

Universidade do Minho
Escola de Engenharia

Ana Sofia Alves dos Reis

Improvement of the projects' elaboration and
execution processes using Lean tools in an
electronic components company

Masters Dissertation

Master in Industrial Engineering and Management

Work done under supervision of:

Professor Anabela Carvalho Alves

Professor Anabela Pereira Tereso

October of 2017

ACKNOWLEDGMENTS

For the conclusion of this dissertation I would like to thank to my master's advisor, professor Anabela Tereso, and co-advisor, Professor Anabela Alves, for the total support and teachings. This project could not be possible without my Bosch's coordinator, Francisco Vieira, that supported me throughout the journey so I thank him for the help, the teachings and the absolute availability during these months of work.

I also thank to my Bosch's supervisors for the availability and for making the beginning of my career so incredible. A big thank you to all my Bosch colleagues and friends for the motivation and easy integration making me feel like home.

A big special acknowledgment to you, my friends and family, for always supporting my work and decisions throughout my journey and making me what I am today. A special thank you to my parents, Francisco Ferreira and Júlia Araújo for the teachings and for making me believe that everything is possible.

Thank you.

ABSTRACT

This dissertation was carried out in the context of the Masters in Industrial Engineering and Management and was developed in the Bosch Production System department in an electronic components company in Braga – Bosch Car Multimedia, S.A. This company, is divided into five business units according to the type of product produced. Each business unit has a *Value Stream Manager* that is aware of the complete value stream and respective *Key Performance Indicators (KPI's)*, contributing for a continuous improvement culture.

The main goal for this dissertation was to reduce the time spent on the project's lead time and hence increase the number of projects concluded and the *Owners'* motivation.

The *System Continuous Improvement Processes (CIP) Approach*, is a systematic approach for pursuing perfection by creating and executing projects focused on the main problems of the company, improving the company's *KPI's*. This systematic approach is divided into three main steps: *System CIP*, *Point CIP* and *Daily Management Meeting (DMM)*. In turn, the *System CIP* is sub-divided into two steps the *System CIP Workshop*, a workshop that occurs two times a year (two revisions), and the *System CIP Projects* where the projects are executed.

In each step different problems were identified such as, the high lead time for the project's conclusion (97 days), the low number of projects concluded in each revision (35%), the lack of training, high amount of time wasted in waiting and the lack of support for the *Owner*. To solve them, management boards were developed, a training cycle was started to guarantee that everyone involved in the systematic had the proper training for it and the standards missing were created and implemented.

With these measures, the systematic was improved, the days needed for the projects conclusion were reduced from 97 to 72, representing a gain of 26%, allowing the inclusion of a new revision per year to create new projects and have the deliverables more rapidly. The percentage of projects concluded per revision increased to 45%, a gain of 10%. It is also expected, the increase of 33% of the company's annual savings by creating a new revision for the systematic CIP where new projects will be created and hence more wastes eliminated.

KEYWORDS

Lean Office, Project Management, *Kaizen*, Visual Management and Standardization

RESUMO

Esta dissertação foi realizada no âmbito do Mestrado Integrado em Engenharia e Gestão Industrial e foi desenvolvida no departamento *Bosch Production System* numa empresa de componentes eletrónicos em Braga – *Bosch Car Multimédia, S.A.* Esta empresa está dividida em cinco unidades de negócio, consoante o produto produzido. Cada unidade de negócio, tem um *Value Stream Manager* que é responsável por toda a cadeia de valor e respetivos *Key Performance Indicators (KPI's)* contribuindo para uma cultura de melhoria contínua.

O principal objetivo desta dissertação foi a redução do tempo necessário para a conclusão dos projetos e, simultaneamente, o aumento do número de projetos concluídos e da motivação dos *Owners*.

System Continuous Improvement Processes (CIP) Approach é uma sistemática para a perseguição da perfeição através da criação e execução de projetos focados nos principais problemas da empresa e consequente melhoria dos *KPI's*. Esta sistemática está dividida em três etapas: *System CIP*, *Point CIP* and *Daily Management Meeting (DMM)*. Por sua vez, o *System CIP* é subdividido em duas etapas, o *System CIP Workshop*, um workshop que acontece duas vezes por ano (duas revisões) e o *System CIP Projects* onde os projetos são executados.

Em cada etapa da sistemática foram identificados vários problemas, como o elevado tempo para a conclusão de projetos (97 dias), o baixo número de projetos concluídos em cada revisão (35%), a falta de formação, elevado tempo desperdiçado em esperas e a falta de uma figura para suportar o *Owner*. Para os resolver, foram desenvolvidos quadros para a gestão dos projetos, foi começado um ciclo de formação para garantir que todos os envolvidos nesta sistemática têm o conhecimento para tal e foram desenvolvidos e postos em prática todos os *standards* em falta.

Através da implementação destas medidas, a sistemática foi melhorada, o número de dias necessários para a conclusão dos projetos foi reduzido para 72, representando um ganho de 26%, permitindo o desenvolvimento de uma nova revisão por ano obtendo os entregáveis mais rapidamente. A percentagem de projetos concluídos aumentou para 45%, um ganho de 10%. É também expectável o aumento de 33% das poupanças anuais da fábrica com mais uma revisão para a sistemática CIP onde surgirão mais projetos de melhoria e consequentemente maior será a eliminação de desperdícios.

PALAVRAS-CHAVE

Lean Office, Gestão de Projetos, *Kaizen*, Gestão Visual e Padronização

TABLE OF CONTENTS

Acknowledgments.....	iii
Abstract.....	v
Resumo.....	vii
Table of Contents	ix
Figure Index	xiii
Table Index.....	xvii
List of Abbreviations and Acronyms.....	xix
1. Introduction	1
1.1 Background.....	1
1.2 Objectives	3
1.3 Research Methodology	3
1.4 Structure of the Dissertation	4
2. Literature Review	7
2.1 Lean Production.....	7
2.1.1 Toyota Production System: The Origin of Lean.....	7
2.1.2 Wastes Types and Symptoms (<i>Muda, Mura and Mur</i>)	10
2.1.3 Principles of Lean Thinking	12
2.2 Lean and Other Tools	13
2.2.1 Kaizen.....	13
2.2.2 Structured problem-solving process.....	14
2.2.3 Standardization.....	16
2.2.4 A3 Problem Solving Approach	17
2.2.5 PDCA	19
2.2.6 5S and Visual Management	20
2.3 Lean Office.....	22
2.3.1 Lean Leadership.....	23
2.3.2 Competence Matrix.....	25

3.	Company presentation	27
3.1	Main Bosch's History Landmarks.....	27
3.2	Bosch in the world	28
3.3	Products	29
3.4	Organizational Structure	30
3.5	Bosch Production System.....	30
3.5.1	BPS principles	31
3.5.2	Continuous Improvement Processes (CIP).....	32
4.	Description and Analysis of the Current Situation	33
4.1	Key Performance Indicators (KPI's) used in Bosch	33
4.2	System CIP Approach.....	34
4.2.1	Parties involved in the System CIP Approach.....	35
4.2.2	System CIP Workshop.....	37
4.2.3	System CIP Projects	41
4.2.4	Point CIP	44
4.2.5	Daily Management Meeting (DMM)	45
4.3	Critical analysis and problem's identification	47
4.3.1	KPI's current values.....	47
4.3.2	Problems identified by the stakeholders	49
4.3.3	Low percentage of projects concluded and high time to conclude the projects.....	49
4.3.4	Deviations from the System CIP Workshops and Bosch standards	50
4.3.5	Many and disorganized folders for System CIP Approach.....	52
4.3.6	Problems identified in the System CIP Projects.....	53
4.3.6.1	Missing requirements, skills and standard work for the VS Manager	53
4.3.6.2	High number of absences in the VS Meeting	54
4.3.6.3	Missing continuous support and motivation	55
4.3.6.4	Lack of training and PDCA cycle is not followed	55
4.3.6.5	Lack of execution of the Point CIP step.....	56
4.3.6.6	Lack of time for improvement.....	56
4.4	Synthesis of the problems identified.....	56

5.	Presentation and implementation of improvement proposals.....	59
5.1	Standard work.....	59
5.1.1	Standard Work for the <i>VS Manager</i>	59
5.1.2	Standard for System CIP Workshop, System CIP Projects and Point CIP	60
5.2	VS Meeting is scheduled separately and KPI's stability defined	63
5.3	SC Meeting standard presentation is utilized	64
5.4	PDCA cycle management and task management	64
5.4.1	PDCA cycle management.....	64
5.4.2	Daily Management Board.....	66
5.4.2.1	The Paper Prototype	67
5.4.2.2	Competency Matrix.....	67
5.4.2.3	The Dot Game.....	69
5.4.2.4	A3 sheet and PDCA Cycle	72
5.4.2.5	Owners' Performance Indicators.....	73
5.4.2.6	Daily Responsibilities' Management	74
5.4.3	Weekly Management Board.....	76
5.4.3.1	Weekly Task Management	79
5.4.3.2	The Race of projects	80
5.4.3.3	Weekly Management Board in the SC meeting	81
5.5	Synthesis of the standards implemented.....	82
6.	Result Analysis and discussion	83
6.1	Stakeholders' satisfaction with the improvements	83
6.1.1	Daily Management Board impact	83
6.1.2	Weekly Management Board impact	85
6.2	Benefits of the standardized process.....	86
6.3	Decrease in the number of neglected projects.....	86
6.4	Shorter Meetings.....	88
6.5	Lead Time Reduction.....	88
6.6	Increase on the percentage of projects concluded	89
6.7	Increase in the Number of Revisions per Year	90

7. Conclusions and future research	93
7.1 Conclusions	93
7.2 Future research	94
References	95
Appendices	97
Appendix I – A3 sheet for the dissertation	99
Appendix II – Current RASIC Matrix	101
Appendix III – Bubble Diagram	103
Appendix IV – Workshop System CIP	105
Appendix V – A3 Sheet	107
Appendix VI – Ishikawa Diagram	109
Appendix VII – Improved RASIC Matrix	111
Appendix VIII – Standard System CIP Workshop	113
Appendix IX – Standard System CIP Projects	115
Appendix X – Standard Point CIP	117
Appendix XI – PDCA Task Management	119
Appendix XII – Flowchart Coach	121
Appendix XIII – PDCA Activities	123
Appendix XIV – Standard Daily Management Board	125
Appendix XV – Standard Weekly Management Board	127
Appendix XVI – Satisfaction Survey for the Daily Management Board	129
Appendix XVII – Satisfaction Survey for the Weekly Management Board	131

FIGURE INDEX

Figure 1 - House of TPS	7
Figure 2 - Pyramid of TPS	8
Figure 3- Innovation, Kaizen and Maintenance Relationship	13
Figure 4 - A3 Sheet Template	18
Figure 5 - A3 sheet and PDCA cycle relation	19
Figure 6 - PDCA cycle.	19
Figure 7 - Bosch's History Landmarks	27
Figure 8 - Bosch's Sectors.	27
Figure 9 – Bosch factories localization: a) Bosch's World Subsidiaries b) regional subsidiaries (Portugal)	28
Figure 10 – Bosch's customers	29
Figure 11 - Bosch Braga Products.....	29
Figure 12 - Organization chart.....	30
Figure 13 – BPS in Bosch.....	30
Figure 14 - Pyramid of BPS.	31
Figure 15 - Principles of BPS.	32
Figure 16 - KPI tree losses.....	33
Figure 17 - Relationship between the steps of the System CIP Approach and the KPI's	34
Figure 18 - Target Condition	35
Figure 19 - Level 2 of the BPS Assessment for the System CIP Approach.....	35
Figure 20 - Parties involved in the System CIP Approach	36
Figure 21 - Example of a CIP Flash	38
Figure 22 - Value Stream: Source, Make and Deliver	39
Figure 23 - a) General Workshop View b) VS Manager mediating the workshop	39
Figure 24 - Project Sheet output from the workshop	40
Figure 25 - PDCA cycle comprised in the A3 sheet	41
Figure 26 - VS Manager board	43
Figure 27 – Project's Sheet	43
Figure 28 - Example of a Project Sheet filled.....	44

Figure 29 - Improvement KPI	48
Figure 30 - Monitoring KPI	48
Figure 31 –Main problems identified by the stakeholders – inquiry results	49
Figure 32 – Percentage of projects concluded in the 2 nd revision of 2016	49
Figure 33 – Average of time to conclude the System CIP Project stage	50
Figure 34 – a) General VS Plant folder b) Standards' folder	53
Figure 35 - Example of a normal environment in the VS Meeting.....	54
Figure 36 - A3 sheet: Description of the current situation.....	57
Figure 37 - A3 sheet: Problems identified	57
Figure 38 - A3 sheet: Future state	59
Figure 39 - System CIP Workshop's guide excerpt	61
Figure 40 – System CIP Projects' guide excerpt	62
Figure 41 - Point CIP's guide excerpt	63
Figure 42 - Folder address for the standards	63
Figure 43 - Calendar from the PDCA task management.....	65
Figure 44 - Automatically filling on the document	65
Figure 45 - One day remaining alert	66
Figure 46 - Task concluded and number of days in arrears.....	66
Figure 47 - Status relation with the due date of the PDCA stage.....	66
Figure 48 – Daily Management Board a) Initial b) Current	67
Figure 49 - Daily management board paper prototype	67
Figure 50 - The four steps of knowledge comprised by the square	68
Figure 51 – a) Final product b) The product being produced.....	69
Figure 52 - Discussion at the end of each round.....	70
Figure 53- Poka-Yoke for the production to avoid defects	71
Figure 54 - A3 sheet and PDCA training a) Owners filling-in the A3 sheet b) Brief explanation	72
Figure 55 - Competency matrix	73
Figure 56 - Personal availability for the project.....	73
Figure 57 - Overdue tasks a) per owner b) per month	74
Figure 58 - Follow-up of the overdue tasks.....	74
Figure 59 - Daily responsibilities management a) Initial b) Current	75
Figure 60 - a) Colors for each phase of the PDCA cycle b) Card necessary data	75

Figure 61 - Project card a) The target condition was attained b) The target condition was not reached	76
Figure 62 - Weekly management board a) First Prototype b) Current.....	76
Figure 63 - Header of the project a) Project sheet b) Project card	77
Figure 64 - Level 3 of the BPS assessment for the System CIP Approach.....	77
Figure 65 - Improvement KPI in the board.....	78
Figure 66 - Section of the weekly management board.....	78
Figure 67 - Standard's card.....	78
Figure 68 - VS Manager board after the weekly management board	79
Figure 69 - Task's cards according to the PDCA cycle.....	80
Figure 70 - Weekly task management.....	80
Figure 71 - Project's race	80
Figure 72 – Car with the project's number	81
Figure 73 - SC meeting before the Weekly Management Board	81
Figure 74 - SC meeting being supported by the board	82
Figure 75 - A3 sheet: standards implemented related with the root causes found.....	82
Figure 76 - Analysis of the Owners' responses for the Daily Management Board.....	84
Figure 77 - Analysis of the Coach's responses for the Daily Management Board.....	84
Figure 78 - Analysis of the Owners' responses for the Weekly Management Board	85
Figure 79 - VS Manager's responses for the Weekly Management Board	86
Figure 80 - Number of projects neglected in the last and current revision.....	87
Figure 81 - Improvement KPI	89
Figure 82 - Number of projects concluded per B.U. in the last and current revision	89
Figure 83 - Monitoring KPI	90
Figure 84 - A3 sheet used for this dissertation.....	99
Figure 85 - Current RASIC Matrix	101
Figure 86 - Bubble Diagram template.....	103
Figure 87 - a) Board 1: Customer Requirements b) Board 2: KPI's c) Board 3: Target Analysis.....	105
Figure 88 - a) Board 4: Inputs from DMM and last revision projects b) Board 5: VSM and Bubble Diagram c) Board 6: BPS Vision.....	105
Figure 89 - a) Board 7: BPS Assessment b) Industry 4.0 c) True North	105
Figure 90 – a) Board 10: Prioritization Matrix b) Board 11: Projects defined for the System CIP Projects	106

