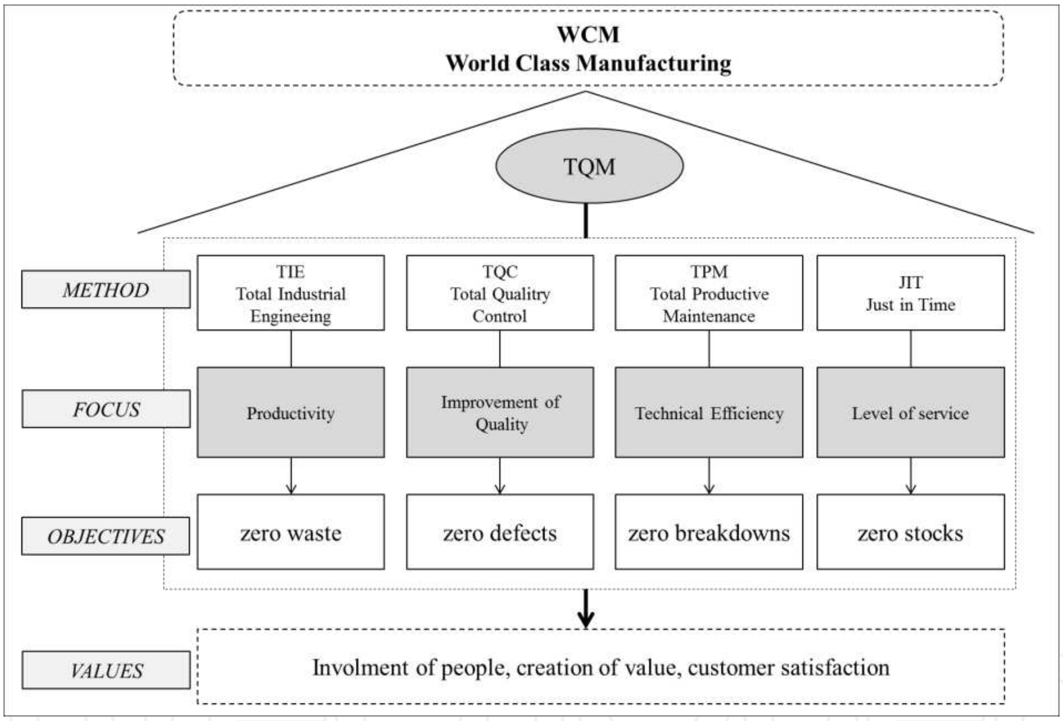

Figure 3. World Class Manufacturing in Fiat Group Automobiles

Fiat Group Automobiles has customized the WCM approach to their needs with Prof. Hajime Yamashina from Kyoto University (he is also member of the Royal Swedish Academy and in particular he is RSA Member of Engineering Sciences), by redesigning and implementing the model through two lines of action: **10 technical pillars**; **10 managerial pillars.**

The definition proposed by Yamashina includes a manufacturing company that excels in applied research, production engineering, improvement capability and detailed shop floor knowledge, and integrates those components into a combined system. In fact, according to Hajime Yamashina the most important thing continues to be the ability to change and quick-

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ly [9]. WCM is developed in 7 steps for each pillar and the steps are identified in three phases: *reactive, preventive and proactive*. In figure 4 an example of a typical correlation between steps and phases is shown, but this correlation could change for each different technical pillar; in fact each pillar could have a different relation to these phases. The approach of WCM needs to start from a "**model area**" and then extend to the entire company. WCM "attacks" the manufacturing area. WCM is based on a system of audits that give a score that allows to get to the highest level. The highest level is represented by "*the world class level*".

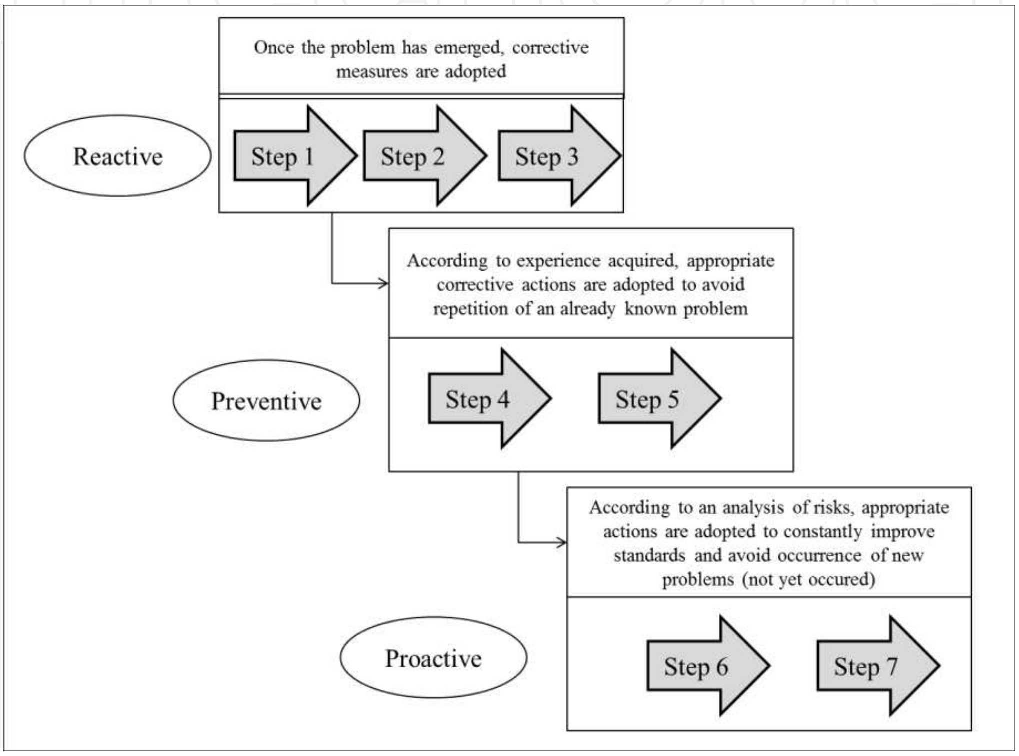


Figure 4. World Class Manufacturing steps

2.1. Mission and principles

The process to achieve "World Class Manufacturing" (WCM) has a number of philosophies and elements that are common for all companies. Therefore, when applied to the manufacturing field, TQM and WCM are synonymous. We would like to observe that customer needs and expectations is a very important element in WCM. The manufacturing strategy should be geared to support these needs. These could be dealing with certification, market share, company growth, profitability or other global targets. The outcomes should be defined so that they are measurable and have a definite timetable. These are also a means of defining employee responsibilities and making them feel involved. Employee education and training is an essential element in a World Class Manufacturing Company. They must understand the company's vision and mission and consequential priorities. As introduced in World Class Manufacturing, well known disciplines such as: Total Quality Control; Total

Productive Maintenance; Total Industrial Engineering; Just In Time and Lean Manufacturing are taken into account. Thus, World Class Manufacturing is based on a few fundamental principles:

- the involvement of people is the key to change;
- it is not just a project, but a new way of working,
- accident prevention is a non-derogated "value";
- the customer's voice should reach all departments and offices;
- all leaders must demand respect for the standards set;
- methods should be applied with consistency and rigor;
- all forms of MUDA waste are not tolerable;
- all faults must be made visible;
- eliminate the cause and not treat the effect.

2.2. Pillars: Description and features

WCM foresees 10 technical pillars and 10 managerial pillars. The levels of accomplishment in technical fields are indirectly affected by the level of accomplishment in administrative fields. The pillar structure represents the "Temple of WCM" (Figure 5) and points out that, to achieve the standard of excellence, a parallel development of all the pillars is necessary. Each pillar focuses on a specific area of the production system using appropriate tools to achieve excellence global.

Figure 5. Temple of WCM

Here below in Table 1 features for each technical pillars are illustrated.