Figure 91 - A3 Sheet Bosch's template.....	107
Figure 92 - Ishikawa Diagram for the high lead time for the project conclusion.....	109
Figure 93 - RASIC matrix for the System CIP Workshop	111
Figure 94 - RASIC matrix System CIP Projects.....	111
Figure 95 - RASIC Matrix Point CIP	112
Figure 96 - Standard: System CIP Workshop	113
Figure 97 - Standard System CIP Projects	115
Figure 98 - Standard: Point CIP.....	117
Figure 99 - PDCA task management document	119
Figure 100 - VBA code for inserting the calendar in the document	119
Figure 101 - VBA code for the calendar to show up when start date cell is selected.....	119
Figure 102 - VBA code that returns the date when the task was concluded	120
Figure 103 - Flowchart guide for the Daily Management Board for the Coach.....	121
Figure 104 - PDCA Activities	123
Figure 105 - Exerpt of the standard for the Daily Management Board.....	125
Figure 106 - Excerpt of the standard for the Weekly Management Board.....	127
Figure 107 – Satisfaction Survey: Daily Management Board - Owner.....	129
Figure 108 - Satisfaction Survey: Daily Management Board – Coach.....	130
Figure 109- Satisfaction Survey: Weekly Management Board – Owners.....	131
Figure 110 -Satisfaction Survey: Weekly Management Board - VS Manager	132

TABLE INDEX

Table 1 - Planned duration for the different stages.....	37
Table 2 - Planned duration for each meeting	42
Table 3 - Type of problem and respective tool to solve it	46
Table 4 - Lead Time: Initial Situation	47
Table 5 - Lead Time: Target	47
Table 6 - Analysis of the workshop's duration	52
Table 7 - Requirements for a VS Manager	54
Table 8 - Planned and real duration for each meeting.....	55
Table 9 - Time spent by using the standard's presentation.....	64
Table 10 - Results of the first round	70
Table 11 - Results of the second round	71
Table 12 - Results for the third round	72
Table 13 - Improvement on the neglected projects	87
Table 14 - Improvement on the VS meeting.....	88
Table 15 – Lead time analysis	88

LIST OF ABBREVIATIONS AND ACRONYMS

BPS: Bosch Production System

B.U.: Business Unit

CC: Chassis system and Control

CIP: Continuous Improvement Processes

DI: Drive Information

DMM: Daily Management Meeting

IRR: Internal Rejection Rate

IS: Instrumentation System

KPI: Key Performance Indicator

KPR: Key Performance Results

MS: Manufacturing Service

MTN: MainTeNance department

NOK: Not OK

OEE: Overall Equipment Efficiency

OPL: Open Point List

PDCA: Plan Do Check Act

PS: Professional System

S.A.: Anonymous Society (Sociedade Anónima)

SC: Steering Committee

SMART: Specific, Measurable, Relevant and Time-limited

TPS: Toyota Production System

VS: Value Stream

VSD: Value Stream Design

VSM: Value Stream Mapping

WIP: Work in Process

1. INTRODUCTION

This chapter presents the background and motivation for this dissertation project. Therefore, in this section the objectives are identified, the research methodology is presented and the dissertation structure is depicted.

1.1 Background

Nowadays, the companies are facing a considerable growth in competitiveness and, simultaneously the client's demand has reached a high point. The tendency for these characteristics is incremental. Thus, continuous improvement, that is, the constant chase of perfection, is crucial to be a strong part of the market and to face the competition. For that, the *Lean* strategy and *Kaizen*, the continuous improvement, are used. The waste elimination is the main goal for this process and it is the responsible for searching and implementing new methods, such as, Six Sigma, Plan-Do-Check-Act (PDCA) cycle and Total Quality Management (Kumiega & Van Vliet, 2008).

Nevertheless, Lean Production is a methodology that, involving these methods, improves productivity and reduces costs. According to Womack, Jones and Roos (1990), Lean Production is a superior way for humans to make things. To achieve this, *Lean* uses a set of techniques that, when combined and developed, allow the reduction and elimination of waste (Wilson, 2009). These tools support a different thinking that defines a new way of producing, the *Lean Thinking* (Womack et al., 1996).

Lean Production had its roots in manufacturing, specifically, in the Toyota Production System (Ohno, 1988) but since then evolved to a philosophy called *Lean Thinking* (Womack & Jones, 2010). *Lean Thinking* has five principles: 1) Value; 2) Value Stream; 3) Flow; 4) Pull production and 5) Pursuit perfection. Nowadays these principles are applied in all areas and sectors (Alves, Kahlen, Flumerfelt & Manalang, 2014) and its application is equally advantageous to the application to the traditional *gemba*¹. One such application is in services, offices and indirect areas of companies and is known as Lean Office, that is, the *Lean Thinking* principles applied to administrative environments. Case studies of this application are, for example, Monteiro, Pacheco, Dinis-Carvalho and Paiva (2015) and Chen and Cox (2012).

¹ *Gemba*. Japanese word that translates the place where the work happens in manufacturing, "the real place"

Project management departments are one of such indirect areas. According to Munns and Bjeirmi (1996), the functions of project management include 1) The definition of the required work; 2) Work extension establishment; 3) Requirement of resources allocation; 4) Work execution planning; 5) Work progress monitoring and 6) Adjustments to plan deviations. Leadership, especially in project management, is crucial. A leader is someone whose followers are willing to follow his orders just because he is ordering. The inherent characteristics of a good leader are his competence, character, position and personality. The choice of a leader has to be pondered and based on the individual as a whole (Wilson, 2009).

The project success is dependent on the elaboration of a realistic and well-defined goal, on the competition, client's satisfaction, profitability, availability of the market, implementation process used and on the value of the project to the company. On the other hand, an inadequate management base to the project, lack of administration support, not well-defined tasks, lack of techniques for project management and their wrong utilization, and the lack of engagement with the project can lead to the project failure (Munns & Bjeirmi, 1996).

All this management process involves a lead time, that is, the total of time that a client waits to have an output of the process (Mehta, 2015). A company with low lead times is more reactive and flexible (Wilson, 2009) thus it is of high importance its reduction. Another *Lean* basis is the standardization, that is, the creation of a guideline for a certain activity where the steps are well-defined. If the standard is respected, it is possible to predict resources, tools and security precautions needed and what and when the output of the process is going to happen (Mehta, 2015).

The business environment is characterized by uncertainty and the future prediction is defying, so it is necessary the constant acquisition of new competences, mainly on project management, where the pursue of knowledge is one of the critical factors for success (Suikki, Tromstedt & Haapasalo, 2006). The development of an organization focused on the apprenticeship is fundamental, an organization that is gifted with creating, acquiring and knowledge transferring, and willing to change their behavior to reflect the learning (Kotnour, 2000).

This kind of environment is characteristic of the company where this project was developed that is an electronic components company, Bosch Car Multimedia, S.A. In this company, it was created a well-defined structure to improve the existing value streams constituted by three levels of Continuous Improvement Processes (CIP): *System CIP*, *Point CIP* and *Daily Management Meeting*. *System CIP* is subdivided into two steps, *System CIP Workshop* and *System CIP Projects*.

Nevertheless, a lot of problems were identified in this process, namely, the lack of standardization, high lead times to conclude the projects, the number of projects concluded and the failure to achieve a suitable style of leadership, among others, originating the need for improvement. Under the *Lean Thinking* philosophy, a project development environment is also suitable to apply *Lean Office*, as lots of processes are necessary and always in progress (Cusumano & Nobeoka, 1998).

1.2 Objectives

The dissertation had its focus on the improvement of the processes performed in projects' execution by using *Lean* tools, allowing the elimination of the existing wastes. In order to accomplish this goal, the research project was based on:

- The reduction of the time needed to conclude the projects;
- The standardization of the project's management practices;
- The increase of the number of projects concluded.

For this section (section 1.2) a SMART (Specific, Measurable, Achievable, Relevant, Time-limited) objective was defined. So, the SMART objective of this dissertation is to reduce the lead time of a project inserted on the *System CIP Approach* from 97 days to 60 days or less and increase the number of projects concluded from 35% to 45% or more and hence move from the level 2 of the BPS (Bosch Production System) assessment to the level 3 in one year.

1.3 Research Methodology

The problem was identified and solved by participating on the activities having in consideration the theoretical lore behind it, which is to say, that the researcher worked under the "learning by doing" process, named Action-Research (O'Brien, 2002). This research methodology was introduced by Kurt Lewin in 1946 and one of the many definitions defends that the research follows five steps 1) diagnosing; 2) action planning; 3) action taking; 4) evaluating and 5) specifying learning (Susman & Evered, 1978). This line of thinking was followed in this dissertation project. The different phases aimed to be accomplished are enumerated below:

1. Literature review: The starting point of the dissertation was an exhaustive research about the topic. The use of filters such as keywords, year of publication and type of documents guided the search process. After a filtration, the first documents were analyzed and a literature review was made.

- 2. Study and analysis of the current situation:** After an exhaustive study of the topic, a diagnosis was developed about the current situation of the company, naming the main problems found. For this to be achieved, appropriate tools were used in order to find the root-cause for each problem, namely, cause-effect diagrams, five Whys, and checklist usage for the expected points for each project process.
- 3. Definition of improvement measures:** After the problems found and described, a planning of the improvement took place. In this step, the creativity to find new and refreshing ideas for improvement of the current situation was required. Quality tools were used to give consistency to the developed ideas.
- 4. Implementation of the new measures:** The next stage involved the implementation of the developed ideas. To attain this, *Lean* tools and workshops with the intent of passing knowledge to the workers took place.
- 5. Analysis and discussion of the results:** Implemented improvements were analyzed using a comparison between the situation before and after the proposals implementation. The results were monitored to assure the success of the process.
- 6. Learning specification:** After the project's consolidation, a critical analysis for the future occurred, with an approach using *Lean* and continuous improvement philosophies.

1.4 Structure of the Dissertation

This dissertation is divided in seven different chapters. The first is where this sub-chapter is inserted, the introduction of the dissertation, that is, where the background is described, the objectives identified and the research methodology used depicted.

The second chapter presents a literature review of the main topics addressed in this dissertation, serving as a theoretical background, where the main *Lean* concepts and its tools that support the methodology, i.e., the waste elimination, are explained.

The company where this dissertation was developed is presented in the third chapter. The main history landmarks for it are identified and the company's journey around the world acknowledged. After that the level of detail starts to increase, deepening to the department in which the dissertation was inserted.

In chapter four the current situation is analyzed and the problems identified, the data gathered is considered and the *System CIP Approach*, a systematic inserted on the continuous improvement process, is explained. After this analysis, a critical one took place in order to identify the existent problems. This analysis was based on the participants' opinion and on the personal involvement in the systematic.

To solve the identified problems, the improvement measures are described in chapter five. In chapter six, the results obtained with the implemented measures are quantified and analyzed. Lastly, chapter seven presents the conclusions of the research and the proposals for future work.

For this dissertation, the A3 sheet tool was used (see Appendix I – A3 sheet for the dissertation) and its different sections are inserted in different chapters through this document.

2. LITERATURE REVIEW

In this section, a literature review was made about the key points of *Lean Production*, *Lean Office* and its tools. These were the most relevant topics for this dissertation development.

2.1 Lean Production

This section presents a briefly introduction to Toyota Production System (TPS) as *Lean* had its roots in this system. Also, waste types and symptoms are presented. Next, *Lean Thinking* principles are described.

2.1.1 Toyota Production System: The Origin of Lean

Toyoda Automatic Loom Works, the basis of the current Toyota Motor Corporation, was founded by Kiichiro Toyoda in 1926. In 1950, after World War II, Japan had recently suffered an attack of two atomic bombs. The country and, hence, the industry, was devastated with the majority of the plants destroyed and consumers had no money to spend, an appalling situation for the country. Under these conditions, Taiichi Ohno, the Toyota's plant manager, based on the Henry Ford's lessons, developed the Toyota Production System, TPS, and, ultimately Lean Production (Womack et al., 1996). To represent all the developed methods in a structured way, Fujio Cho, an Ohno's disciple, summarized them into a house diagram, Figure 1.



Figure 1 - House of TPS (Liker & Morgan, 2006)

The top of the house represents the main goals of the TPS, best quality at a lowest cost with short lead times but never disregarding safety and morale. To attain this, the foundation of the house that gives the

stability needed for the pillars construction, are the stable and standardized processes and the leveled production, *heijunka*. *Heijunka* is the production's levelling, to make the same amount and mix of products everyday (Liker, 2004). Once this is ensured the standard and stability opportunities occur, this processes guarantee the house's overall stability (Liker & Morgan, 2006).

The house's pillars are, primarily, the *just-in-time* production and, secondly, the *jidoka*. *Just-in-time*, JIT, it's a principle for getting the right part to the right place at a right time, creating a rapid and efficient flow without inventory. *Jidoka*, also referred to as *autonomation*, "a machine with human intelligence", where the intelligence is applied to stop the process when a defect occurs, making it impossible to go through the production (Liker & Morgan, 2006). TPS is focused not only on technical parts but also on getting everyone involved in the continuous improvement process (Liker, 2004). The heart of the house is converged in continuous improvement, *kaizen*, to get every part of the process engaged in it (Liker & Morgan, 2006).

"The insight that Toyota applies underlining principles rather than specific tools and processes explains why the company continues to outperform its competitors" (Spear, 2004). According to Liker (2004) there are four general categories organized in a pyramid, Figure 2, for the 14 existent principles of TPS.

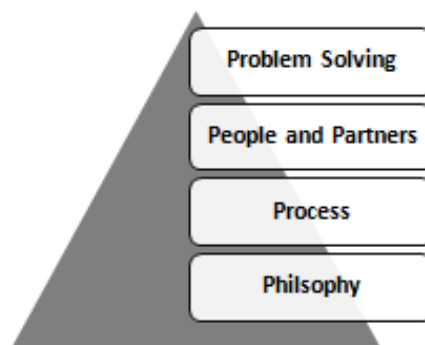


Figure 2 - Pyramid of TPS (Liker, 2004)

The *Philosophy* is the support of the TPS structure. This slice comprises the first principle:

- **1st principle:** there is the need for a long-term philosophy that surpasses any short-term decision to align the whole organization to a common purpose.

"The right process will produce the right results" (Liker, 2004). Many companies, misguidedly follow only the broad category that is *Process* and think that alone it translates "lean thinking" but to achieve the state of a complete lean company all layers have to be respected (Liker, 2004). This second layer of the 4P's Toyota pyramid comprises 7 principles, these are:

- **2nd principle:** stresses the importance of a continuous process flow to make problems easily visible;
- **3rd principle:** works when the customer's order is the trigger for the start of the production, where it is given to the client what he wants in the quantity he needs and when he wants it and this will result in a decrease in stock and work in process;
- **4th principle:** enhances the *heijunka*, that is, the leveling of the production, which supports the third principle. The client's demand is not predictable, Toyota has found that the leanest operations are not always made to order but by leveling the production schedule;
- **5th principle:** is focused in *Jidoka*, this enhances the need to stop the process to fix the problems and consequently have the quality demanded at the first time; this will have thus the overproduction prevention and the problems control (Sugimori, Kusunoki, Cho, & Uchikawa, 1977);
- **6th principle:** it is stressed the basis of the continuous improvement culture, the standard. A standardized process is the key for a continuous flow and a pull system which facilitates the prediction of the process allowing a regular output and timing and simultaneously increases the flexibility in the team, because the work that is required can be taught easily;
- **7th principle:** addresses the importance of the visual control usage, when a system uses visual control that allows them to check if the standard is being fulfilled and the problems come to the surface which makes it easier to correct them;
- **8th principle:** enhances the importance of the technology and when to use it. The technology should be an assistance to the worker and not a replacement; the usage of technology must be encouraged, but always pondered because new technology is always untrustworthy and to standardize it is a challenge.

Workers play an important role in Toyota, thus a system of respect for humans was developed (Sugimori et al., 1977). The third layer of the pyramid is the *People and Partners*. This layer comprises three principles:

- **9th principle:** enhances the need of creating a leader that clearly understands the work, lives the philosophy and is able to teach it to others;
- **10th principle:** It is believed that a true Toyota leader has to live and meticulously understand the Toyota culture which leads to a “non-shopping” leaders from outside culture, a leader is grown from within and has to be a role model respecting the company's culture. This principle

stresses the importance of creating extraordinary people whom comprehend and follow the company's culture;

- **11th principle:** is underlined the need of challenging the outside partners aiming to make them grow and develop always with respect throughout the process.

The top layer of the pyramid is the *Problem Solving*, which covers the continuous improvement and learning process through it. The last three principles are inserted on this layer:

- **12th principle:** undertakes the practical way of solving problems, that is, the “go to the *gemba* and see” to accurately understand the problem situation, *genchi genbutsu*²;
- **13th principle:** a decision has always to be made slowly and having on consideration the possible options and from the moment the decision is made this has to be implemented the fastest way possible using the *nemawashi*, that is, the process of discussing the problem and possible solutions with all the involved in it;
- **14th principle:** translates the aim to become a learning organization per the usage of continuous improvement to find the root causes to apply effective actions, to eliminate inventory that hides the existent waste, to protect organizational knowledge by making usage of *hensei*, that is reflection throughout the process and create countermeasures to ensure that the problems don't happen again and focus the learning process by standardizing the best measures created. The errors are seen as opportunities to learn and evolve, the company's culture is based on the learning with the mistakes by empowering people to apply the actions that are thought to best fit the problem following a *kaizen* culture.

These fourteen principles work as guidelines to become a real lean culture. In this dissertation, the current situation will be compared with each one of them to find the proper counter-measures to correct the root causes behind the barriers to achieve a culture fully lean.

2.1.2 Wastes Types and Symptoms (*Muda, Mura and Muri*)

Firstly, for a systematic waste elimination, the companies should put effort to understand what is valuable for the client (Flinchbaugh, 2005). After identifying what are the value-adding activities, the remaining activities can be reduced or eliminated.

² *Genchi Genbutsu*: Japanese word that means “go and see for yourself”, this involves going to the shop-floor and analyze the production processes (Hindle, 2009)

Secondly, to achieve a philosophy of systematic waste elimination is necessary to persistently pursue it, that is, developing a passion for eliminating waste (Flinchbaugh, 2005). Most of the companies ignore the importance of *mura* and *muri* (Rose et al., 2008) so in some references these are mentioned to as the forgotten M's (Pereira, 2008).

Muri means overburdening people or equipment and outcomes in safety and quality problems. Sometimes *muda*³ leads to *muri* because what is consistent occasionally causes an overburden of all the involved (Rose et al., 2008). *Mura*, inconsistency, is the result from an irregular production schedule due to internal problems. "*Muda* will be a result of *mura*" (Liker, 2004). *Muda*, meaning waste, are the activities that don't add value to the client's order (Rose et al., 2008). Shingeo Shingo identified seven types of *muda* (Rose et al., 2008):

- **Overproduction:** Ohno considered this as the main waste because is the trigger for the other existent wastes (Liker, 2004). The overproduction happens when it is produced more quantity or earlier than is needed, leading to the production of items that weren't ordered (Hines, Riccardo, & Bartolini, 2002). Some of the aftereffects of this overproduction are the anticipation of the purchases of raw materials to produce which leads to an increase of stock which hides the problems through the production processes, resulting in a non-flexible planning, since the warehouses are full of materials that aren't needed, leaving no space for what the client really wants (Amaro & Pinto, 2007);
- **Defects:** these are identified errors in the production. These defects lead to rework, production replacement, scrap and inspection (Liker, 2004) which brings an increase in stock to compensate the defective products reducing the productivity and increasing the cost of the products and services (Amaro & Pinto, 2007)
- **Unnecessary inventory:** high levels of stock, that is, excessive storage, causes longer lead times and higher cost, because of the extra time and money that is needed to transport, production and storage of the extra quantity (Liker, 2004). Other issue is the coverage of the problems with stock such as feeble machines layout, high setup times, the existence of bottlenecks and quality problems (Amaro & Pinto, 2007);
- **Over processing or inappropriate processing:** select useless steps to process the parts, wrong tools instigate unnecessary movements and defects whereas often a simpler tool would be more effective (Amaro & Pinto, 2007);

³ *Muda*: Japanese word meaning waste (Liker, 2004)

- **Excessive transportation:** transportation includes any type of material being transported. The transportation systems occupy the company's space, increase the production time and sometimes the product is damaged while being transported. It cannot be expected an elimination of the total time spent in transportation; one way to see it can be the reduction of the distance between processes and the creation of flow between them (Amaro & Pinto, 2007).
- **Waiting:** it refers to the time wasted by people, machines or product on waiting. This is an unproductive time that increases the lead time of the whole process (Amaro & Pinto, 2007).
- **Unnecessary motion:** all the unnecessary movements performed by the employees during the sequence of their work, or the movements that are too slow, too fast or excessive (Amaro & Pinto, 2007).

Liker (2004) identified an extra *muda*, the unused employee creativity. This waste meets the *People and Partners* layer of the pyramid and stresses the loss of the human potential, ideas, skills, improvement and learning opportunities by not engaging on listening to the employees. The eight wastes are mainly comprised on a manufacturing perspective but these can be allocated to the indirect areas as well. Lean is the watchword to fight these wastes.

2.1.3 Principles of Lean Thinking

The Lean Production was made renowned by Womack et al. (Van Amelsvoort, P., & Benders, 1996) and had its roots in TPS (Ohno, 1988) but since then it evolved to a philosophy called Lean Thinking.

Lean can be seen from two different perspectives, practical and philosophical (Boyle, Scherrer-Rathje & Stuart, 2011). From a practical perspective, *Lean* involves the usage of tools and techniques, such as, 5 Why's, Six Sigma and *Kaizen*, to reduce and then eliminate the waste (Wilson, 2009). From a philosophical perspective, these practices are interrelated to eliminate waste in functional areas, improve the integration and quality (Boyle, Scherrer-Rathje & Stuart, 2011).

This philosophical perspective is called Lean Thinking (Womack & Jones, 2010). Lean Thinking is based on five steps: 1) Value: the first step is to specify what is the value for the client; 2) Value Stream: secondly, the lean company must identify the value stream, i.e., the processes that a product needs to go through; 3) Flow: after eliminating the identified *muda*, the remaining steps must create flow. A complex task insofar as the human being is formatted to think in "departments" and "functions" and not with an holistic view; 4) Pull: the client's order will trigger the whole process which makes the company produce only what is needed, the demand's prediction will be facilitated because of the throughput time reduction

when the flux is created and 5) Pursuit of Perfection: the last step is the constant search of perfection; people should have the ability to continually improve (Womack et al., 1996).

2.2 Lean and Other Tools

This section presents some *Lean* tools and other tools used in the *Lean* context such as PDCA (Plan-Do-Check-Act) and SDCA (Standard-Do-Check-Act).

2.2.1 Kaizen

Kaizen, a Japanese word translated as continuous improvement was first introduced by Imai in 1986 and it was described as an “ongoing improvement involving everyone - top management and workers - and entails relatively little expense” (Imai, 2005). Kaizen is all about small incremental changes that bring major improvements to the process, which makes companies always look out of their comfort zone (Imai, 2005). , The comparison between innovation, maintenance and *kaizen* is represented in Figure 3, where the different classes of a company's contributors can be seen.

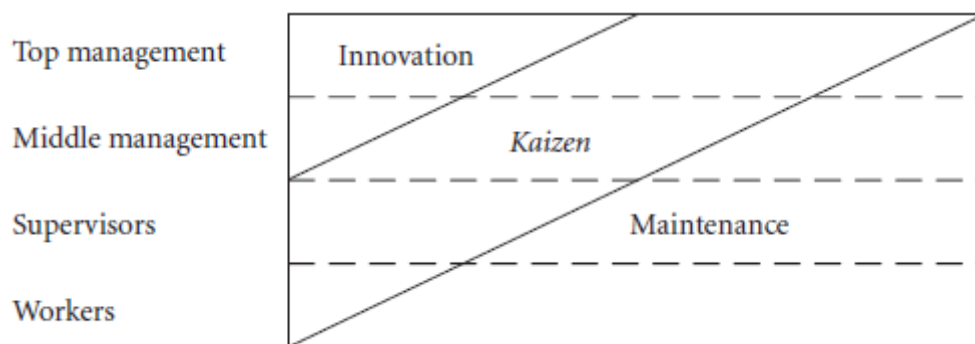


Figure 3- Innovation, Kaizen and Maintenance Relationship (Imai, 2005)

Management, in general, is divided into *maintenance* that infers the monitoring of the current standards and *improvement* that is an act to amend the current situation and hence improve the current standards (Shingeo Shingo, 2007). This *improvement*, in turn, can be classified as *innovation* or *kaizen*. The first, innovation, includes a radical improvement with a massive investment in resources that involves top and middle management whereas *kaizen* implies small and inexpensive improvements as a result of enduring efforts and covers all layers of contributors (Imai, 2005).

The secret for a great longevity of a company is to develop the capacity to adapt, develop continual and incremental improvements and maintain them to satisfy the client's demand (Rother, 2010). This little and incremental improvements allow a learning process to make adjustments to the system and discover the best way to achieve the main goal that is desired (Rother, 2010).

On a competitive point of view, when you achieve the cost and quality goal with the sum of incremental changes, which are difficult to copy, leads to a competitive advantage (Rother, 2010). Despite of this clear gain with developing incremental changes, it's thought that the usage of cutting-edge technology is an easy way to win over our competitor but this is deceiving since this frequently gives a temporary competitive advantage and not a prolonged one (Rother, 2010).

Improvement shouldn't be a periodic situation (Rother, 2010). The impressive statistics that corroborate the outstanding performance of Toyota are due to the continuous improvement where the productive processes are enhanced daily (Rother, 2010). Although there are clear advantages in follow a *kaizen* culture, it can only occur when a process is stable and standardized, since the problems are only visible when these are attained and there is a constant opportunity to learn with the improvements (Liker, 2004).

Improvement is only possible when the current situation is fully understood and for this it is necessary to (1) find the problem, (2) clarify it and (3) find the cause. These are steps named as essential for problem solving by Shingo (2007). Although the Shingo's book was only published in 2007, it was written in 1958, and since then the problem solving evolved to a more structured and detailed guideline.

2.2.2 Structured problem-solving process

Toyota's philosophy defends that the financial results that the company wants to attain will be achieved if the focus is on the process itself and on the continuous improvement (Liker, 2004). This improvement can only occur when a "process is stable and standardized" for that the problem solving is required (Liker, 2004). Mann (2005) identified three categories for improvement:

- **Solve an immediate problem:** this task has a duration from one to five days and can be fixed using daily task assignment boards;
- **More complex problem-solving, where the root cause analysis, solutions and recommendations are hard to find:** here a visual project plan updated weekly with a duration from 6 to 30 days is needed; the A3 sheet, section 2.2.4, can be used;
- **Long-term and complex problems:** like the more complex problem-solving, the management will be made by using a visual project plan but the duration is extended from 30 to 90 days.

According to Mann (2005) the difference between a batch-and-queue system and a lean environment is the response towards the problem. In the first, the solution is to work around the problem whereas in a lean environment the problem is not hidden in creative or unconventional solutions. Instead the problem is confronted and the reason behind it is studied. For that, a structured problem-solving process is

necessary. The kaizen story, best known in Japan as QC story, is when the kaizen activities made by a small-group of the company's staff and managers are recorded in a standardized way (Imai, 2005) and follows the Plan-Do-Check-Act cycle, described in section 2.2.5. The standardized eight-steps of this system are:

- **Step 1: Select the theme.** Here the theme is the motif of the project and may have different justifications for it, to achieve the business requirements or depend on different factors of the current circumstances;
- **Step 2: Understand the current situation and define objectives.** One way to understand the current state is to gather the data and the other way is to follow the five *gemba* principles, called the “five golden rules” which are (Imai, 2005):
 1. When there is a problem, go to the *gemba*. The managers must swap the traditional conference room for the *gemba* to fully understand the problem and hence solve the problems;
 2. Check the *gembutsu*⁴ the actual material and problems (Liker, 2004). In *gemba* analyze the *gembutsu* and recur to the simple 5Why's tool to find the root cause;
 3. Take temporary countermeasures on the spot. On the *gemba-gembutsu* find ways to fix the problem temporarily while the situation is analyzed. This type of countermeasures are named short-term due to the abidance of the countermeasure; it is compared to a “band aid” that will fix the situation temporarily until a long-term one is implemented (Liker & Meier, 2006);
 4. Find the root cause. Around 90 percent of the problems can be solved right on the spot if the managers insist that it must be solved right away;
 5. To avoid recurrence of the problem, standardize the new procedure. At this stage the SDCA cycle must be involved;
- **Step 3: Analyze the collected data to identify the root causes.** As mentioned on the Step 2, one way to understand the data is to collect it and on this step the data is analyzed;
- **Step 4: Define countermeasures according to the data analysis.** After the understanding of the problem define countermeasures to act against it. These countermeasures are named long-term and the aim is to eliminate permanently the root causes. Toyota defines the time to implement

⁴ *Gembutsu*; Japanese term that means the real product. This represents a mindset where before solving a problem is necessary to go as nearest to it as possible (Liker, 2004)

the actions as 8 days, but when this time is extended, the task should be divided into smaller incremental changes that can be checked in an easier manner and more frequently (Liker & Meier, 2006);

- **Step 5: Implement the countermeasures.** The defined countermeasures are implemented as fast as possible;
- **Step 6: Investigate the impact of the countermeasures.** After the implementation its impact has to be measured;
- **Step 7: Reconsider the standard to prevent recurrences.** If the countermeasure had the expected impact, it will become a standard to avoid recurrences;

Step 8: Review the proceeding processes and work on the next steps. The *kaizen* story creates a guideline to solve the problems based on the data gathering and analysis. From the *kaizen* story, other approaches were developed for problem solving such as *kobetsu kaizen*, mostly used on Total Productive Maintenance (TPM), A3 problem-solving approach explained in section 2.2.4 (Imai, 2005).

2.2.3 Standardization

Imai (1986) stated that it is impossible to improve a process if it is not standardized. Considered the first stage of the continuous improvement, standardization, is the key for improvement (Liker & Meier, 2006). Being the support of the TPS house and one of the three main *kaizen* activities – 5S, described in section 2.2.6, standardization and *muda* elimination – standard work is seen as a translating tool where technological and engineering requirements are translated to the workers. They are considered the most important part of the standardization process because only when they fully understand the process they can contribute for its improvement (Imai, 2005).

To improve a process, it is crucial to standardize it. For example, if someone creatively applies changes to work whether they had any impact or not, the process only improves when this specific person is doing it. From the moment the standardization begins, the platform for improvement is created empowering teams to continuously improve the process and to become a learning organization, that is, an organization that learns with errors and transfers the knowledge (Liker & Meier, 2006; Liker, 2004).

Standardization is a way to avoid recurrences and maintain the improvement (Imai, 2005). For creating standardized processes, it is necessary to define, clarify by making it visible and use methods to achieve the best possible results. This is translated in an ongoing process of identifying problems, developing the best methods, stabilize them and define the way to use them (Liker, Jeffrey K. Meier, 2006).

The standardization has many advantages for the products and processes, such as quality and cost related advantages. In addition, it was noticed that when a product is standard, the claims and conflicts decrease, hence unplanned costs are diminished (Shook, 2008). The traditional manufacturing standardization process is focused on the cost, that is, to reduce to the maximum the cost per unit and create standards considering individual efforts. Although Toyota seeks the same aim of cost reduction, the main goal is the *muda* elimination (Liker, & Meier, 2006).

While there are many advantages of standardization, companies find it challenging to implement it. There are different myths stressed by Liker and Meier (2006), that represent barriers for companies to adopt correctly this culture of improvement. When applying standardized work, companies have the misleading thought that the documents where the work steps are defined translate the complete work made by the employee, which makes everyone able to learn how to do the work just by looking at the documents, but this can be unfavorable for both, the employee and the organization, because it seems the employees' competency is undervalued by the organization (Liker & Meier, 2006).

Furthermore, the standardized work sheet is a document to describe the most effective process after the waste elimination. It is considered a tool with the aim to identify waste and eliminate it, illusory details and standards often are used by companies to achieve their unrealistic goal. Workers' empowerment is sometimes confused with letting the workers define their own standard work, which makes the management reticent and worried that the worker will fail and will take advantage of this opportunity to reduce his amount of work.

This is far from the truth because the standardized work is developed by engineers after the process of waste elimination and must be followed by employees. There is a big difference between theoretical and practical standardized work; it is not enough to have the documents it is necessary to guarantee that the standard is followed. For that, it is required that others are visually attentive to assure that the standard is being followed (Liker & Meier, 2006).

Despite of its challenges, standardization is mandatory for a company to be fully *lean*.

2.2.4 A3 Problem Solving Approach

The A3 problem-solving approach was created by Toyota and the A3 is the size of the paper where the problem-solving steps are described (Imai, 2005). This sheet concisely describes the problem, determines the root causes, suggests the alternative and recommended solutions and has a cost-benefit

analysis. This sheet must be read from the top left corner and then move to the top right column (Liker, 2004).

The A3 report on the Toyota Kata book is divided into six sections (Rother, 2010). Every section is build based on the previous one (Rother, 2010). The first section is the theme and business case, the background of the sheet the reason for why it is needed. When the theme is well-defined the easier it is to describe the current situation. The current situation is described based on the “go and see” philosophy and the better it is described the more accurate will the target situation description be and so on (Rother, 2010).