Technical Pillar	Why	Purpose
SAF Safety	Continuous improvement of safety	To reduce drastically the number of accidents. To develop a culture of prevention. To improve the ergonomics of the workplace. To develop specific professional skills.
CD Cost Deployment	Analysis of the losses and costs (losses within the costs)	To identify scientifically and systematically the main items of loss in the system production-logistics business. To quantify the potential economic benefits and expected. To address the resources and commitment to managerial tasks with greatest potential.
FI Focused Improvement	Priorities of actions to management the loss identified by the cost deployment	To reduce drastically the most important losses present in the system manufacturing plant, eliminating inefficiencies. To eliminate non-value-added activities, in order to increase the competitiveness of the cost of the product. To develop specific professional skills of problem solving.
AA Autonomous Activities	Continuous improvement of plant and workplace	It is constituted by two pillars: *AM Autonomous Maintenance.* It is used to improve the overall efficiency of the production system through maintenance policies through the conductors (equipment specialists). WO Workplace Organization. It is develops to determine an improvement in the workplace, because often the materials and equipment are degrade; in particular because in the process there are many losses (MUDA)to remove.
PM Professional Maintenance	Continuous improvement of downtime and failures	To increase the efficiency of the machines using failure analysis techniques. To facilitate the cooperation between conductors (equipment specialists) and maintainers (maintenance people) to reach zero breakdowns.
QC Quality Control	Continuous improvement of customers' needs	To ensure quality products. To reduce non-compliance. To increase the skills of the employees.
LOG Logistics & Customer Service	Optimization of stocks	To reduce significantly the levels of stocks. To minimize the material handling, even with direct deliveries from suppliers to the assembly line.
EEM Early Equipment Management EPM Early Product Management	Optimization of installation time and costs and optimization of features of new products	To put in place new plants as scheduled. To ensure a rapid start-up and stable. To reduce the Life Cycle Cost (LCC). To design systems easily maintained and inspected.

Technical Pillar	Why	Purpose
PD People Development	Continuous improvement of the skills of employees and workers	To ensure, through a structured system of training, correct skills and abilities for each workstation. To develop the roles of maintenance workers, technologists, specialists such as major staff training.
ENV Environment ENE Energy	Continuous improvement environmental management and reduce energy waste	To comply with the requirements and standards of environmental management. To develop an energy culture and to reduce the energy costs and losses.

Table 1. Description of pillars

As regards the ten Managerial Pillars there are: 1) Management Commitment; 2) Clarity of Objectives; 3) Route map to WCM; 4) Allocation of Highly Qualified People to Model Areas; 5) Organization Commitment; 6) Competence of Organization towards Improvement; 7) Time and Budget; 8)Detail Level; 9) Expansion Level and 10) Motivation of Operators

3. The main tools for World Class Manufacturing: Features and description

WCM requires all decisions to be made based on objective measured data and its analysis. Therefore, all the traditional data analysis tools such as scatter diagrams, histograms and checklists are used. Thus, from literature survey it is inferred that it is not possible to use the specific single tool to achieve world-class performance and address all the manufacturing components. It is inferred that to address all the components of the manufacturing system the following tools are necessary (see Table 2):

Main Tools	Description
5 G	It is a methodology for the description and the analysis of a loss phenomenon (defects, failures malfunctions...). It based on the facts and the use of the 5 senses
4M or 5M	It is used by the list of possible factors (causes, sub-causes) that give rise to the phenomenon. For the 4M the causes are grouped into 4 categories: Methods; Materials; Machines; Mans. And for the 5M, there are the same 4M more the fifth that is the environment.
5 S	It is used to achieve excellence through improvement of the workplace in terms of order, organization and cleanliness. The technique is based on: Seiri (separate and order); Seiton (arrange and organize); Seiso

Main Tools	Description
	(clean); Seiketsu (standardized); Shitsuke (maintaining and improving).
5W + 1H	It is used to ensure a complete analysis of a problem on all its fundamental aspects. The questions corresponding to the 5 W and 1 H are: Who? What? Why? Where? When? How?
5 Whys	It is used to analyze the causes of a problem through a consecutive series of questions. It is applied in failures analysis, analysis of sporadic anomalies, analysis of chronic losses arising from specific causes.
AM Tag	It is a sheet which, suitably completed, is applied on the machine, in order to report any anomaly detected.
WO Tag	It is a sheet which, suitably completed, is used in order to report any anomaly detected for Workplace Organization
PM Tag	It is a sheet which, suitably completed, is used in order to report any anomaly detected for Professional Maintenance.
Heinrich Pyramid	It is used for classifying the events that have an impact on safety such as fatalities, serious, minor, medications, near-accidents, accidents, dangerous conditions and unsafe practices over time.
SAF Tag	It is a sheet which, suitably completed, is used in order to report any anomaly detected for Safety.
Equipment ABC Prioritization	It is used to classify plants according their priorities of intervention in case of failure.
Cleaning cycles	Are used for activities on Autonomous Maintenance, Workplace Organization and Professional Maintenance.
Inspection cycles	Are used for activities on Autonomous Maintenance, Workplace Organization and Professional Maintenance.
Maintenance cycles	Are used for activities on Autonomous Maintenance and Professional Maintenance.
Control cycles	Are used for activities on Autonomous Maintenance, Workplace Organization and Professional Maintenance.
FMEA-Failure Mode and Effect Analysis	It is used to prevent the potential failure modes.
Kanban	It is a tag used for programming and production scheduling.
Kaizen (Quick, Standard, Major, Advanced)	It is a daily process, the purpose of which goes beyond simple productivity improvement. It is also a process that, when done correctly, humanizes the workplace, eliminates overly hard work.
Two Videocamera Method	It is used to perform the video recording of the transactions in order to optimize them.

Main Tools	Description
MURI Analysis	Ergonomic analysis of workstations.
MURA Analysis	Analysis of irregular operations.
MUDA Analysis	Analysis of losses.
Spaghetti Chart	It is a graphical used to detail the actual physical flow and distances involved in a work process.
Golden Zone & Strike zone Analysis	Analysis of work operations in the area that favors the handling in order to minimize movement to reduce fatigue.
OPL (One Point Lesson)	It is a technique that allows a simple and effective focus in a short time on the object of the training.
SOP (Standard Operation Procedure)	Standard procedure for work.
JES (Job Elementary Sheet)	Sheet of elementary education.
Visual Aid	It is a set of signals that facilitates the work and communication within the company.
Poka Yoke	It is a prevention technique in order to avoid possible human errors in performance of any productive activity.
TWTTP (The way to teach people)	It is an interview in 4 questions to test the level of training on the operation to be performed.
HERCA (Human Error Root Cause Analysis)	It is a technique for the investigation of events of interest, in particular accidents, which examines what happened researching why it happened.
RJA (Reconditional Judgment Action Analysis)	Analysis of judgment, recognition and action phases at work.
5Q 0D (Five Questions to Zero Defects)	Analysis of the process or of the equipment (machine) through five questions to have zero defect.
DOE	It is a techniques enables designers to determine simultaneously the individual and interactive effects of many factors that could affect the output results in any design.
ANOVA	It is a collection of statistical models, and their associated procedures, in which the observed variance in a particular variable is partitioned into components attributable to different sources of variation.
PPA (Processing Point Analysis)	It is used for restore, maintain and improve operational standards of work by ensuring zero defects.
QA Matrix (Matrix Quality Assurance)	It is a set of matrices which shows the correlations between the anomalies of the product and the phases of the production system.
QM Matrix (Matrix Maintenance Quality)	It is a tool used to define and maintain the operating conditions of the machines which ensure performance of the desired quality.

Main Tools	Description
QA Network quality assurance network	It is used to ensure the quality of the process by eliminating rework.
QuOA quality operation analysis	Preventive analysis of the work steps to ensure the quality.
SMED (Single Minute Exchange of Die)	It is a set of techniques to perform operations of development, set-up, with a duration < 10 minutes.
Rhythmic operation analysis	Analysis of the dispersion during the work cycle.
Motion Economic Method	Analysis used to evaluate the efficiency of movement and optimize them.
Value Stream Map	It allows to highlight the waste of a process business, helping to represent the current flow of materials and information that, in relation to a specific product, through the value stream between customer and suppliers.
Material Matrix	Classification of materials according to tree families A – B - C and subgroups.
X Matrix	It is a tool for quality improvement, which allows compare two pairs of lists of items to highlight the correlations between a list, and the two adjacent lists. X matrix to relate defect mode, phenomenon, equipment section and quality components.

Table 2. Main Tools and description

3.1. Key Performance Indices and Key Activity Indicators

In World Class Manufacturing the focus is on continuous improvement. As organizations adopt world class manufacturing, they need new methods of performance measurement to check their continuous improvement. Traditional performance measurement systems are not valid for the measurement of world class manufacturing practices as they are based on outdated traditional cost management systems, lagging metrics, not related to corporate strategy, inflexible, expensive and contradict continuous improvement [10]. To know the world class performance, measurement is important because *"if you can't measure it, you can't manage it and thus you can't improve upon it"*.

Here below in Table 3 is shown a brief report on different indices and indicators defined by several authors in order to "measure" WCM.