There is no right template for an A3, the common logic must be followed but the format and wording are flexible and can be adapt to the situation (Shook, 2008). The A3 sheet below, Figure 4 , shows the common logic but is only one example of how to format the A3 sheet.

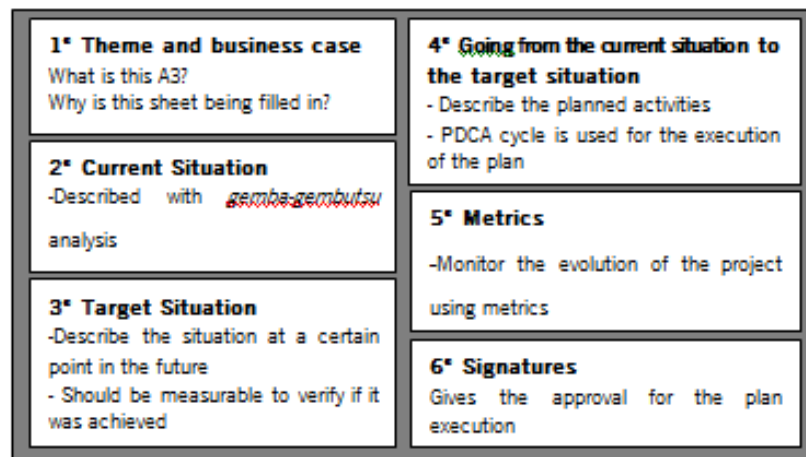


Figure 4 - A3 Sheet Template (Rother, 2010)

One advantage of this type of logical process is the meetings management. Using only a sheet to explain the problem-solving steps allows to efficiently run a meeting (Liker, 2004).

There is a close relation between the A3 sheet and the *PDCA* cycle (Imai, 2005). The A3 sheet is a logical story of the problem solving where the deliverables of each stage of the *PDCA* cycle are described (Imai, 2005). On the image below, Figure 5 , it can be seen an example of how an A3 sheet template is related to the *PDCA* cycle.

Each phase of the *PDCA* cycle requires deliverables to solve the problem (Imai, 2005). The *Plan* phase entails the clarification of the current situation, target definition, root cause analysis and countermeasures definition (Imai, 2005). In the A3 sheet these will normally be represented on the left side of the sheet, as represented in Figure 5. After the countermeasures defined it's time to implement them (Imai, 2005), *Do* phase, this is represented on the top right corner of the sheet. *Check*, that is, evaluate the impact of

the actions on the problem solving and analyze the results and process (Imai, 2005). The final stage, *Act*, involves the standardization and transferring of the practices (Imai, 2005). The *Check* and *Act* are represented on the lower right corner of the sheet.

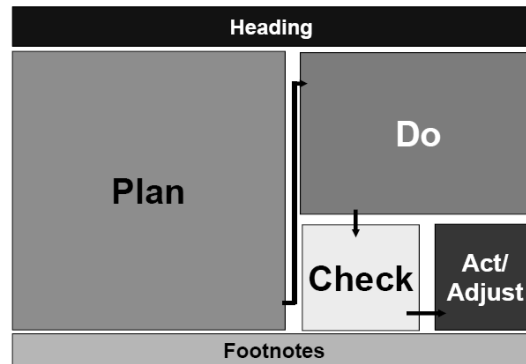


Figure 5 - A3 sheet and PDCA cycle relation (LaHote, 2005)

2.2.5 PDCA

Plan-Do-Check-Act cycle also known as Deming cycle or Shewhart cycle was developed firstly by Shewhart in 1939 (Rother, 2010). When the way to achieve the solution for the problem is hidden in darkness it is necessary the *Plan-Do-Check-Act* cycle, Figure 6, to light it up and find the solution (Rother, 2010). The *PDCA* cycle execution is a scientific process to acquire knowledge, it's a practical way to attain the target condition and to achieve continuous improvement (Rother, 2010).

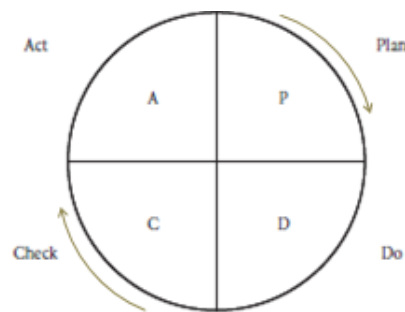


Figure 6 - PDCA cycle.
Adapted from (Imai, 2005)

The first stage of the cycle is the *Plan*. On this stage the target condition to be achieved, an hypothesis and prediction of what is going to be done and what is going to be attained are defined (Rother, 2010). After the target definition is necessary to define actions to achieve the pre-established target condition (Imai, 2005). The plan needs to be clear and aligned with everyone involved (Liker & Meier, 2006). This stage is finalized with defined actions to attain the target condition. Succeeding, on the *Do* stage these actions are implemented. It is common, in the middle of the implementation, to find opportunities for improvement. This improvement is always welcome but the actions' impact has to be measured on the

next step (Liker & Meier, 2006). The next step of the cycle is *Check*. At this point the actions will be kept on track and the real improvement will be compared with the planned to check if the impact of the implemented actions was sufficient to attain the target condition (Imai, 2005). If the actions had the expected impact, in the *Act* segment the procedures will be standardized to prevent recurrences and always, with a kaizen culture in mind, new targets for improvement will be set and the *PDCA* cycle will be reset (Imai, 2005; Rother, 2010).

PDCA means never being satisfied with the current situation (Imai, 2005). The responsible for setting challenging targets to cultivate the *PDCA* continuous improvement on the workers is the company's management (Imai, 2005). In Toyota, the management has the principle of being gentle with the workers and hard on the process, but this attitude cannot be confused with a “pat on the back” by the management to the worker but as a coach motivating the workers to achieve the goals (Rother, 2010).

Following the *PDCA* cycle is not an easy task mostly because demands consistency and discipline, the “fire-fighting” on a company, that is only following the first two steps of the *PDCA* cycle Plan-Execute, has to stop. On the “fire-fighting” environment the workers have the tendency to neglect the importance of checking what happens and why (Suzaki, 1993). Although the *PDCA* cycle should be followed individually, when it is followed as a group its strength is massive.

Suzaki (1993) compares it to a “heartbeat”. When the “heartbeat” is strong and stable, it is possible to move faster and without complications. It can take a while to achieve this state but with work and training this can be accomplished throughout the company and when there are cooperation and dedication of everyone involved, this can lead to a common “heartbeat” for the organization (Suzaki, 1993).

2.2.6 5S and Visual Management

The 5S concept, also known as housekeeping, translates the caring towards the company to best sell the product. The five S's according to Imai (2005) are:

- *Seiri* (Sort): the necessary and unnecessary materials are separated and the needless are removed;
- *Seiton* (Straighten): the necessary material is organized to facilitate the access to it;
- *Seiso* (Scrub/Shine): clean everything, machines and material and eliminate the dirt source. This will prevent the equipment and cables damage because of the dirt.
- *Seiketsu* (Systematize): according to Imai (2005) the *seiketsu* step is the next step and means the continually work on the *seiri*, *seiton* and *seiso*. Without a systematic, it's easy for the

improvements to go back to the initial situation. On the other hand, Ortiz (2006) identified this as the last step, where weekly 5S audits and follow-up for the 5S improvements are created, resulting in a healthy competition between the employees and on a lifting up of the morale.

- *Shitzuke* (Standardize): for Imai (2005), this is the last step of the 5S program and means self-discipline, i.e., making the previous three steps a part of their daily routine and only in this step it is required the 5S performance evaluation. Contrariwise, Ortiz (2006) identified this step after *seiso*, and means to make the program consistent by using identification and colors.

5S and visual management are close related because both contribute for making the problems visible, facilitating the continuous improvement, and thus the *kaizen* culture.

Dombrowski and Zahn (2010) point out visual management as a field of activities for *lean*. It's a means of communication that with the usage of simple visual tools, such as, *andons*⁵, space borders and information boards with performance indicators, makes the current situation and information simpler and easier for everyone to understand (Parry & Turner, 2006; Shingo, 1989). Visual management allows the comparison between what was expected and what is occurring. This comparison allows the identification of where the improvement is needed (Mann, 2005).

One tool used for visual management is the information board. There is an old battle against these boards because they are seen as old-fashion compared to existent high-tech options, but there are many advantages such as physical management.

Visual management makes all problems visible allowing its fast resolution. Frequently to solve a problem it has to go up many managerial layers to achieve the desirable top management. On the way, the detailed information gets lost, which makes the problem solving time-consuming and unreliable. Whereas with visual management a walk through the *gemba* is enough to see and understand the problems (Imai, 2005). Pinto (2008) refers some requisites for a visual management system such as, show how the work should be executed, the status of the process must be visible, alert when someone needs support, indicate the stock control level and support the error-proof activities.

According to Hall (1987) the aims of visual management are to:

- Make the information accessible and simpler to everyone, hence the work of the employees is facilitated;

⁵ *Andon*: Japanese word for a visual production-control device that gives real time information about the production status and gives an alert if there is an imminent problem

- Increase the number of employees involved by getting the information shared with the largest possible number of workers;
- Promote team spirit since everyone has the same access to the information;
- Increase the employees' autonomy;
- Grow the culture of information sharing inside the organization.

These goals will bring many secondary benefits such as efficient meetings management, throughput time reduction and increase the employees' motivation (McKellen, 2005).

2.3 Lean Office

Lean can be applied to indirect areas and the benefits are proven to be equally advantageous as Lean applied to the manufacturing environment (Monteiro, M. F., Pacheco, C. C., Dinis-Carvalho, J., & Paiva, 2015). On the majority of the companies the administrative tasks represent 25% of the total cost of the product (Lago, Carvalho, & Ribeiro, 2008), and as all the manufacturing processes, the indirect areas have non-value adding activities that can be eliminated. Case studies of this application are, for example, Chen & Cox (2012), Monteiro, Pacheco, Dinis-Carvalho & Paiva (2015) and (Foster, 2017).

Lareau (2003) identified, among other wastes to the indirect areas, these 10 wastes listed below:

- **Goal alignment waste:** when the goals are poor-defined and people spends energy to pursue and correct them to achieve an effective result;
- **Assignment waste:** an unnecessary or unsuitable task is done; this waste reflects the personal effort to complete it;
- **Waiting waste:** there is no value in waiting, for example, waiting for a signature or response;
- **Motion waste:** needless movement that doesn't add value;
- **Processing waste:** when a work isn't executed in the best way possible;
- **Control waste:** the energy spent in monitoring or controlling that doesn't contribute to improve the performance;
- **Variability waste:** when extra resources are used to compensate the non-achievement of the expected output results in a variability waste;
- **Tampering waste:** when something is changed and the consequences for that act are not studied beforehand, this results in a waste of time spent in correcting the consequences;
- **Strategic waste:** when there is an action that has fulfilled a short-term goal but does not add value to the client or stakeholders;

- **Reliability waste:** time spent on correcting a problem without knowing the causes.

To eliminate these wastes the *Lean Thinking* is applied and is named *Lean Office*. One of the main barriers for an organization to become a *Lean* organization is, and often forgot, the *lean* management that sustains it. For that it is necessary to follow a *Lean* leadership.

2.3.1 Lean Leadership

Frequently the problems behind an organization are, for example, inconsistency on follow-up of new responsibilities and processes, non-clear explanation of why the change of workers and the people's questions are often ignored (Mann, 2005). Everybody needs to be involved on *Kaizen* but mainly top management who has to set the example (Imai, 2005). Without a strong *lean* management system, it is easy to come back to the old habits; a lot of *lean*'s implementation fail due to the lack of parallel development of *lean* management (Mann, 2005).

The customer defines what a value-adding activity for the product is and what is not. Following this logic, "leadership can't never be a value-adding activity"; the shop floor worker is the one whom adds value to a product. Therefore, a leader is someone that defines the strategy, creates the team and motivates it. For this team creation, it is necessary to define clearly the roles for each member. For that, the RASIC matrix is used, that is, a matrix where for the different activities the responsibilities are allocated (Bilnoski, 2011):

- **R:** Responsible, this figure is responsible for the activity success;
- **A:** Approves, the person who gives the approval of the activity;
- **S:** Supports, gives the support when needed for the activity execution;
- **I:** Is informed, this person is informed about the activity but is not involved in the decision-making;
- **C:** Cooperates, gives essential input for the activity.

Lean leadership can be defined as a logical system for successfully implement *lean* and continuously improve it (Dombrowski & Mielke, 2013).

Mann (2005) identified eight dimensions of lean leadership:

- **Passion for Lean:** it can be something more than mere conduct; it is something that needs seriously commitment. One of the factors that most contribute for this passion is the fierce competitiveness that push the companies to be the best they can be to thrive in the world. When

there are enthusiasm and intensity about a topic translated in deep knowledge about it, that is passion; this can be learned and obtained through time;

- **Responsibility towards the process:** one essential part of lean's implementation is to use a pursuing process for it to check the evolution according to the due dates. It is necessary to reinforce the focus on the process; the role of the leader is to set the discipline to truly execute the processes;
- **Oriented to Project Management:** it is crucial in a project environment the creation of a follow-up system for task assignments. The work breakdown structure is important to this creation, that is, when the big task is spread-out in subtasks, when these are completed, the result is the conclusion of the big single task. By doing this is easier to make the responsible for the task to conclude it one step at a time and get experience and learn the work breakdown structure through the process. This can be support with a visual management tool to follow-up the planned activities and those responsible;
- **Lean Thinking:** the pursuit of perfection is the main goal for a lean leader; if the leader is always chasing improvement, these habits will be followed by the organization. The skills demanded to a lean leader is the capability of lead improvement and problem-solving processes and to coach the tools and the thinking technique;
- **Ownership:** the lean leader of an ongoing process sets the expectations to a high level; s/he creates the environment to which those in the area can participate in making changes to achieve the main goal and vision. The leader encourages and supports others to think for themselves, to give suggestions on how to attain the established vision;
- **Tension between applied and technical details:** commonly a leader doesn't get into technical details leaving them to the engineers or local lean resources. For example, the consequences of changeover times reduction which affects the process performance can be influenced by the lack of technical knowledge. Thus, a lean leader needs to fully understand how lean works. Often this is achieved with "experiential learning" that is changing one action at a time, for example, inventory reduction highlighting the lean system by making the weakness visible and fix it to a high level of performance. Experience translates how real *lean* is learned;
- **Balance between production and management systems:** the management has an important role in *lean* systems. The lean leader work doesn't stop when the technical lean implementation is complete. It is required to the *lean* leader to follow-up the technical *lean* by defining a support *lean* management system to continuously improve it;

- **Effective relations with support groups:** the support groups - production control, engineering, maintenance, human resources, quality, safety, accounting – must be seen as resources by the lean leader incorporated in daily improvement and problem solving and not as a group to blame for the failures on the system.

Likert (1961) stresses that “Nothing changes until leader behavior changes”; for a successful lean conversion, what the leaders learn is key together with consistency (Mann, 2005).

2.3.2 Competence Matrix

“Make people before making parts” to attain this golden rule for TPS it’s necessary to have a structured competency system. Suzuki (1993) identified different types of competences:

- **Improvement skills:** skills for problems identification and its resolution motoring;
- **Individual skills:** ability to analyze and execute the tasks;
- **Maintenance skills:** this type of competence translates the capacity to follow standards, manuals and complete an operation in time without accidents or defects;
- **Team work skills:** required ability to communicate and lead in order to be a part of a team;
- **Specific tasks skills:** technical skills needed for operations’ execution;
- **Management skills:** competence for coordinate, communicate and cooperate with others.

To track the associates’ training level, a competence matrix can be used. Suzuki (1993) mentioned four levels of competences:

1. On training, has knowledge: at this level, the associate has had the training about the topic but didn’t apply it;
2. Executes the operation with some assistance: here the associate is able to execute the theoretical knowledge obtained under supervision;
3. Autonomous: the associate is completely autonomous to execute the operation;
4. Able to teach others: the higher level translates the ability to teach the theoretical knowledge to others.

This matrix shows the different levels of knowledge, the date that a level was acquired and the planned date for the next step. It is necessary a global optimization instead of local one, i.e., it is required the incentive for the mutual learning. This can be achieved for example by sharing the conclusions of a book or seminar with the rest of the associates. If it is possible to exchange knowledge, ideas or experiences the work becomes more pleasant and enriching.

3. COMPANY PRESENTATION

The project that this dissertation was based on was developed in an electronic components company, Bosch Car Multimedia Portugal S.A., located in Braga and headquartered in Stuttgart Germany. In this section, the Bosch Group's history landmarks and the department focused on the continuous improvement will be described.

3.1 Main Bosch's History Landmarks

Long gone are the times when Bosch was only an automotive supplier. The company has grown to be a diversified corporate group focused on innovative technologies. This journey is represented in Figure 7 below.

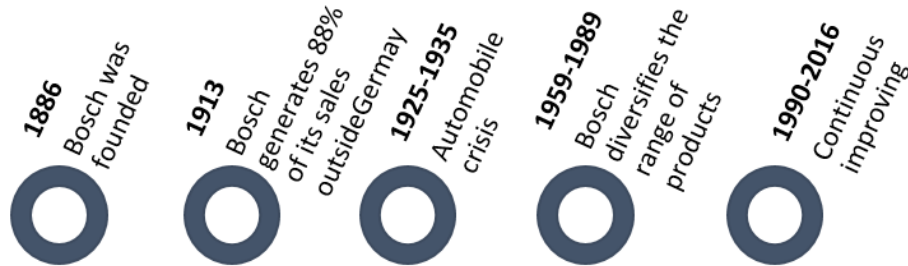


Figure 7 - Bosch's History Landmarks (Bosch, 2016)

One of the most important marks that operated as a trigger for the diversified corporate group that is Bosch today, was the automobile crisis of 1925. One of the lessons learned was the risk of a company to be focused only on one sector. From that moment on, Bosch matured to the different sectors that are known today: mobility solutions, consumer goods, energy and building technology, and industrial technology (Bosch, 2016), Figure 8.

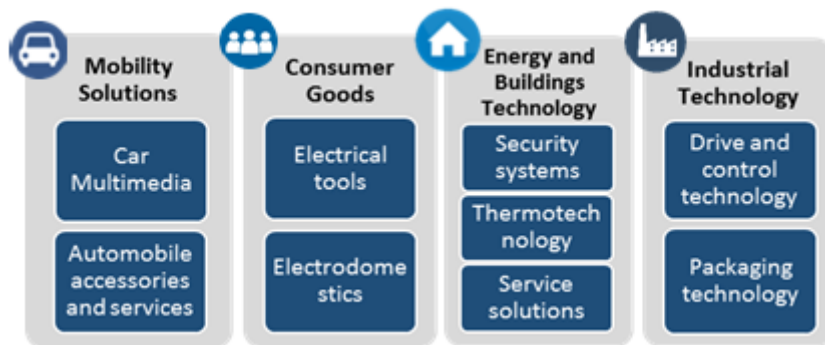


Figure 8 - Bosch's Sectors. Adapted from Bosch (2016)

3.2 Bosch in the world

Bosch Group has a total of 375.000 associates, distributed among different countries. From 1901 until now, Bosch outgrew itself, with 440 subsidiaries and regional subsidiaries in 60 countries and a global presence in 150 countries including sales and service partners. Below can be found the map with the different Bosch's subsidiaries in the world, Figure 9a), and the regional subsidiaries in Portugal, Figure 9 b).

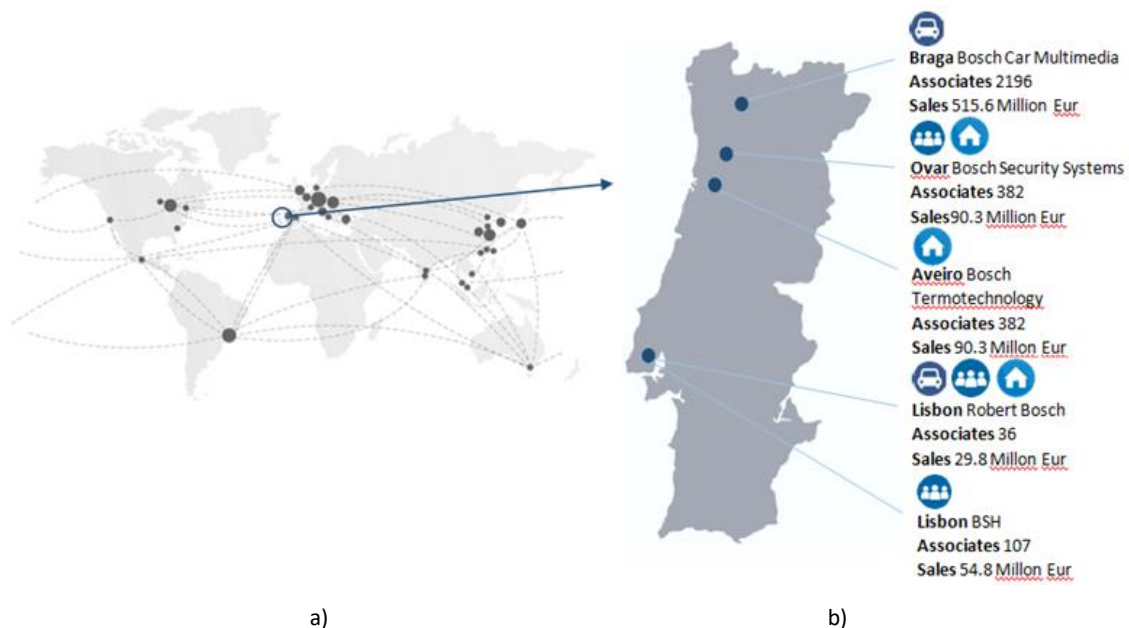


Figure 9 – Bosch factories localization: a) Bosch's World Subsidiaries b) regional subsidiaries (Portugal). Adapted from (Bosch, 2016)

Withal around 3.600 associates, Bosch is one of the major employers in Portugal. Present, since 1913 and headquartered in Lisbon, the main developed activities are the production of thermo solutions, car multimedia and security systems, which are exported for 50 countries around the globe. Bosch in Braga was founded in 1990, currently the principal focus is on car multimedia where different products are manufactured, being on the top ten exporting companies in Portugal.

Bosch Car Multimedia is divided into five Business Units (B.U.): Instrumental System (IS), Drive Information (DI), Chassis systems Control (CC), Professional System (PS) and Manufacturing Service (MS).

Figure 10 shows some of the Bosch clients. Volkswagen, Fiat and PSA group are considered the main clients of the company.



Figure 10 – Bosch's customers(Bosch, 2014)

3.3 Products

When a product is developed, innovation is a priority. In the Bosch Group, each working day, 22 patents are registered which reflects the growing investment on research and development, an investment around 20 Billion Euros in the past 5 years.

In Bosch Car Multimedia S.A., located in Braga, the current product portfolio encompasses: 1) Navigation Systems; 2) Instrumentation Systems; 3) Next Infotainment Gen; 4) Steering Angle Sensor; 5) House-hold Electronics; 6) Control Units Systems. Figure 11 shows the products currently produced in Bosch Braga.



Figure 11 - Bosch Braga Products

3.4 Organizational Structure

At Bosch Braga, there are two managers who run the company and report directly to the headquarters, one is responsible for the commercial area (PC) and the other one for the technical area (PT). The first, PC, has an indirect intervention in product manufacturing and in the technical processes associated with the production. On the other hand, the technical area tries to manage the departments directly interfering in the quality, reliability and productive efficiency of the organization (Figure 12).

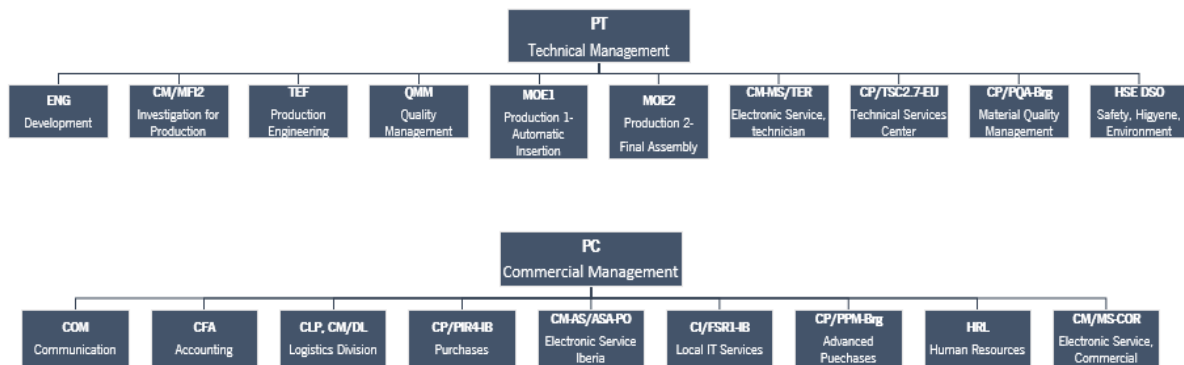


Figure 12 - Organization chart
(Bosch, 2015)

Although not being an independent department, the *Bosch Production System* (BPS) is part of the whole technical part, contributing for the continuous improvement of the processes; can be considered as a Plant Coordinator, Figure 13.



Figure 13 – BPS in Bosch

The B.U./Family VS Managers work to support the whole organization and they are a key factor in the continuous improvement culture.

3.5 Bosch Production System

BPS, Bosch Production System, founded in 2002, is a systematically approach of improvement processes on the value stream. Before the BPS's development, the waste elimination throughout the productive process was not a priority, which led to high levels of stock, failure to meet the deadlines, long transport distances and hence client's complaints.

BPS worked as a mindset's change for the company. The focus started to be on the reduction of waste all the way through the value stream. Each production's process comprises value-added and waste processes. In Bosch Group this waste is divided into visible waste, unnecessary waste that doesn't add value to the production process nor to the delivery to the customer, and hidden waste, type of waste that can't be eliminated because although it doesn't add value to the output, it's necessary for the production process's execution. The goal is to eliminate the visible waste and convert it to value-adding processes and reduce the hidden waste. BPS can be represented in a pyramid divided in three layers, Figure 14.

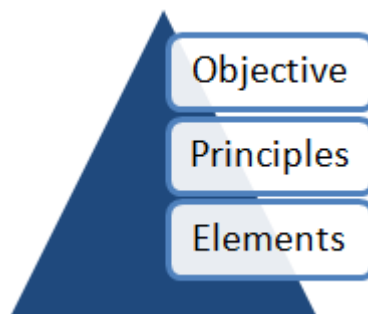


Figure 14 - Pyramid of BPS. Adapter from (Bosch, 2013)

The objective has its place in the top layer, that is, the development of the best processes amongst the category they fit in and established them at all Bosch companies around the world. The middle layer represents the principles. The third layer, the elements, are the tools necessary to the principles implementation at an operational level, such as, System CIP approach, Levelling and 5S, among others. This dissertation thesis will be focused on the System CIP approach element.

3.5.1 BPS principles

The middle part of the pyramid is represented by the principles; there are eight main general principles that describe the BPS and work as mandatory guidelines for the development of all sub processes, Figure 15.

4. DESCRIPTION AND ANALYSIS OF THE CURRENT SITUATION

In this chapter, the current situation will be described and a critical analysis will take place. Firstly, the current situation of the *System CIP Approach* is described. After this description, a critical analysis is made to identify the existent problems. Using the A3 sheet, the problems will be listed, the objective defined and the KPI's chosen. This KPI's will reflect the results achieved with improvements' proposals.

4.1 Key Performance Indicators (KPI's) used in Bosch

There are three types of KPI's in Bosch: the *Key Performance Results (KPR)*, the *Monitoring KPI* and the *Improvement KPI*. The KPRs translate the requirements for a value stream into indicators; they are productivity, delivery performance, among others. The *Monitoring KPI's* are indicators that can't be seen directly in the shop-floor, but are necessary to run and monitor the system such as the Overall Equipment Efficiency (OEE) or the changeover losses. Contrariwise, the *Improvement KPI's* can be observed directly in the process, such as the number of units lost when a problem occurs, for example, the high number of scrap or the number of occurrences of the problem, for example, the blockages in some machine. Improvements are directly reflected in this KPI.

Despite of their differences, they are related. On the KPI tree, Figure 16, the relationship is clear. The improvement KPI's are the lowest level of the tree, whereas the monitoring KPI's are the medium and the KPR are the highest.

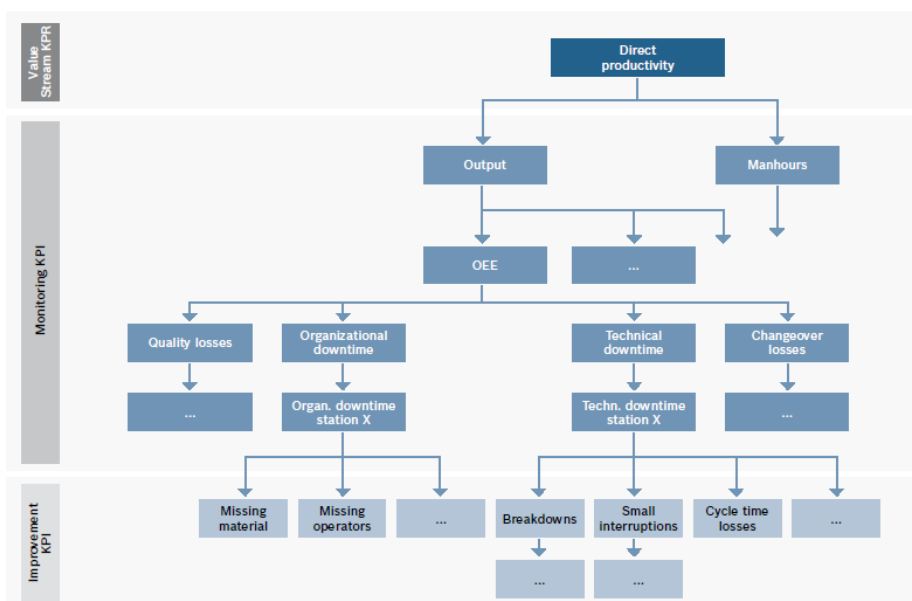


Figure 16 - KPI tree losses (Bosch, 2015)

4.2 System CIP Approach

The *System CIP Approach* is a systematic inserted on the continuous improvement culture where the main aim is the waste elimination and hence the improvement of the *Monitoring KPI's* with the execution of well-structured projects focused on the company's main technical problems. On Figure 17 the systematic steps and the relationship with the *KPI's* stability are represented. There are three major steps for the *System CIP Approach*: *System CIP*, *Point CIP* and *Daily Management*. The *System CIP* is subdivided into the *System CIP Workshop* and *System CIP Projects*.

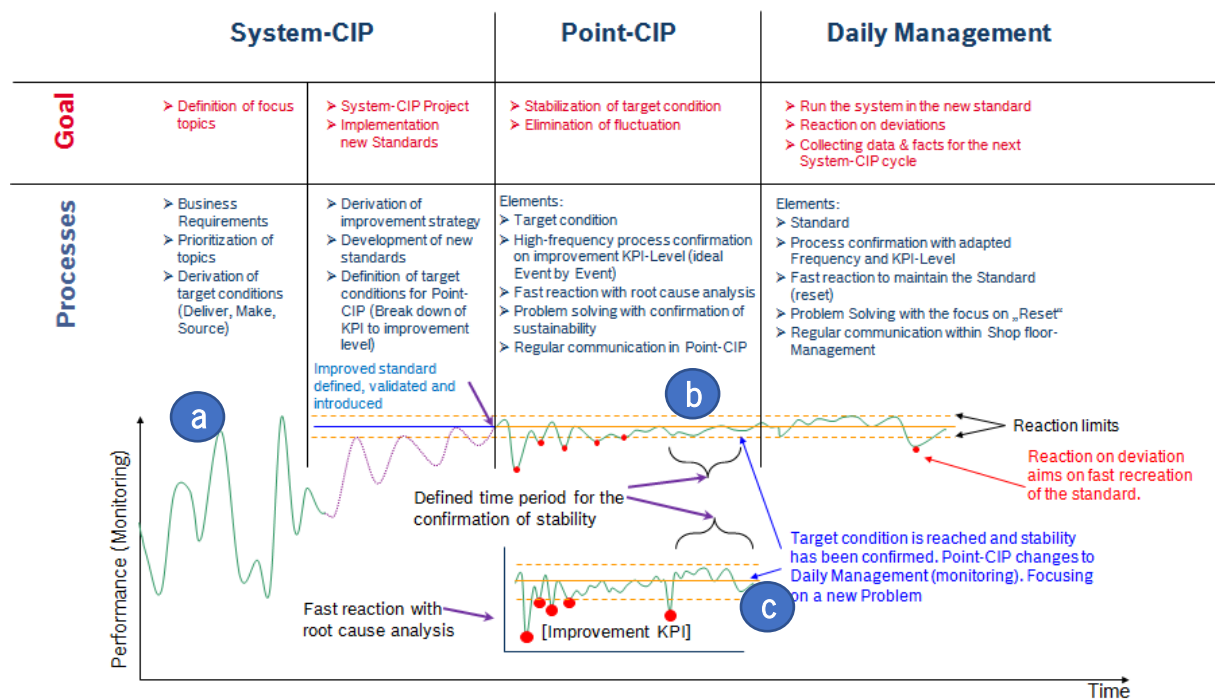


Figure 17 - Relationship between the steps of the System CIP Approach and the KPI's Bosch (2015)

By the analysis of Figure 17, in the first step, *System CIP Workshop*, the *Monitoring KPI* a) is unstable, that is, the *KPI's* value is out of target having a high-level of oscillation. To fight this instability, projects focused on the general problems that are causing this oscillation are defined and through the *System CIP Projects* stage are executed at an *Improvement KPI* level b), that is a level where the impact of the improvements implemented can be directly measured contributing for the *Monitoring KPI*. Slowly, standards start to be implemented and the *Improvement KPI* starts to get closer to the target condition c), that is, the sum of the target, stability criteria defined in the workshop and the standards implemented in the *System CIP Projects*, Figure 18 .