However, some authors [15; 16] proposed only productivity as a measure of manufacturing performance. Kennerley and Neely [17] identified the need for a method that could be used for the development of measures able to span diverse industry groups. From this point of view we would like to note that it is necessary to develop a more systematic approach in order to improve a project and process. In particular, in WCM we can use two types of indicators: Key Performance Indicator (KPI) and Key Activity Indicator (KAI). KPI represents a result of project improvement, e.g. sales, profit, labor productivity, equipment performance

	Authors			
Indices/Indicators	Kodali et al. [11]	Wee and Quazi [12]	Digalwar and Metri [13]	Utzig [14]
Broad management/Worker involvement				+
Competitive advantage	+			
Cost/Price	+		+	+
Customer relations/Service	+		+	
Cycle time				+
Engineering change notices				+
Facility control			+	
Flexibility	+		+	+
Global competitiveness			+	
Green product/Process design		+	+	
Innovation and Technology			+	
Inventory	+		+	
Machine hours per part				+
Measurement and information management.		+		
Morale	+			
Plant/Equipment/Tooling reliability				+
Problem support				+
Productivity	+			+
Quality	+		+	+
Safety	+		+	
Speed/Lead Time			+	+
Supplier management		+		
Top management commitment		+	+	
Total involvement of employees		+		
Training		+		

Table 3. Main indices/indicators defined by different authors

rate, product quality rate, Mean Time to Failure (MTBF) and Mean Time to Repair (MTTR) [18, 19]. KAI represents a process to achieve a purpose of project improvement, e.g. a total number of training cycles for employees who tackle performance improvement projects, a total number of employees who pass a public certification examination and an accumulative number of Kaizen cases [20]. A KAI & KPI overview applied step by step is seen in Figure 6.

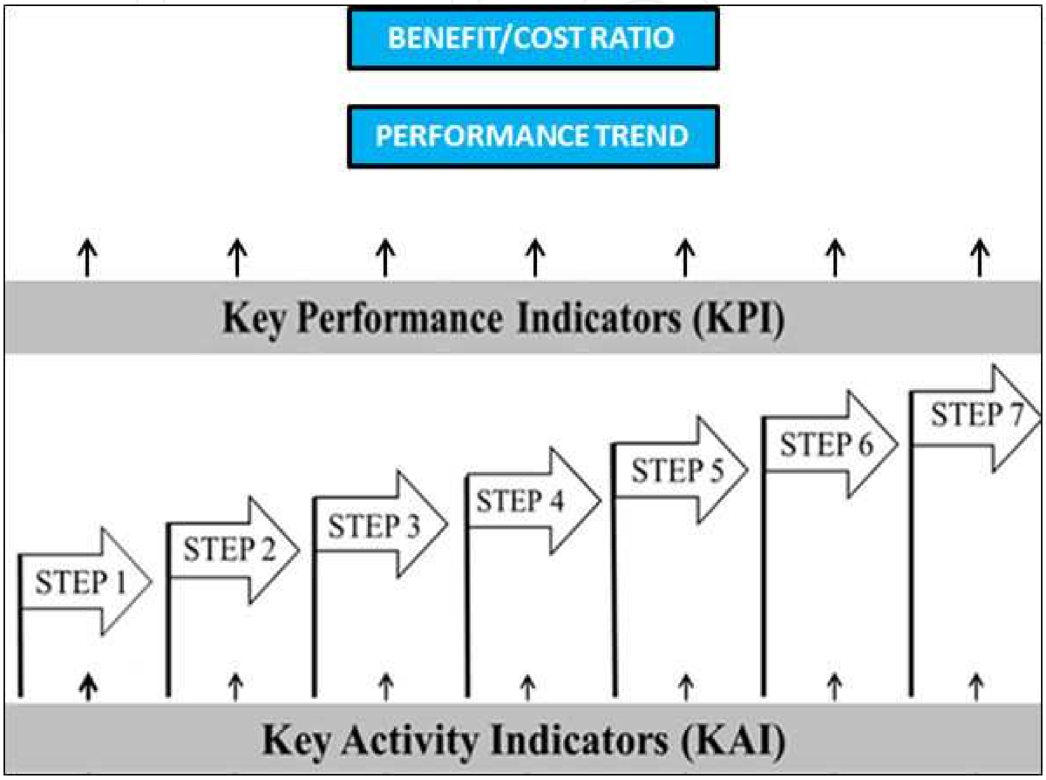


Figure 6. A KAI & KPI overview applied step by step

4. Industrial case study

The aim of this work is to present establishments of the basic model of World Class Manufacturing (WCM) quality management for the production system at Fiat Group Automobiles in order to make products of the highest quality eliminating losses in all the factory fields an improvement of work standards. In fact, World Class Manufacturing is a manufacturing system defined by 6 International companies including Fiat Group Automobiles with the intent to raise their performances and standards to World Class level with the cooperation of leading European and Japanese experts and this includes all the plant processes including quality, maintenance, cost management and logistics etc. from a universal point of view. Thus, automotive manufacturing requires the ability to manage the product and its associated information across the entire fabricator. Systems must extend beyond their traditional role of product tracking to actively manage the product and its processing. This requires coordinating the information flow between process equipment and higher level systems, supporting both manual and automatic interfaces. A case study methodology was used to collect detailed information on division and plant strategic objectives, performance measurement systems, and performance measurement system linkages. The result of this research was to develop principles on strategic objectives, performance measurement systems and performance measurement system linkages for improved organizational coordination. The purpose of this study is to examine the relationship between division and plant performance measurement systems designed to support the firm's strategic objectives and to improve organizational coordination. We will focus our attention on the Cost Deployment Pillar, Autonomous Activities/Workplace Organization Pillar and Logistics/Customers Service Pillar.

4.1. Company background

Fiat Group Automobiles is an automotive-focused industrial group engaged in designing, manufacturing and selling cars for the mass market under the Fiat, Lancia, Alfa Romeo, Fiat Professional and Abarth brands and luxury cars under the Ferrari and Maserati brands. It also operates in the components sector through Magneti Marelli, Teksid and Fiat Powertrain and in the production systems sector through Comau. Fiat operates in Europe, North and South America, and Asia. Its headquarters is in Turin, Italy and employs over 137,801 people [21]. Its 2008 revenues were almost € 59 billion, 3.4% of which were invested in R&D. Fiat's Research Center (CRF) can be appropriately defined as the "innovation engine" of the Fiat Group, as it is responsible for the applied research and technology development activities of all its controlled companies [22]. The group Fiat has a diversified business portfolio, which shields it against demand fluctuations in certain product categories and also enables it to benefit from opportunities available in various divisions.

4.2. Statement of the problem and methodology

The aim of the project is to increase the flexibility and productivity in an ETU (Elementary Technology Unit) of Mechanical Subgroups in a part of the FGA's assembling process in the Cassino Plant through the conventional Plan-Do-Check-Act approach using the WCM methodology:

- PLAN - Costs Analysis and Losses Analysis starting from Cost Deployment (CD) for the manufacturing process using the items and tools of Workplace Organization (WO) and for the handling process the Logistic and Customer Services (LOG) applications.

- **DO** - Analysis of the non-value-added Activities; analysis of re-balancing line and analysis of re-balancing of work activities in accordance with the analysis of the logistics flows using the material matrix and the flows matrix. Study and realization of prototypes to improve workstation ergonomics and to ensure minimum material handling; Application of countermeasures found in the production process and logistics (handling).

- CHECK – Analysis of results in order to verify productivity improvement, ergonomic improvement (WO) and the optimization of the internal handling (in the plant) and external logistics flows (LOG). Check of the losses reduction according to Cost Deployment (CD).

- ACT - Extension of the methodology and other cases.

Here below is a description of the Statement of the Problem and methodology.

4.2.1. PLAN: Costs analysis and losses analysis (CD) for the manufacturing process (WO) and for the handling process (LOG)

In this first part (PLAN) were analyzed the losses in the assembly process area so as to organize the activities to reduce the losses identified in the second part of the analysis (DO). Object of the study was the Mechanical Subgroups ETU - Elementary Technology Unit (in a part of the Cassino Plant Assembly Shop). The aim of this analysis was to identify a program allowing to generate savings policies based on Cost Deployment:

- Identify relationships between cost factors, processes generating costs and various types of waste and losses;
- Find relationships between waste and losses and their reductions.

In fact, in general a production system is characterized by several waste and losses (MUDA), such as:

- Non-value-added activities;
- Low balancing levels;
- Handling losses;
- Delay in material procurement;
- Defects;
- Troubleshooting Machines;
- Setup;
- Breakdown.

It is important to give a measure of all the losses identified in process examination. The data collection is therefore the "*key element*" for the development of activities of Cost Deployment. Here below in Figure 7 an example of losses identified from CD from the Assembly Shop is shown and in Figure 8 is shown an example of CD data collection regarding NVAA (Non-Value-Added Activities) for WO (for this case study we excluded check and rework losses) in the Mechanical Subgroups area. Finally Figure 9 shows Analysis of losses Cost Deployment.