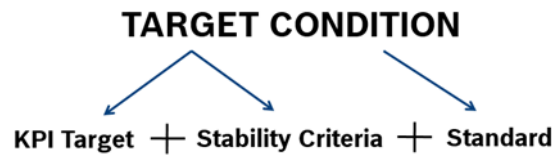


Figure 18 - Target Condition

In the *System CIP Projects*, the target condition is attained. From that moment on, the target condition starts to be stabilized, *Point CIP*. After verifying a stabilization of the *Improvement KPI* through 22 consecutive events (events can be days, shifts, when a quick changeover occurs, among others depending on the project), that is, the Bosch defined time for stabilization, the project is handover to the *Daily Management*, where the stabilization is done at a *Monitoring KPI* level.

Once a year there is the *BPS assessment* that is an evaluation of the BPS's elements according to the Bosch requirements where opportunities for improvement are identified. There are four levels for this assessment where the fourth is the highest. For this systematic, *System CIP Approach*, the Bosch Car Multimedia is inserted in the level two with three months to attain the target condition and three months to stabilize it, Figure 19.

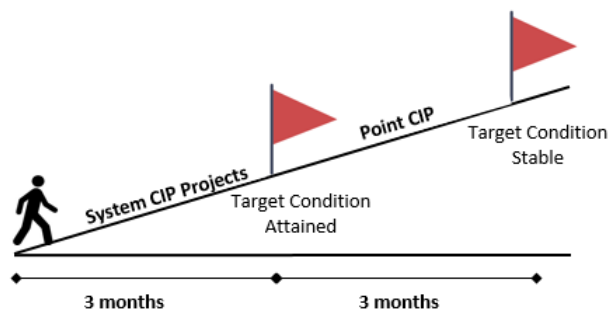


Figure 19 - Level 2 of the BPS Assessment for the *System CIP Approach*

4.2.1 Parties involved in the System CIP Approach

This systematic approach aims to involve everyone in the continuous improvement culture, empowering people. Figure 20 below outlines the parties comprised by the *System CIP Approach*, these are: the *Plant Manager*, *Value Stream (VS) Manager*, *Coach*, *Project's Owner*, *Team Leader*, *Workers* and the BPS.

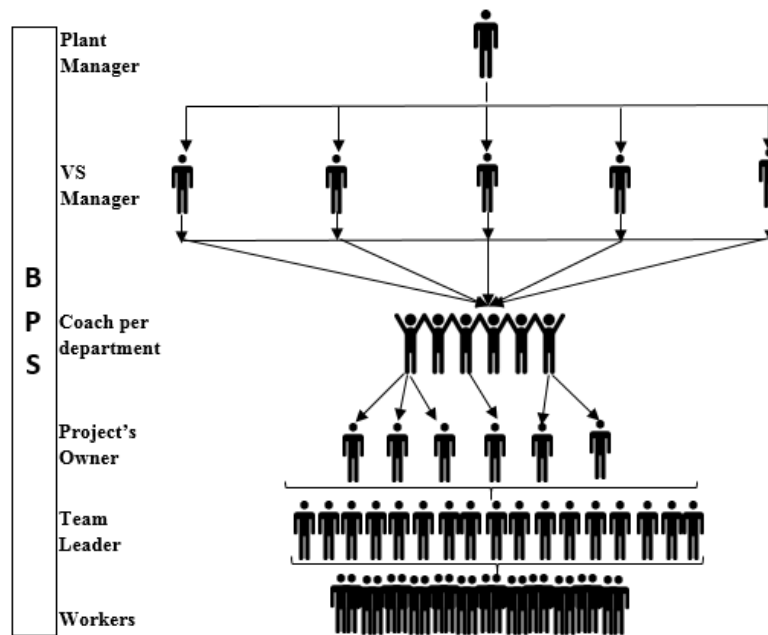


Figure 20 - Parties involved in the System CIP Approach

There is only one *Plant Manager* at Bosch and he is responsible for the (1) target alignment between the different business units (2) target deployment within the plant to value streams functional areas without conflicting targets and (3) employees, infrastructure and further development of the plant. In Bosch Car Multimedia, S.A. s/he is also responsible for choosing the *VS Manager* for each B.U. A *VS Manager* is rotative, which means that every section head should experience the continuous improvement systematic. There is a RASIC matrix existent for the *VS Manager*, see Appendix II – Current RASIC Matrix.

According to the Bosch norms, the inherent tasks for a *VS Manager* are:

- Set value stream KPI-targets according to the business requirements agreed by the *Plant Manager* and know the KPI tree;
- Guarantee the KPI-target achievement someone that is results oriented;
- Lead the value stream planning process;
- Decide about main improvement activities and required *Point CIP*, guarantee that *kaizen* culture is followed;
- Report the improvement progress;
- Be aware of each element and principle of BPS;
- Assure required BPS-qualification for the value stream team and promote it in the entire value stream;

The *Coach* is responsible for motivating and supporting the *Owner*. Currently s/he is represented by the head of the department where the *Owner* is inserted. In turn, the *Owner* is the person responsible for the project's execution. The projects are allocated to the *Owners* in the *System CIP Workshop*. The *Team Leader* is fully responsible for the *Point CIP*, i.e., for the follow-up of the *Improvement KPI* and for the deviations identification and its immediate correction. The *Worker*, the last to sign the A3 sheet, is the client for the projects since s/he is the one to work directly with the implemented improvements. The BPS is a department present throughout the process and gives support to whomever needs it.

4.2.2 System CIP Workshop

The *System CIP Workshop* is the first step of the *System CIP Approach*. The workshop comprises three stages, the first two for the workshop's preparation and the last one for the workshop's execution:

1. **VSM + Flash Kaizen:** each business unit, in different days, develops the current value stream map for each business unit under the *VS Manager* leadership;
2. **System CIP preparation:** the *VS Manager* is responsible for collecting the business requirements and for organizing the *System CIP Workshop*; at this stage two business units are assigned for different days;
3. **System CIP workshop:** here the workshop is executed and new projects are defined. For this activity, a pair of business units is allocated to different days. On Table 1 there are the planned duration for each stage.

Table 1 - Planned duration for the different stages

Stages	Planned Duration
VSM+ Flash Kaizen	2h30 min./B.U.
System CIP preparation	2h30 min./pair of B.U.
System CIP workshop	2h30 min./pair of B.U.

There are two revisions or workshops per year, one in March and one in September. In this workshop, the critical points of the value stream are identified, the targets are defined and the *System CIP Projects* to attain the business requirements are specified by the *VS Manager* using different inputs translated into boards, nine in total. These are:

1. **Customer requirements:** Represents the customer's requirements based on the general planning and technical capacity;

2. **Indicators:** In the indicators board, there are the general *KPR's*, *Monitoring KPI* and *Improvement KPI* of the company and for each B.U. The analysis of these indicators is made from a higher level, *KPR*, to a lower one, *Improvement KPI*;
3. **Target analysis/KPI tree losses:** In this input, the specific problems can be identified since the detail level is higher. In the target analysis, the production line performance is measured by the analysis of the *Monitoring KPI*. The *KPI* tree losses enables the unfolding of the *Monitoring KPI* into more detailed indicators, *Improvement KPI*. If an indicator is identified with a negative trend or out of target a project is developed to improve it;
4. **Inputs from DMM/Last revision System CIP projects:** On this board, the potential improvements obtained from the daily management meeting are put together, that is daily meetings in the *gemba* where the *KPI's* and *KPR's* are analyzed, and the projects from the last revision are gathered. The *DMM* inputs can be selected by many reasons, such as, the complexity of a current problem that needs a multidisciplinary team to solve it in an organized and efficient way.

The last revision of the *System CIP Projects* are projects from the last revision that weren't concluded in three months and need to be discussed if they are moved to the current revision or not;
5. **VSM+CIP Flash / Bubble Diagram:** The value stream is mapped, which facilitates the waste identification throughout the value stream. This identification is represented in a form of CIP Flash, Figure 21. The bubble diagram shows the flux of the product and the processes relationship, Appendix III – Bubble Diagram.



Figure 21 - Example of a CIP Flash

6. **BPS Vision:** Value Stream Design (VSD) represents the goal situation for the next three years and the activities to be executed annually in the three different production phases to achieve the goal: 1) Source, comprises the supplier and the delivery to the company; 2) Make, it's translated by the production processes; 3) Deliver, the delivery from the company to the client, Figure 22;

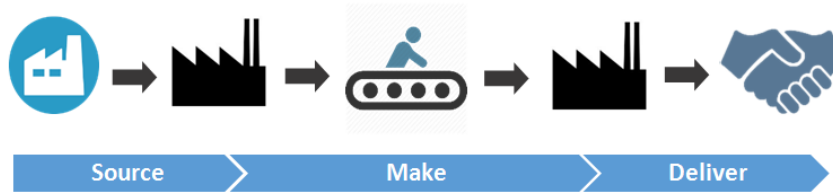


Figure 22 - Value Stream: Source, Make and Deliver

7. **BPS Assessment:** The Bosch central management evaluates the BPS according the requirements for each element and for each level, where there are four levels being the fourth the highest. This board is a summary of the opportunities for improvement originated from the last BPS assessment;
8. **Industry 4.0:** Improvement opportunities related to the industry 4.0 that originate new projects;
9. **True North:** It's the point reference for the ideal situation. In Bosch, that situation is translated by 100% added value, 100% delivery fulfillment, one piece flow and zero defects;
10. **Prioritization Matrix:** It's used for project's classification where the benefit and effort ratio is analyzed to prioritize the projects with more impact to the institution, that is, the ones with high benefits and, simultaneously, low efforts.

This workshop occurs in a small room where the head of each department, *Plant Manager*, *VS Managers* and BPS department are present. This workshop is led by the *VS Manager* of each B.U., where its function is to analyze and identify problems that can originate new projects, Figure 23. This analysis is made by following a logical way through the inputs in the order mentioned. Each input is represented by a board where the data is analyzed and the problems identified. There is a total of eleven boards - nine for inputs and two for the output, in the Appendix IV – Workshop System CIP are the photos of each board.



a)



b)

Figure 23 - a) General Workshop View b) VS Manager mediating the workshop

The outputs of the *System CIP Workshop* are the project's definition. This definition comprises the project's name and *Owner*, suitable *Improvement KPI* and *Monitoring KPI* and the definition of the target slice of the target condition. The standards of the target condition can only be defined when the current situation and problem are well described by the *Owner*. So, from this workshop only the *Improvement KPI*, *Monitoring KPI* and respective initial situation, target and stability limits can be defined. A stability criterion creates a “wall” with maximum and minimum limits where the KPI is stable.

For each B.U. there is a project sheet where the projects allocated to it are listed with the respective *KPI*'s. From this step, the output represented on the project's sheet is translated to a table represented in Figure 24.

Business Unit	Project Owner	Derived	KPI Improvement	Initial situation	Target
Project's Name	Project Owner	VSM			
		VS	KPI Monitoring	Initial situation	Target
		S/M/D			

Figure 24 - Project Sheet output from the workshop

The outputs are:

- **Project's name:** name of the project;
- **Project's owner:** *Owner's* name. Sometimes, in the workshop, the *Owner* for the project is not defined because there is not enough information about the *Owners* that are inserted in a certain department, being difficult to assign the project. In these cases, only the department name is defined and the project is handed over to the head of the department to choose the *Owner* that best fits the project;
- **Derived:** the board/input where the project was derived from the *System CIP Workshop*;
- **S/M/D:** where in the value stream the project is inserted, source, make or deliver;
- **Improvement KPI and Monitoring KPI:** initial situation and target for the *KPI*'s;

From this moment on, the workshop is finalized and the project can be executed on the next step, the *System CIP Projects*. The handover of the project is made by the *VS managers* that are responsible for notifying the *Owners* and respective *Coach* of the project's existence.

4.2.3 System CIP Projects

In this step, the projects need to be well-defined to be executed properly. The BPS department created different templates to provide the *Owners* with the tools that they need to execute a project; these are:

- **A3 sheet:** the filling of the Bosch A3 sheet template is mandatory to facilitate the project's execution by creating a logical way of thinking always following the PDCA cycle;
- **Ishikawa Diagram:** this diagram is used to analyze the different causes to a problem in a structured way to find the root causes for it;
- **5 why's:** this tool is utilized to find the root causes for a problem simply by asking why five times;
- **Pareto analysis:** helps to classified the items according to their relative importance;
- **Histogram:** this quality tool assists the data management by counting the occurrences of each class and group them to represent the data in a more concise way to facilitate the information extraction about the problem's behavior;
- **Actions Plan:** on the *Do* stage of the PDCA cycle of the project, the actions that need to be implemented are registered and followed according to the PDCA cycle of the actions. The actions that had a positive impact on the *Improvement KPI* are considered standards for the project and need to be follow.

For this step, it's mandatory to fill the A3 sheet, Appendix V – A3 Sheet. On Figure 25 the PDCA cycle comprised in the A3 sheet template used by Bosch is represented.



Figure 25 - PDCA cycle comprised in the A3 sheet

The *A3 sheet* translates the deliverables for each stage of the PDCA cycle where the projects are inserted. The P translates the *Plan* stage, where the *KPI's* that were defined are monitored, the reason why the project is needed is described and the current situation is analyzed and the problems are identified. After the problem description, the objective of the project is defined in a SMART (Specific, Measurable, Attainable, Relevant and Time-limited) way and the conditions for the future state are defined; these are

the standards that need to be attained at the end of the project. After the problem's definition and the conditions cleared, the *Owner* continues with a root cause analysis using quality tools such as Ishikawa diagram. The root causes found are described in the *A3 sheet*.

In D, the *Do* stage, the standards implemented are described in the project's *A3 sheet* to get permanently on the system.

In the *Do* table of the *A3 sheet* where the standards created are described among other columns, is the "Impact" column, the impact of the standards is quantified. This quantification represents the *C, Check*, where the impact is measured through 22 events to guarantee its stabilization and success of the implemented improvements.

In the section *A*, there is the *Act* stage that comprises the *Daily Management Meeting (DMM)*, *yokoten*⁶ that is, when the stabilized standard is transferred to other areas. The follow-up for the *yokoten* needs to be made in the *A3 sheet*. The last section of the sheet is for the signatures, comprised in the fourth part. Every client of the project, which are, top management, head of department, head of section, *Team Leader* and *Worker* must sign the *A3 sheet* in the mentioned order. The *Worker* is the "direct customer" of the improvements and the last to sign.

There are three types of meetings throughout this step: the value stream (VS) meeting; steering committee (SC) meeting and the team meeting. In Table 2, the planned duration, location, frequency and the mediator for each meeting, are represented.

Table 2 - Planned duration for each meeting

Meeting	Where?	Frequency	Planned duration	Mediator
VS meeting	In the <i>gemba</i>	1 p/week p/B.U	30 min.	VS manager
SC meeting		1 p/month p/B.U.	1 hour 30 min.	VS manager
Team meeting		Not fixed	30 min - 1 hour	Owner

In the VS meeting the last week's *Improvement KPI*, *Monitoring KPI* data and if there are any standards implemented these are given by the *Owner* to the *VS manager* to be validated. The board used for the VS meeting is the *VS Manager* board, Figure 26, where there are general *KPIs*, *KPI's* of the business unit, VSM, VSD and Bubble diagram, the follow-up of the *KPI's* deviations and standards implemented description, the *KPI* Tree and the projects allocated to that B.U.

⁶ *Yokoten*: Japanese word that translated in English means best practice sharing, that is, when the best measure is found this is shared through different processes.

22 consecutive events, the project is concluded and a smiley face is placed, Figure 28, a red face if the A3 sheet is not signed by the parties involved and a green one if it's signed.

Otherwise, the week box is painted in red.

Projects_B.U.	Project Owner	Derived	Improvement KPI		Status_System CIP Projects / PDCA																CW Status - Point CIP															
			N° of Screws NOK (number)	Initial Situation	Target	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64							
1	Decrease number of Screws NOK in the machine XPTO line Y	John	KPI Tree	200	50	200	230	50	180	80	78	71	47	46	30	40	30	60	30	35	40															
				Monitoring KPI																																
			VS	OEE line Y (%)																																
				80	90	80	82.3	85.3	86.6	87	90	83	91	90	92	90	89	90	91.3	93	91	DMM														
Possible Savings /month	Savings Achieved /month	Total of Standards		Σ	0	0	0	1	1	1	1	2	2	2	2	2	3	3	3	3																
10.000 €	10.500 €	M	Total n° of deviations from target condition ()		Point CIP																															

Figure 28 - Example of a Project Sheet filled

The steering committee BPS is a monthly meeting where the top management are present. The KPI's and KPR's of the respective business unit are analyzed by the *VS Manager* and the evolution of the project is presented by the *Owner*. The discussion of the project's evolution and the exchange of ideas is encouraged.

The team meeting is normally a weekly meeting between the *Owner* and the project's team where the project development is discussed and new activities are planned.

If the *Improvement KPI* target was attained through three consecutive weeks and there are standards implemented, the project is delivered by the *Owner* to the next step, *Point CIP*.

4.2.4 Point CIP

The *Team Leader* or line leader is responsible for following this step. The standards defined in the *System CIP projects* are stabilized at an *Improvement KPI* level where the deviations to the standard are identified and then eliminated. There are five elements for the *Point CIP*. (1) process confirmation; (2) target condition; (3) structured communication; (4) fast reaction system and (5) problem solving. These need to be attained to fulfill this step.

The process confirmation is where the standards are confirmed throughout the 22 events, the defined time in Bosch for stabilization. Events can be, for example, days, shifts or when a changeover occurs, depending on the project. Some standards don't need this confirmation because they cannot be changed, for example, when changing the color of a table there is no need to confirm through 22 events if the color remains the same. In these cases, the *Owner* needs to justify why it doesn't need confirmation. On the other hand, if the standard is something such the standard's work change, this needs to be confirmed to guarantee that is being fulfilled.

Despite of the confirmation being dependent on the standard, the target condition is mandatory. In the target condition, the *Improvement KPI* is monitored through the 22 events to guarantee that there are no deviations to the stability limits. If there is a deviation, it must be analyzed and immediately corrected. In this case, the first step is to analyze the standards. If they are "NOK" the root cause has to be found and immediately implement an action. If they are "OK", it's necessary to use a problem-solving sheet to study new problems that the actual standards couldn't solve and create new standards.

The fast reaction system aims the rapid elimination of problems and defect; the basis of this system is the reaction limits. When these are activated, alerts are triggered and the problem-solving cycle starts. The *Workers* are the responsible for the alert process and in turn the *Team Leaders* are responsible for evaluating the problem and decide the proper action.

These step needs a close follow-up, for that the structured communication is needed. The communication is structured on a regular basis and in a time limited period. There are three types of meetings:

- *Point CIP* meeting, where there is the information exchange about the process's performance, the problem-solving status and stabilized standards;
- Standard management meeting, the problem solving is evaluated, the standards' improvement is revised and the goals of the *System CIP* and *Point CIP* are reconsidered;
- Directive meeting, where the effective problem-solving and new standards are transferred to other departments.

In order for the project to be handover to *DMM* where the standards will be follow indirectly with the *Monitoring KPI*, there has to be no deviations to the target condition through 22 consecutive events.

4.2.5 Daily Management Meeting (DMM)

Daily Management Meeting is a systematic that aims the preservation and improvement of the actual performance of the processes by the constant collection of the data and follow-up of the *Monitoring KPI*. It is the last step of the *System CIP Approach*.

Similar to *Point CIP*, this step comprises the same 5 essential elements but addressed in a different way. Every time the target condition is stabilized in *Point CIP*, it's transferred to *DMM*. In *Point CIP* the KPI to follow was the *Improvement*, whereas at this step the follow-up is made at a *Monitoring KPI* level and the stabilized standards are followed in order to maintain their original conditions and, if possible, improve them.

The target condition in *DMM* is similar to the *Point CIP* element, here the *Monitoring* KPI for example OEE, Productivity and IRR have stability criteria inside which the indicator variation is considered acceptable. It is necessary a regular comparison between the existent standards and the *Monitoring* KPI to understand which standards are necessary to attain the target condition.

Sustainable problem-solving allows the identification and analysis of the problem cause, as well as their sustained elimination. If the actions had impact on the problem, these can be integrated in the existing standard and considered new ones. The problem-solving process should be initialized when there are deviations to the *Monitoring* KPI and when the reaction limits are achieved. The type of problem defines the way to go. In Table 3 there are the different tools to use in each type of problem.

Table 3 - Type of problem and respective tool to solve it

Type	Problem resolution tool
Type 1: Known root cause and solution	Tracking by the list of open points (OPL)
Type 2: Known root cause and unknown solution	PDCA card
Type 3: Unknown root cause and solution	Problem solving sheet

The element “Process confirmation” aims the maintenance of the current standards guaranteeing that these are followed by using planned checkups with defined frequency. There are many standards to confirm the process such as, *Standard Work*, *Manufacturing and Control Instructions* and *Quick Changeover*.

The goal of “Fast reaction system” is the immediate problem and defects elimination. The basis for this element are the reaction limits, that when achieved, the alerts are triggered and the problem-solving cycle begins. These reactions limits must be continually revised, its reduction should be made according to the *Monitoring* KPI and to the rhythm of the problem-solving capacity.

The exchange of information is inserted on the “Structured communication” element. This communication is based on a daily meeting, *DMM*, where the actions in progress are presented. The meeting happens in the *gemba* with the planned duration of 10 min., and the *Team Leader* has the responsibility of the meeting management, being mandatory the presence of the responsible for the actions for that day. To minimize the meeting duration and to define correctly the tasks to be assigned, it is necessary to prepare the meeting. This preparation comprises the gathering of the *Monitoring* KPI data of the previous day and the verification of the existence of deviations. If there are deviations, the main problems and its root causes must be identified to allocate its resolution to a proper responsible. From the total of ongoing actions, the points to discuss according to their planned closer date and importance must be selected.

4.3 Critical analysis and problem's identification

After a close analysis of the current situation it was possible to build a critical view of it. From this view, the problems to be corrected were identified.

4.3.1 KPI's current values

By elaborating an A3 sheet based on the Bosch's template for this dissertation, the KPI's to measure the efficiency of the improvements implemented were selected. The *Improvement KPI* for this dissertation is the lead time necessary for the project conclusion, from the *System CIP Workshop* until the *Point CIP*. The initial situation that is, the current duration from the project creation until the conclusion is approximately 97 days, Table 4.

Table 4 - Lead Time: Initial Situation

Phase	Duration (days)
Workshop	Average time WS/ 24h = $3h16/24 = 0,136$ days
Handover to System CIP Project	15 days
System CIP Projects	3 months = $20 \times 3 = 60$ days
Point CIP	1 month = 22 days
Total	97,14 days

The aim is to reduce the duration from 97 days to 62 days, Table 5.

Table 5 - Lead Time: Target

Phase	Duration (days)
Workshop	2h / 24h = 0,083 days
Handover to System CIP Project	3h / 24h = 0,125 days
System CIP Projects	2 months = $20 \times 2 = 40$ days
Point CIP	1 month = 22 days
Total	62, 2 days

The *Improvement KPI* is represented in the graph below where the 2nd revision of 2016, that is, the initial situation is represented, Figure 29. The line represents the target of 62 days or less, the colour red signifies that the ideal situation is beneath the target line. The red sad face translates that the duration is out of target.

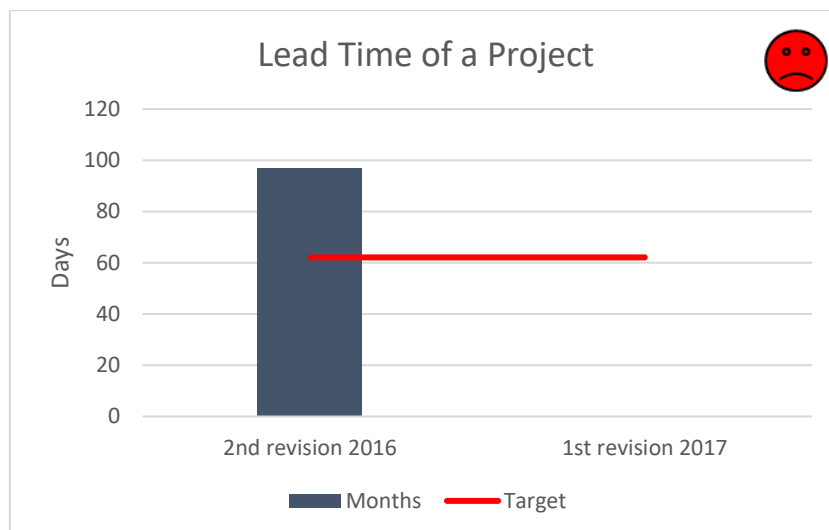


Figure 29 - Improvement KPI

For the *Monitoring KPI* there is the percentage of projects concluded, i.e. the quantity of projects concluded divided by the total number of projects. Currently, from the last revision, Figure 30, there were 35% of the total projects among every B.U. concluded in 6 months (level 2 BPS assessment). The aim is to increase this number to 45% or more, that is, 45% or more of the projects will be concluded in 62 days, represented by the green line that, on the contrary of the red line, signifies that the ideal situation is to be equal or higher than the target.

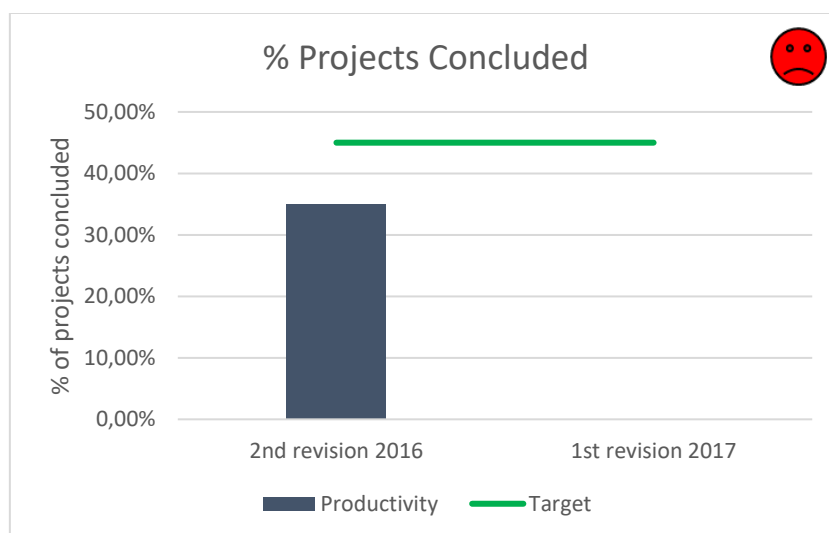


Figure 30 - Monitoring KPI

4.3.2 Problems identified by the stakeholders

To have a clear idea which were the problems, firstly, it was asked to a sample of 30 participants where 25 were *Owners* and 5 *VS Managers*, in their opinion, which were the main problems of the System CIP Approach. The results are represented in Figure 31.

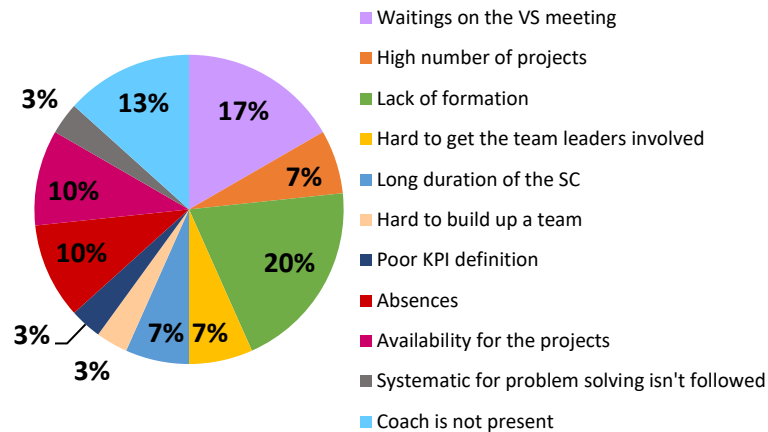


Figure 31 –Main problems identified by the stakeholders – inquiry results

By the analysis of the graph it can be concluded that the main problems are with 20% of the responses the lack of training about the systematic, 17% think that the *Owners* waiting by their turn in the VS meeting is too long and a waste of time, 13% stress the importance of the *Coach's* support and 10% the lack of availability for the projects and the high number of absences in the VS meeting.

4.3.3 Low percentage of projects concluded and high time to conclude the projects

Also, it was decided to study what happened with the projects concluded in each B.U. They were gathered and analyzed. In Figure 32, the percentage of projects concluded per B.U. is represented.

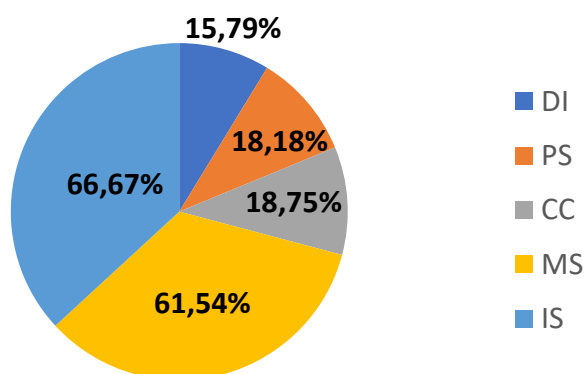


Figure 32 – Percentage of projects concluded in the 2nd revision of 2016

By the analysis of the graph, the most successful B.U. is the IS with 67% of the projects concluded followed by MS with 62%. The total of projects concluded among the five B.U. are 26 projects of a total of 74 projects, only 35% of the total projects were concluded.

It's necessary to evaluate if the duration needed is inserted in the three months maximum defined in the BPS assessment, chapter 4.2. The graph with the average time to finish the System CIP Projects stage is represented in Figure 33.

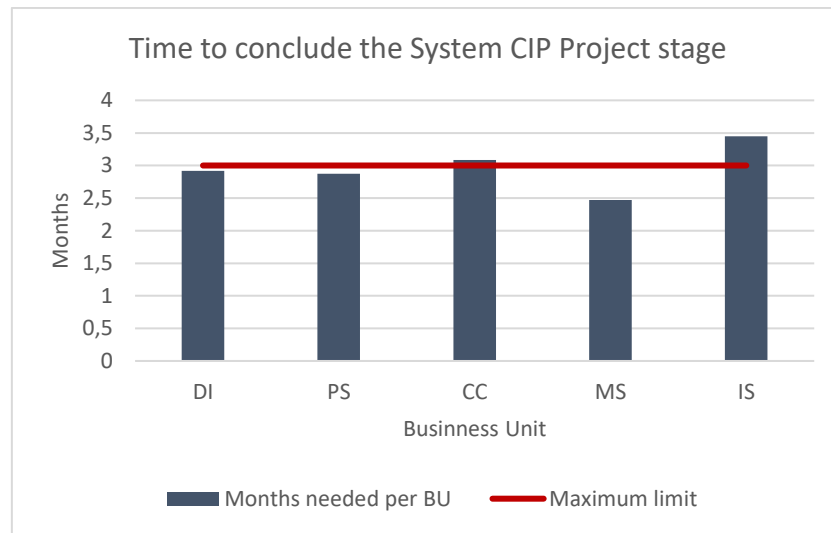


Figure 33 – Average of time to conclude the System CIP Project stage

According to the graph, the B.U. of CC and IS exceed the maximum limit of three months defined. Despite of this exceedance, the average of all the B.U.'s remains approximately equal to the three months target. This study is the starting point for the problem's identification but for a true understanding of the initial situation, the participation in every step of the systematic was required.