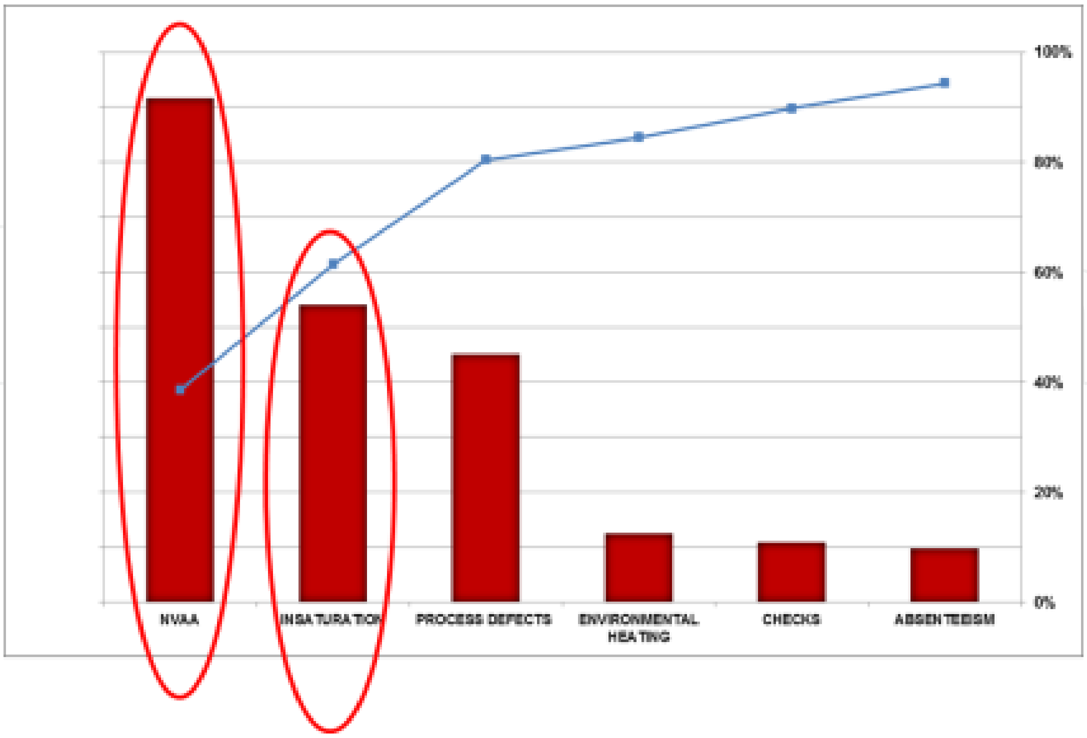


Figure 7. Analysis of losses Cost Deployment – Stratification of NVAA losses for Mechanical Subgroups ETU - Elementary Technology Unit (figure highlights the most critical workstation)

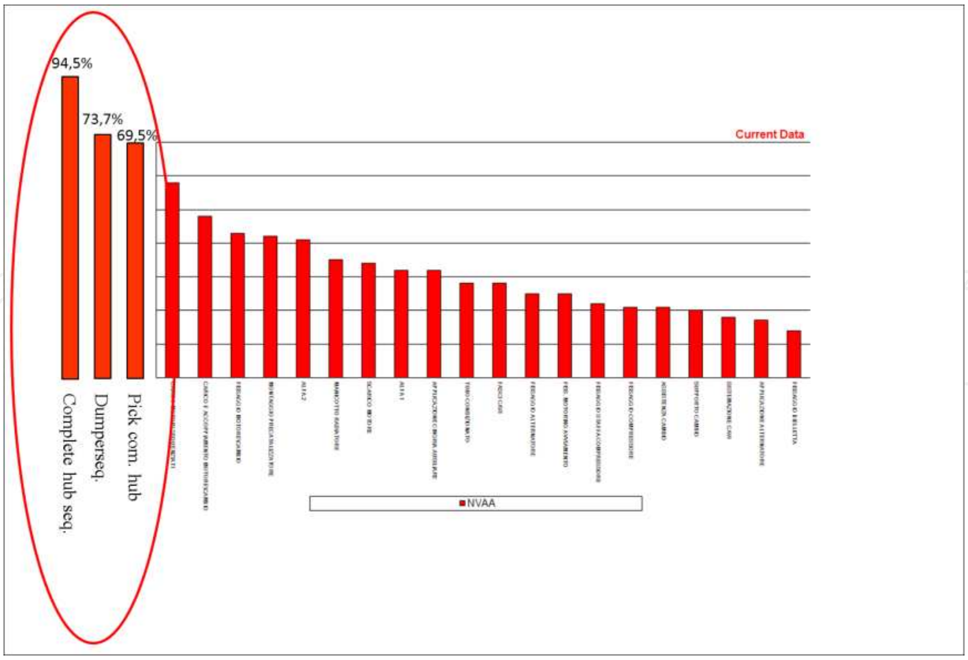


Figure 8. Analysis of losses Cost Deployment – Pareto Analysis NVAA Mechanical Subgroups ETU - Elementary Technology Unit

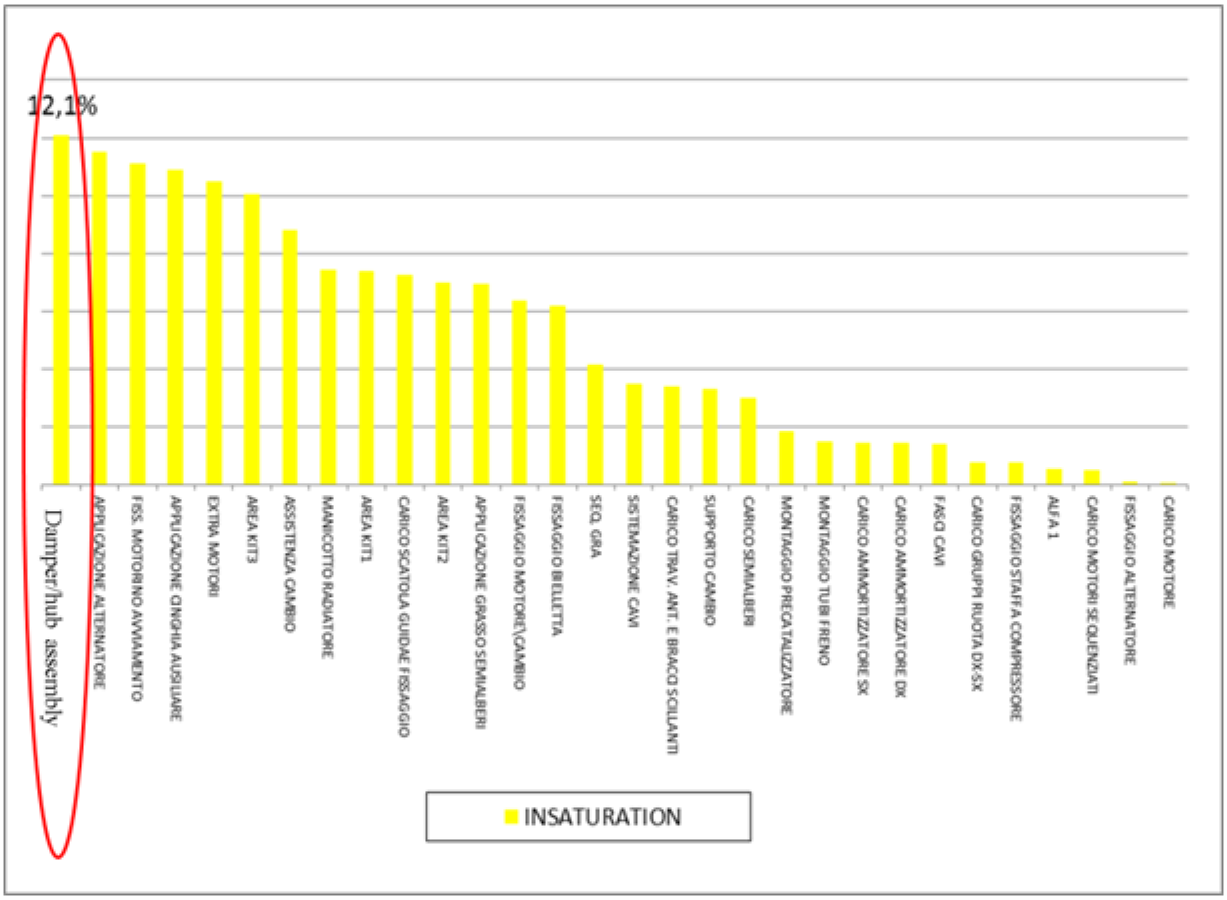
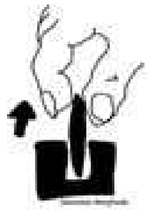
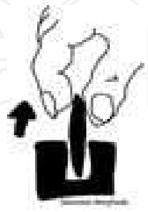
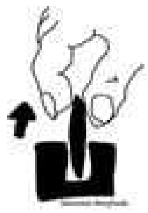
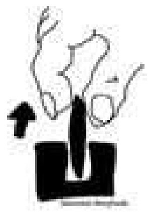
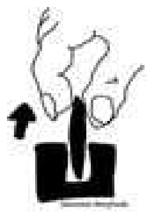


Figure 9. Analysis of losses Cost Deployment – Pareto Analysis Line Balancing Losses or Insaturation on Mechanical Subgroups ETU - Elementary Technology Unit

4.2.2. DO - Analysis of non-value-added activities, of the re-balancing line and analysis of re-balancing of work activities

According to figure 9 and figure 10 were analyzed the losses regarding NVAA and Insaturation. In fact were analyzed all 4 critical workstations (because they have the worst losses) and were identified 41 types of non-value-added activities (walking, waiting, turning, picking....) in the various sub-phases of the production process. In Table 4 is shown some examples of non-value-added activities analyzed (MUDA Analysis).

Some examples of standard tools used to analyze NVAA reduction (MUDA Analysis) for the 4 workstations are shown here below in Figures 10, 11 and 12) job stratification (VAA - Value Added Activities; NVAA – Non-Value-Added Activities; LBL - Low Balancing Level; EAWS - European Assembly Work Sheet – Ergonomy); 2) Spaghetti Chart and 3) Kaizen Standard.

N°	Losses identified	Solution	Non-value-added activities identified	
1	Pick picking list for sequencing	Complete hub sequencing	To pick	
2	Pick the box for sequencing	Complete hub sequencing	To pick	
3	Select sheets for the different model	Unification of the sheets from 3 to 1	To select	
4	Pick sheets for the different process	Unification of the sheets from 3 to 1	To pick	
5	Pick identification sheet	Unification of the sheets from 3 to 1	To pick	
6	Go to the printer to pick up sticker	Print sticker	To walk	
7	Pick identification hub label	Digital label with barcode	To pick	

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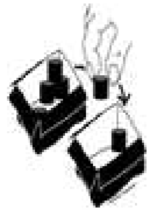
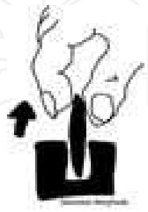
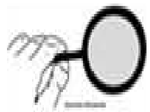
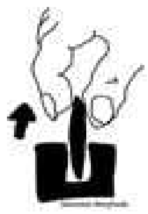
N°	Losses identified	Solution	Non-value-added activities identified	
8	Throw liner nameplate into the waste container	Print labels directly onto sheet unified	To trow	
9	Pick equipment for reading labels coupling	Automatic reading	To pick	
10	Combination of manual pallet	Automatic combination	To check	
11	Use of a single box	Enabling a second workstation	To walk	
12	Pick hub	Pick subgroup (hub+ damper	To pick	
13	Use of electrical equipment through keyboard	New air equipment without keyboard	To arrange	
14	Use of air equipment through keyboard	New air equipment without keyboard	To wait	

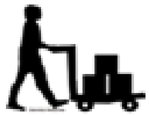
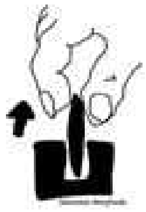
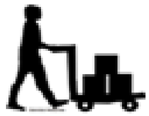
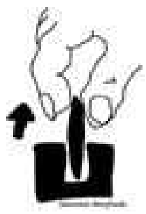
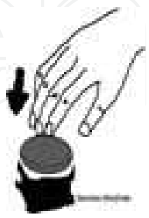
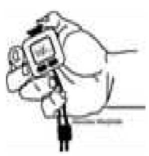
N°	Losses identified	Solution	Non-value-added activities identified	
15	Transport empty box hub sequencing to put the full box	Complete hub sequencing	To transport	
16	Walk to the line side to pick damper	Complete hub sequencing	To walk	
17	Remove the small parts to pair with damper	Complete hub sequencing	To pick	
18	Transport empty box damper sequencing to put the full box	Complete damper sequencing	To transport	
19	Pick the hub and put on the line	Pick subgroup (hub+ damper)	To pick	
20	Select the work program for the next workstation	Select the work program	To select	
21	Press the feed button for the damper	Use a single workstation after the sequencing of the subgroup in order to press a button once	To push	
22	Wait for the translational motion of the pallet	Use a single workstation after the sequencing of the subgroup and match processing activities during the translation of the pallet	To wait	

Table 4. MUDA Analysis - NVAA

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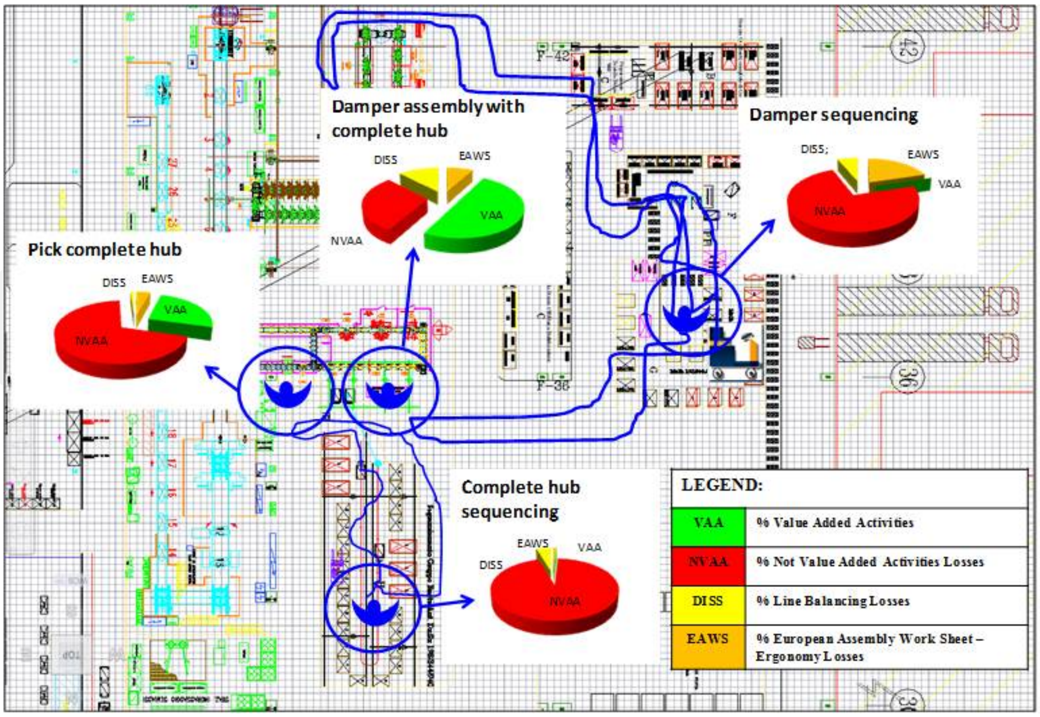


Figure 10. Details of the 4 workstations

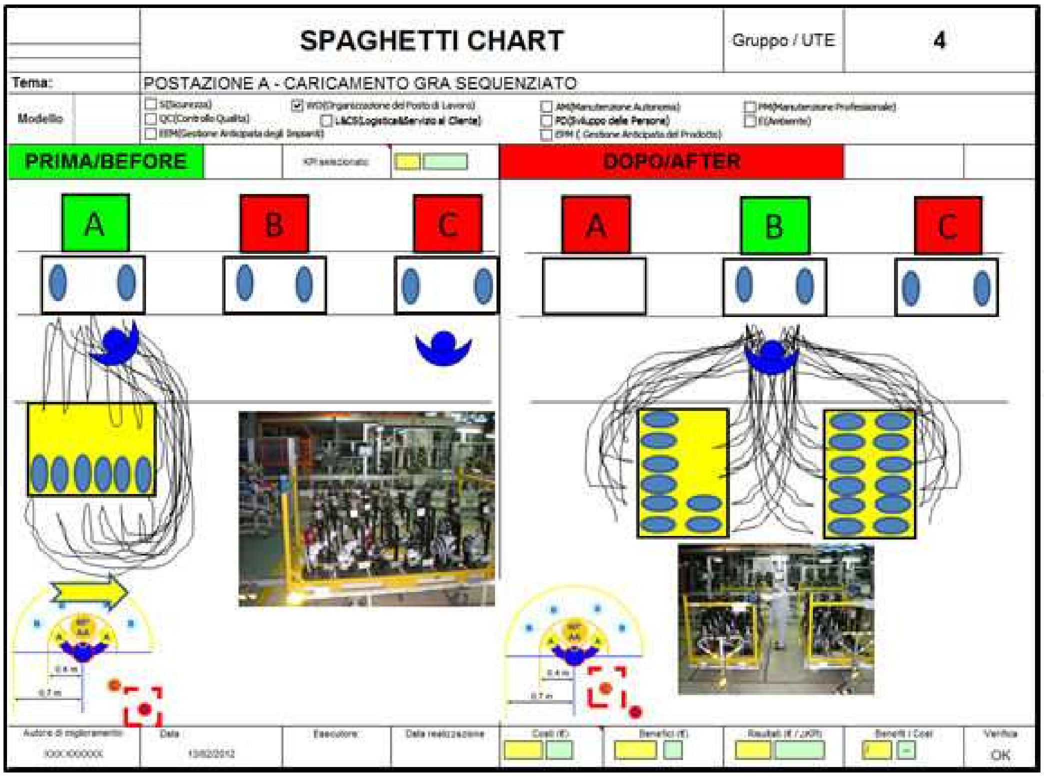


Figure 11. Spaghetti Chart Example

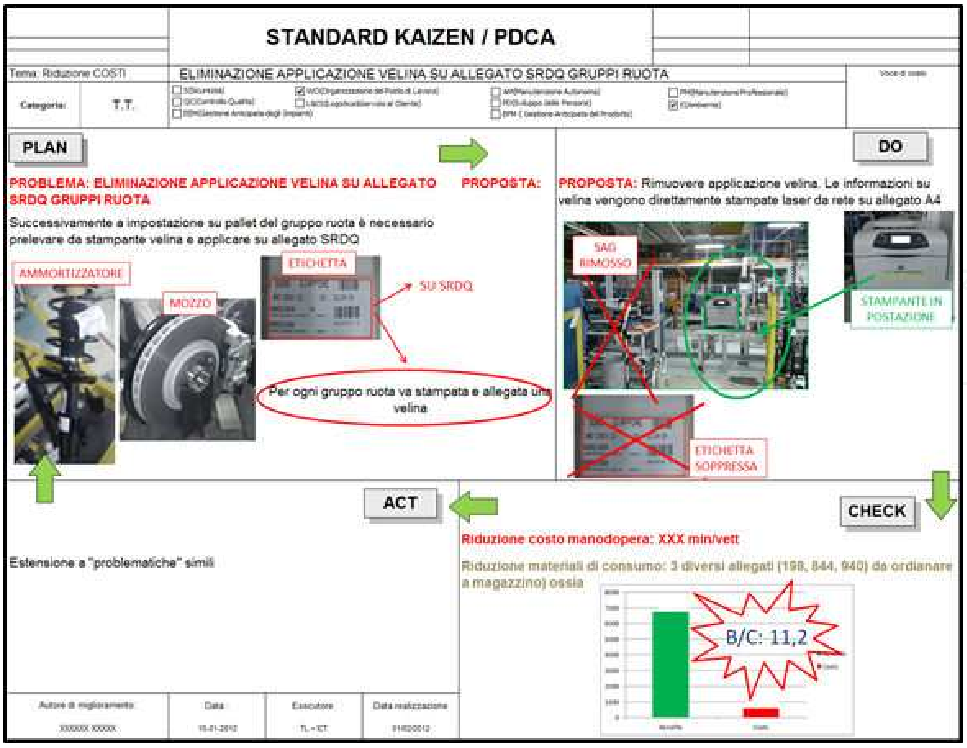


Figure 12. Standard Kaizen analysis Example

Figure 13 shows the initial scenario analyzed to identify problems and weaknesses.

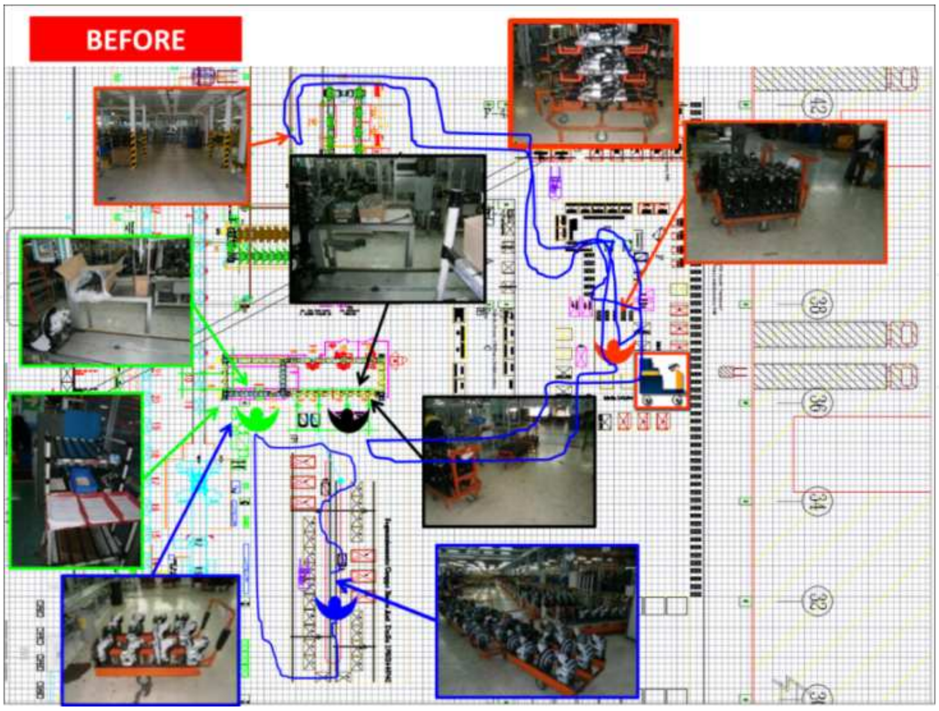
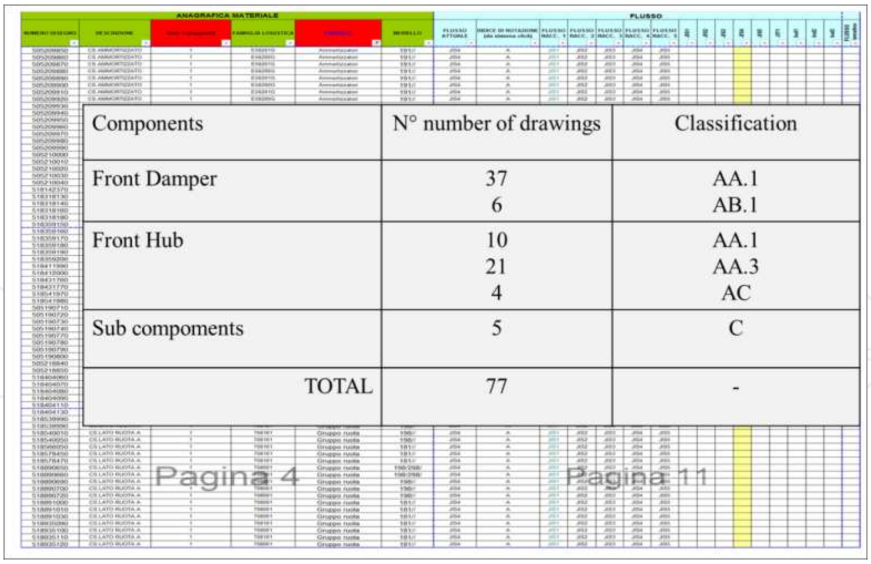


Figure 13. Details of the 4 workstations

http://dx.doi.org/10.5772/54450



Components	N° number of drawings	Classification
Front Damper	37 6	AA.1 AB.1
Front Hub	10 21 4	AA.1 AA.3 AC
Sub compoments	5	C
TOTAL	77	-

Figure 14. Material matrix example

At this point was assumed the new flow of the complete damper (corner) = damper + complete hub sequencing according to the material matrix considering losses relating to handling (material matrix classification – see figure 14). The material matrix classifies the commodities (number of drawings) in three main groups: A (bulky, multi-variations, expensive), B (normal) and C (small parts) and subgroups (a mixture of group A: bulky and multi-variations or bulky and expensive etc.). For each of these groups was filled out the flow matrix that defines the correct flow associated: JIS (and different levels), JIT (and different levels) and indirect (and different levels). After identifying the correct flow, in the JIS case, was built a prototype of the box (bin) to feed the line that would ensure the right number of parts to optimize logistic handling. However, the new box (bin) for this new mechanical subgroup must feed the line in a comfortable and ergonomic manner for the worker in the workstation, for this reason was simulated the solution before the realization of the box (bin) (see figure 15).

At the end of the Muda analysis (NVAA analysis) were applied all the solutions found to have a lean process (the internal target is to achieve 25% of average NVAA losses) and was reorganized the line through a new line balancing level (rebalancing) to achieve 5% of the average line balancing losses (internal target). Another important aspect was the logistics flows analysis (see figure 16) considering *advanced warehouses* (Figure 17). The simulation scenario was defined using trucks from the Cassino plant warehouses that also feed other commodities to achieve high levels of saturation to minimize handling losses.

At the end of the handling analysis (flow, stock level…) thanks to this new "lean" organization of material matrix was used the correct line feed from the Just In Sequence warehouse. It was reduced the internal warehouse (stock level), the space used for sequencing (square metres), the indirect manpower used to feed the sequencing area and we obtained zero fork-

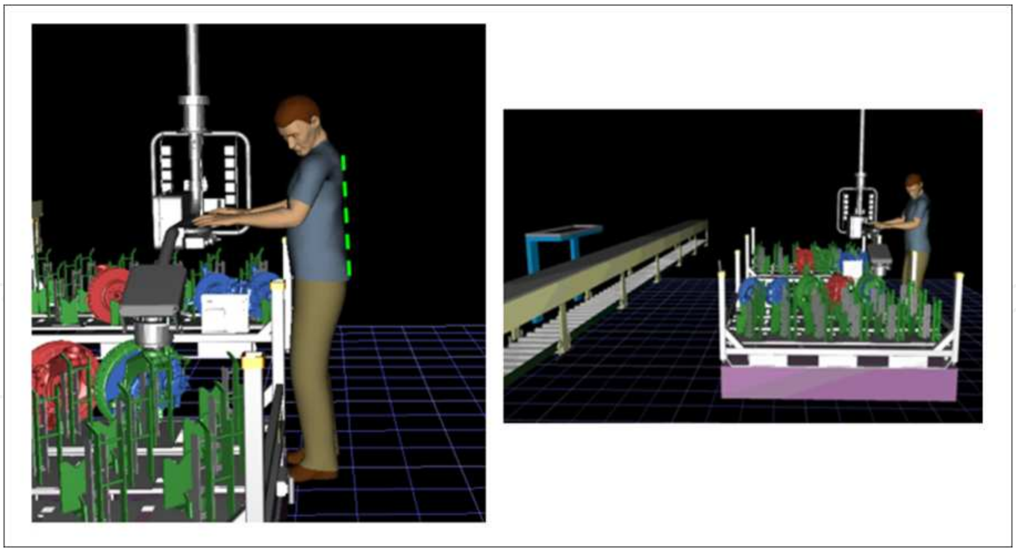


Figure 15. Simulation of an ergonomic workstation

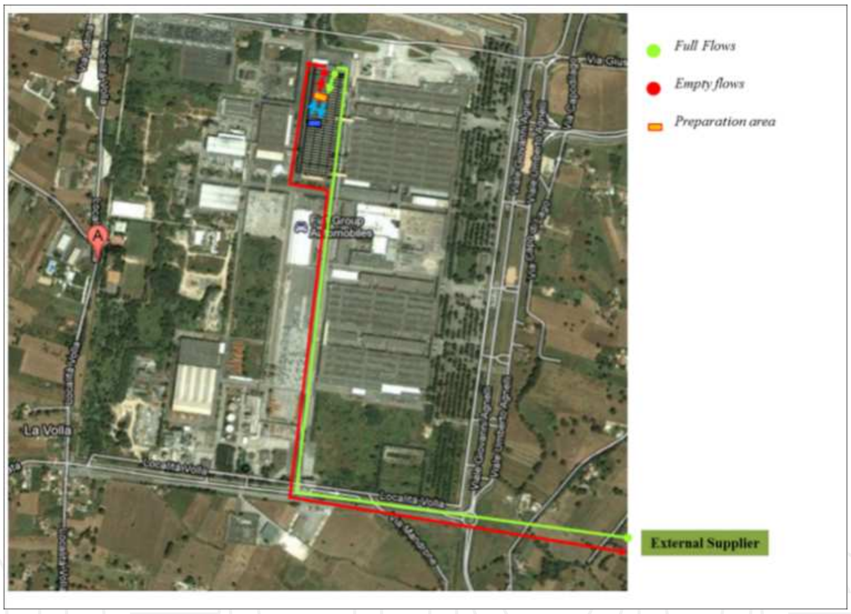


Figure 16. Initial logistic flows

lifts on the shopfloor because we used the ro-ro (roll in - roll out) system. Figure 18 shows the final scenario in which we have 1 operator instead of 4 operators.

4.2.3. Check – Analysis of results to verify productivity and ergonomic improvement and optimization of logistics flows

In detail the main results and savings can be summarized as follows:

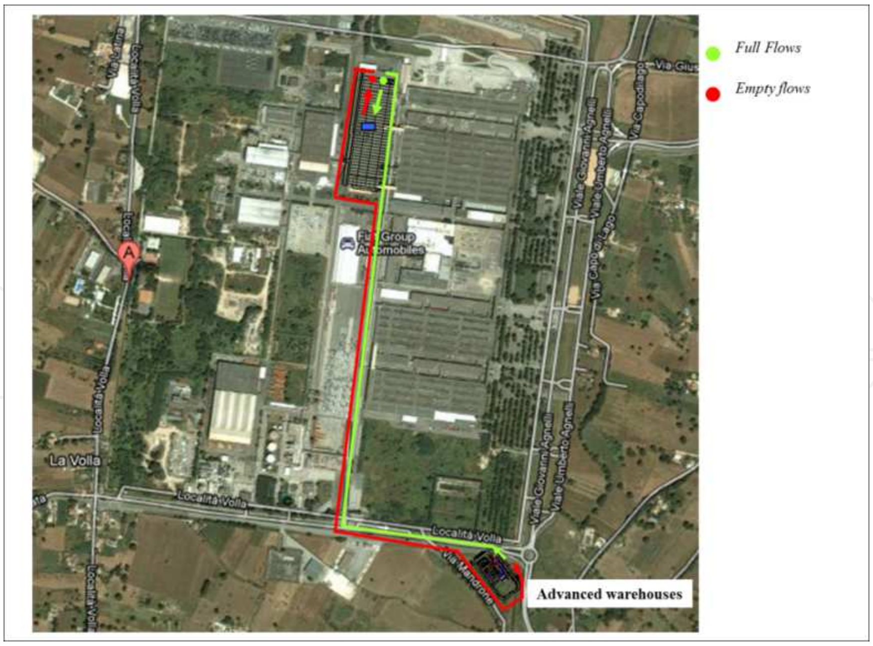


Figure 17. Logistic flows considering advanced warehouses

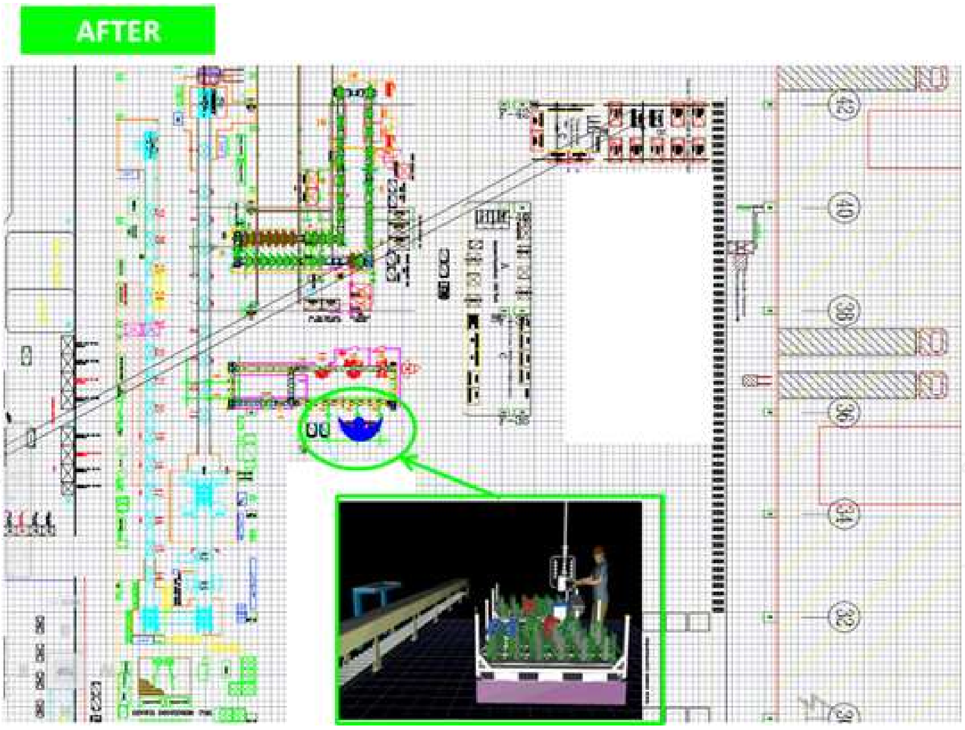


Figure 18. Details of the final workstation

- Productivity improvement +75% (Figure 19) direct labour;

- Ergonomics improvement +85% (Figure 20) according to the rest factor;
- Optimization of logistic flows (Figure 21) according to the flow matrix.

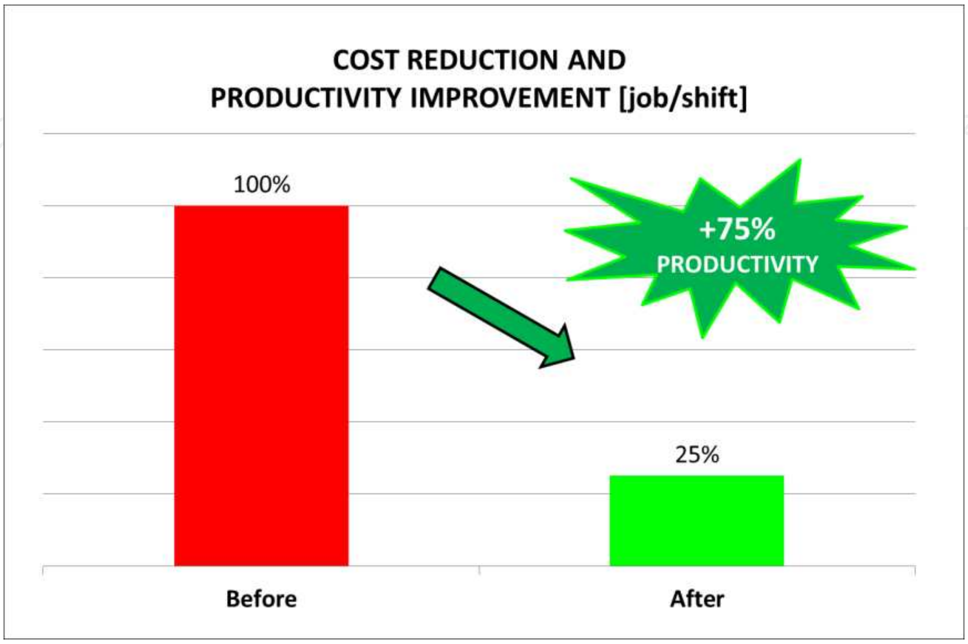


Figure 19. Productivity optimization

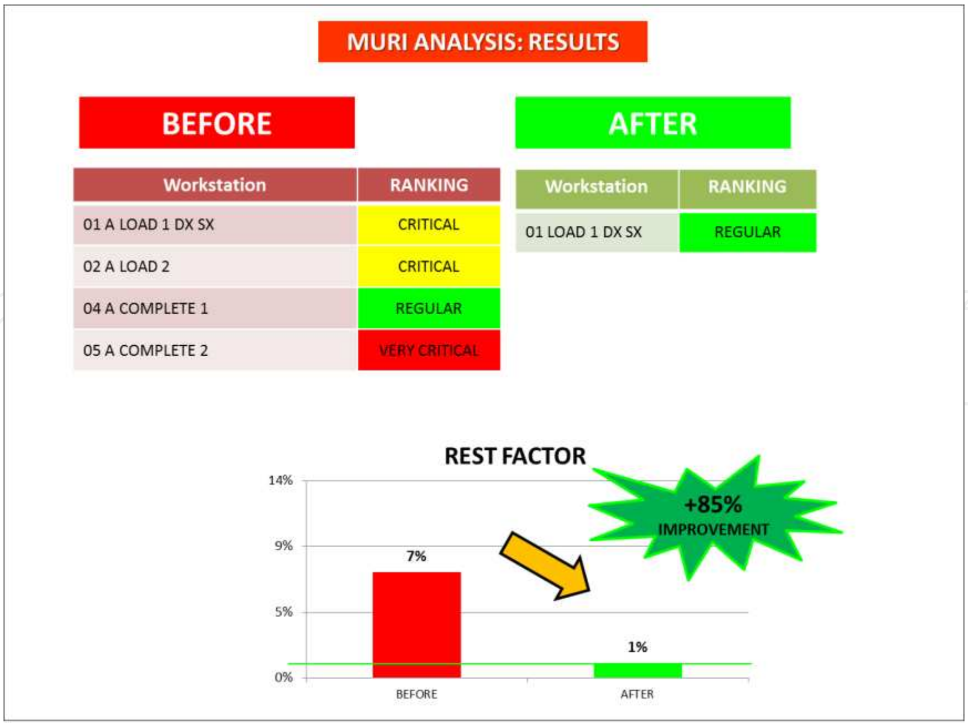


Figure 20. Ergonomics improvement

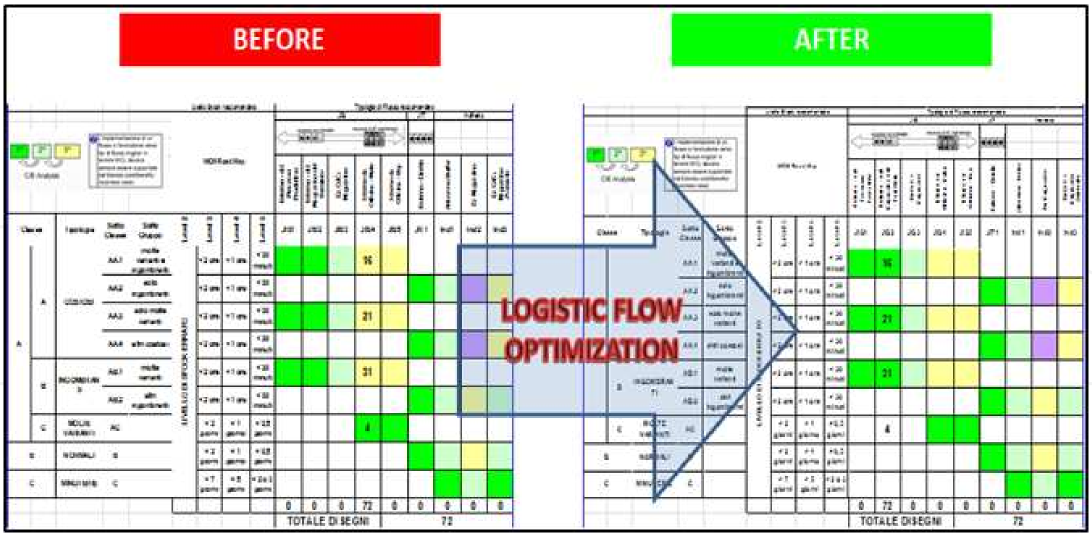


Figure 21. Optimization of logistic flows

4.2.4. Act - Extension of the methodology and other cases

Future developments include the extension of the methodology to the entire plant. Here below in Table 5 we can see the activities and status adopted. to achieve the results shown in the "check". We used traditional tools and methodology for the analysis and new tools to simulate the sceneries on the line and for the logistic problems we involved other resources outside the plant (ELASIS and CRF - FIAT Research Center, Fiat Central Department and Public Universities).

ACTIVITIES	TOOL	STATUS
NVAA Reduction	NVAA Std analysis	+
	NVAA Database	+
LBL Reduction	Balance line	+
	Check Saturation (Flexim Software/Plant simulation)	+
Ergonomics Improvement	Jack Software	+
	Excel Human Model	+
Optimization of logistics flow	Value stream map	+
	Check Saturation Flexim/Plant simulation	+

Table 5. Activities and status

5. Conclusions

A key industrial policy conclusion is that intelligently designed selective policies can be effective in developing production systems. Intelligent industrial policies need to be shaped to respond to contingent factors which are specific to a sector, period and country. Fundamentally, it is not a question of whether these selective policies work, but under what circumstances they work.

From this point of view, World Class Manufacturing is a “key” concept. This is the reason why the concept constituting “World Class Manufacturing” has received considerable attention in academic literature, even though it has been developed principally in relation to the needs of larger scale manufacturing organisations. Regards our case study we can conclude that WCM allows to reduce losses and optimize logistics flows. Thus, the main results can be summarized as follows:

1. greater efficiency because the inner product is cheaper because it is possible to use external warehouses or suppliers - outsourcing - specialized and more cost-effective for the company;

2. greater flexibility because it is possible to work more models (in Cassino with these logical sequencing and kitting there are 4 different model brands on the same assembly line: *Alfa Romeo Giulietta, Chrysler, Lancia Delta and Fiat Bravo*;

3. no space constraint (in this example we get only 1 container already sequenced line side)

Definitely the new process and the internal flows are very lean and efficient. In this case study it was implemented a servo system using Low Cost Automation. This system ensures only one picking point in order to have only one container at the side of the production line.

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Author details

Fabio De Felice[1], Antonella Petrillo[1*] and Stanislao Monfreda[2]

*Address all correspondence to: a.petrillo@unicas.it

1 University of Cassino, Department of Civil and Mechanical Engineering, Cassino, Italy

2 Fiat Group Automobiles EMEA WCM Cassino Plant Coordinator, Cassino, Italy

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