4.3.4 Deviations from the System CIP Workshops and Bosch standards

In this step the projects are created, so it's necessary the clear definition of the KPI-target comprised by the target condition. After attending to the workshop for each business unit, i.e., summed to five workshops, it was possible to identify different deviations between them and the Bosch norms.

These workshops occur in three different days, two times a year. The first B.U.'s of the first revision of 2017, were PS and DI, the second IS and CC and on the last day it was the MS and general projects. These are projects that have impact on the company's entire value stream, for example, the projects allocated to logistics and the projects focus on the industry 4.0.

The B.U.'s that inaugurate the workshop were the PS and DI; as mentioned, the *VS Manager* is rotative among the B.U. This was the case for DI, so there were two *VS Managers* to mediate the workshop, the

current and the previous one to help the new one. The mediator didn't control the participants which resulted in a loud and unorganized environment. The logical way of mediating the workshop, is following each of the numerated input boards, make a relationship between them and identify opportunities for improvement. Unfortunately, the guide was not followed neither by the *VS Manager* of PS neither the *VS Manager* of DI.

The projects were written before-hand which gave the workshop no purpose, due to lack of preparation for the workshop, the projects creation didn't follow the logical line of inputs. The prioritization matrix wasn't utilized because they could not measure the level of effort and benefit for each project; this was a clear difficulty even when the *Owner* was chosen because how can the availability for the project be measured if the effort needed to conclude the project is not quantified? This resulted in a "push game" for the *Owner's* selection, a general hard resistance among every department to accept a project.

The following B.U. were the IS and CC. In IS the *VS Manager* changed, but in this case the new one didn't need support, she was objective and concise when mediating. Although, the projects were previously defined, the required logical path of inputs was followed which gave a clear explanation where were the projects coming from and why, which resulted in a big positive gap comparing to the rest of the *VS Managers*. In CC, on the other hand, the lack of knowledge about the systematic and *Lean* theory behind it was evident, which goes against the ninth principle of the TPS; a leader needs to clearly understand the work, live the philosophy and can teach it to others.

The *VS Manager* focused its attention on his direct problem in his production area and not in the improvement opportunities. For the *System CIP Approach*, the project's definition must be detailed and not general, for example "The increase of productivity in CC area" is a wrong definition for a project that needs to be concluded in six months maximum because this is a very embracing project which results in a misdirected *Owner* with an unconcluded project. For this to be a well-defined project, the causes for the low productivity had to be previously studied and different projects created from that analysis.

The planned and real duration and the time waste on waiting for the participants to show up per B.U. and respective average is represented in the table below, Table 6.

Table 6 - Analysis of the workshop's duration

B.U.	Planned Duration	Waiting	Real Duration
PS and DI	2h30	30 min	3h30
IS and CC			3h
MS and general projects			3h20
Total	7h30	1h30	9h42
Average / workshop	2h30	30 min.	3h47

By the analysis of the total time spent in this workshop, 9h and 42 minutes, gives a total of 1 hour and 42 minutes higher than a work day, 8 hours. Like the shop-floor environment where the stock hides the waste, here the average duration surpasses the planned which hides waste, such as: time wasted in waiting, the standard is not followed, unnecessary discussions such as outside matters and long debate when the *Owner* is defined.

The handover of the project to the next step is made by the *VS Manager* that is responsible for notifying the *Owner* and respective *Coach* about the project. This handover takes a long time to be made, a mean of 10 days reflecting the need for a standard. This culminates in an unmotivated and unproductive *Owner* that knows about the project one day before the steering committee meeting or doesn't have access to the project folder that comprises the tools necessary for the project's execution.

4.3.5 Many and disorganized folders for System CIP Approach

The next stage is the *System CIP Projects* where the projects are executed. After participating in every meeting inherent to this phase, 71 VS meetings and 21 SC meetings in total, many problems were identified. The project execution is made by using the BPS tools templates. The difficulty is that these precise tools need to be clearly understood to be functional. Currently, these tools are seen as unnecessary extra work and not as a helpful tool due to the lack of training about the systematic CIP, many *Owners* start a project not knowing the steps needed to conclude it.

Although, there are many standards for this systematic, with each phase well-described, these are inserted in a single folder named "Standards". This folder is aside the folder where the project data is inserted, *Figure 34a*) inside the "Standards" there are many sub-folders and in turn inside each there are more folders and so on, *Figure 34b*) concluding the *Owners* thought it was difficult to find the standards.

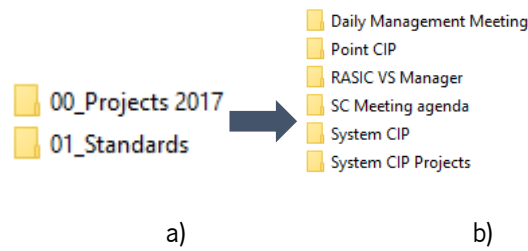


Figure 34 – a) General VS Plant folder b) Standards' folder

4.3.6 Problems identified in the System CIP Projects

Missing requirements, skills and standard work for the VS Manager, high number of absences in the VS Meeting, missing continuous support and motivation, lack of training and *PDCA* cycle is not followed, lack of execution of the *Point CIP* step, lack of time for improvement.

4.3.6.1 Missing requirements, skills and standard work for the VS Manager

In the VS meeting, the *VS Manager* is responsible for filling the project sheet with the KPI's data of the previous week, for the standards' approval and for giving the support needed. When comparing the different *VS Managers* mediating the meeting, there was a clear difference between them such as how they follow the *Lean* culture, the support given and the importance given to the *System CIP Approach*. In Table 7 there are the different requirements for a *VS Manager*. The X represents the *VS Manager* that has the required characteristics.

Table 7 - Requirements for a *VS Manager*

	Results Orientation	Management Skills	KPI Tree	<i>Kaizen</i> Culture	Attendance of the VS Manager	System CIP Approach	Agenda for the meeting is followed
DI							
IS	X	X	X		X	X	X
CC							
PS							X
MS	X	X	X		X		X

By the analysis of the table it is clear the lack of standard work between the different *VS Managers* which goes against the 6th principle of TPS, the standard is the basis for the continuous improvement, a problem that is reflected by the results of each business unit, that is, the number of projects that are concluded successfully.

There is a RASIC matrix for the *VS Manager*, although existent, it is incomplete and is not visible for everyone.

4.3.6.2 High number of absences in the VS Meeting

Adding to the lack of standard work, the VS meeting results in an unproductive time where there are a high number of absences, average of 63% of absences in every B.U. where the higher is CC with 78% of absences and the lower MS with 46%. The *Owners* present normally appear at the same time which results in time waste in waiting and disorganization with the *Owners* standing near the small table in the *gemba* where the project sheets and standard sheet are mixed, total of 10 A3 sized sheets resulting in bewilderment and time waste searching for the right sheet, Figure 35. Hereupon, the *Owner* absences can be easily explained by the unproductiveness behind the meeting, where s/he is only there to give the data and standards implemented for the previous week.



Figure 35 - Example of a normal environment in the VS Meeting

As can be seen in Table 7, the *VS Manager's* absences is also a problem. If the *VS Manager* isn't present, the *Owner* feels unmotivated because there is no one to support him when he needs it since the *Coach* is an inexistent figure in the systematic.

4.3.6.3 Missing continuous support and motivation

The SC meeting is a meeting where the project status is presented to the steering committee. Unfortunately, a lot of *Owners* only move forward with the project execution on the week before the SC because there is no continuous support and motivation; the *Coach* is an absent figure in the systematic. This meeting starts with the *VS Manager* explaining the *Monitoring KPI* and KPR deviations describing the reason behind it. It's clear that the majority of the *VS Managers* aren't aware of the value stream, not respecting one of the main requirements of this role, i.e., being percipient of the entire value stream and respective deviations.

Next, it is the *Owner's* turn to present the project status. For that, there are standard presentations for each phase of the project (*Plan, Do, Check* or *Act*) but these are not followed originating a long meeting with unfocused people. After the presentation, the discussion between the participants is encouraged. On Table 8 it can be seen the planned and real average duration for each meeting and the difference between them.

Table 8 - Planned and real duration for each meeting

Meeting	Planned duration	Real duration	Mediator
VS meeting	30 min.	45 min.	VS manager
SC meeting	1 hour and 30 min.	1 hour and 22 min.	VS manager
Team meeting	30 min to 1 hour	1 hour	Owner

By the analysis of the table, the problems mentioned are represented by the real duration. Despite of the high percentage of absences in the VS meeting, the real duration surpasses the planned one by 15 minutes where the identified difficulties are comprehensible justifications for this unevenness.

4.3.6.4 Lack of training and PDCA cycle is not followed

It was clear the lack of knowledge about the BPS basic principles, the systematic CIP and quality tools. How can an *Owner* execute a project if s/he doesn't know how to? This resulted in a general demotivation and high lead time to execute a project since the PDCA cycle was not known or followed.

4.3.6.5 Lack of execution of the Point CIP step

This step is inserted in the *Check* phase of the PDCA cycle. Considered the main stage because, for a standard to prevail and hence the improvement to remain, is necessary the stabilization of the standard. This stabilization involves the five elements mentioned before, section 4.2.4..Although the clear importance of this step, due to the lack of training, this is neglected and the five elements aren't followed. By the analysis of the total of projects concluded from the last revision, 16% didn't execute the *Point CIP* and were considered concluded, which corroborates the negligence of this step.

The *Team Leader* has to be the responsible for this stage, resulting in the involvement and the contribution for the *Jidoka* since s/he has to have the autonomy to correct the identified deviations. Unfortunately, this was not verified because the *Team Leader* was not inserted in the continuous improvement culture since s/he is always worried with "fire-fighting" and has no time for doing what he was supposed to do - improvement.

This step, according to the Bosch norms, must be supported by a structured communication, that is, frequent meetings between the *Team Leader*, *Workers* and *Owner* to discuss the behavior of the improvement KPI through the 22 events. This isn't being respected, concluding the *Point CIP* doesn't exist.

4.3.6.6 Lack of time for improvement

The last and continuous step, *DMM*, aims the continuous improvement culture where every deviation to the *Monitoring KPI* is studied and corrected by following the five elements mentioned, section 4.2.5. This meeting is extended for the whole company, that is, each group of production lines in every B.U. have to be monitored. Once again, the *Team Leader* is the main figure in this meeting, and because of the lack of time available for the improvement, there is no focus in this meeting and therefore in the continuous improvement culture.

4.4 Synthesis of the problems identified

One of the key tools for a project is the A3 sheet, for that reason this was used for this dissertation and will work as a summary of each general section. The first step of an A3 sheet is to justify the need for this project, describe the current situation, and identify the key performance indicators to measure the evolution through the project and the root cause analysis.

Figure 36 shows the first part of the *A3 sheet* where it is justified why the project is needed, the current situation is described, the objective identified and the conditions necessary to conclude the project with success listed.

1. Why this project? (Justify)
The low number of projects concluded, that is, in six months 35% and the high lead time to conclude it approximately 97 days.
2. Current situation (Describe)
SYSTEM CIP WORKSHOP Poor project's definition: owners, KPI and the project itself Long unproductive workshops Long time to handover the project to the Owner, approximately 15 days SYSTEM CIP PROJECT Lack of training about the System CIP Approach, Lean and Lean tools Lack of Standard Work for the VS Managers Coach is a non-existent figure resulting in the lack of support of the Owner PDCA cycle is not followed Long and tiring SC meetings Unproductive VS meeting where there are 63% of absences and average of 30 min. waste in waiting by the Owners and an unorganized environment due to the high number of paper sheets in the small gemba table POINT CIP AND DMM The five elements of Point CIP and DMM are not followed The Team Leader doesn't participate in the improvement processes

Figure 36 - A3 sheet: Description of the current situation

The *Ishikawa Diagram* and *5 Whys* tools were used to find the root causes for the problem. The analysis of the main causes using the *Ishikawa Diagram* are represented in the Appendix VI – Ishikawa Diagram, the root causes were found and are represented in Figure 37.

6. What are the Problems Exactly? Root Cause Analysis							N°	Root Cause
Man	Machine	Material	Method	Environment	Other			
			X				1	Lack of Standard Work for the VS Manager
			X				2	The parties involved find it difficult to find the standards
			X				3	There are no stability limits for the project's KPI's
			X				4	VS meeting is scheduled with all Owners at the same time
X							5	<i>The PDCA cycle is not followed</i>
			X				6	Lack of task management
X							7	Lack of a competency matrix
			X				8	In the System CIP Workshop the present don't know the availability of the <i>Owners</i> for the project
			X				9	Coach is an absent figure
			X				10	Team Leader is not involved from the beginning of the project
			X				11	Lack of customization in the different projects, project's complexity is not quantified

Figure 37 - A3 sheet: Problems identified

5. PRESENTATION AND IMPLEMENTATION OF IMPROVEMENT PROPOSALS

In this chapter, the improvement measures to solve the problems mentioned before will be presented. These improvements were developed based on the root cause analysis using the *Ishikawa Diagram* methodology.

Figure 38 shows the conditions to attain at the end of this dissertation by implementing different improvements in the system.

4. Condition (Future state)
Every participant in the systematic has the proper training for it, creation of a training cycle There is task management to manage the <i>Owners</i> Arrange a precise hour to the meeting of VS with each Owner The PDCA cycle is understood and followed All the VS Managers know their function and put it into practice according to the standard Eliminate the high amount of paper in the Systematic Create a standard for the project's handover for each phase All <i>Owners</i> use the standard presentation for the SC meeting Arrange the logical path of the System CIP Workshop, reducing the duration RASIC elaboration for the System CIP Approach Standard with the steps for each phase of the System CIP Approach Stability limits definition for the <i>Improvement KPI</i>

Figure 38 - A3 sheet: Future state

5.1 Standard work

This section presents the standard work documents that were missing for the systematic CIP and that were created.

5.1.1 Standard Work for the *VS Manager*

To fight the confusion towards responsibilities and roles through the systematic, the first step for the *VS Manager* standard work was the improvement of the RASIC matrix.

Although there is an existent matrix, this was general, not clear and not visible for everyone which caused ambiguity. The new matrix, Appendix VII – Improved RASIC Matrix, is divided by the different phases of the systematic and the activities are detailed and concrete.

The second stage was to define the best conduct for a *VS Manager*. The *VS Manager* can be seen has a lean leader that must be aware of the all value stream, for that s/he must constantly follow the deviations to the KPI's to know the reason why they happen and correct them. In the *VS Manager* board, there is a sheet for this follow-up, so whenever the KPI is out of target, the reason why that happen must be described so that the problems are visible. Although existent, this sheet is not correctly filled because the

motif behind the deviation is not reported that shows a lack of *Lean* culture that advocates that the problems must be visible to everyone and the pursuing for perfection a constant. Therefore, to be a *VS Manager* to the fullest s/he should:

- Know the Value Stream and its KPIs;
- Follow the deviations;
- Follow-up the task assignments for the *Owners*;
- Support the *Owner*;
- Have management skills;
- Understand each principle and element of BPS;
- Be passionate for *Lean*;
- Constantly be pursuing perfection.

Right now, the only criteria to be a *VS Manager* is to be a production head section. To improve this, it is necessary to have a competency matrix where the training needed is given to guarantee that whom is chosen is appropriate for it. This matrix will be focused in *Lean* and its tool, management, BPS elements and principles and the KPI's.

5.1.2 Standard for System CIP Workshop, System CIP Projects and Point CIP

One of the problems mentioned was the difficulty to find the standards for each phase of the *System CIP Approach* and the lack of a guide where the steps for each phase were described. To minimize that difficulty, a guide using the flowchart with the standards attached, represented by the red pins, were created for the System CIP Workshop, Appendix VIII – Standard System CIP Workshop, System CIP Projects, Appendix IX – Standard System CIP Projects , Point CIP, Appendix X – Standard Point CIP.

The System CIP Workshop is the trigger for the complete systematic but a lot of Owners don't know how it works. So it was created with the guide and instruction for it, Figure 39, where the responsible is the *VS Manager*. The first step is to map the value stream and identify opportunities for improvement. Gather all the inputs for the workshop, analyze them and prepare the workshop by arranging a room, boards, participants and the analysis' results. The workshop occurs according to the standard attached and the final step is to notify the *Owners* about the project with a maximum limit of one day after the workshop to do it.

Standard: System CIP Workshop
Responsible: VS Manager

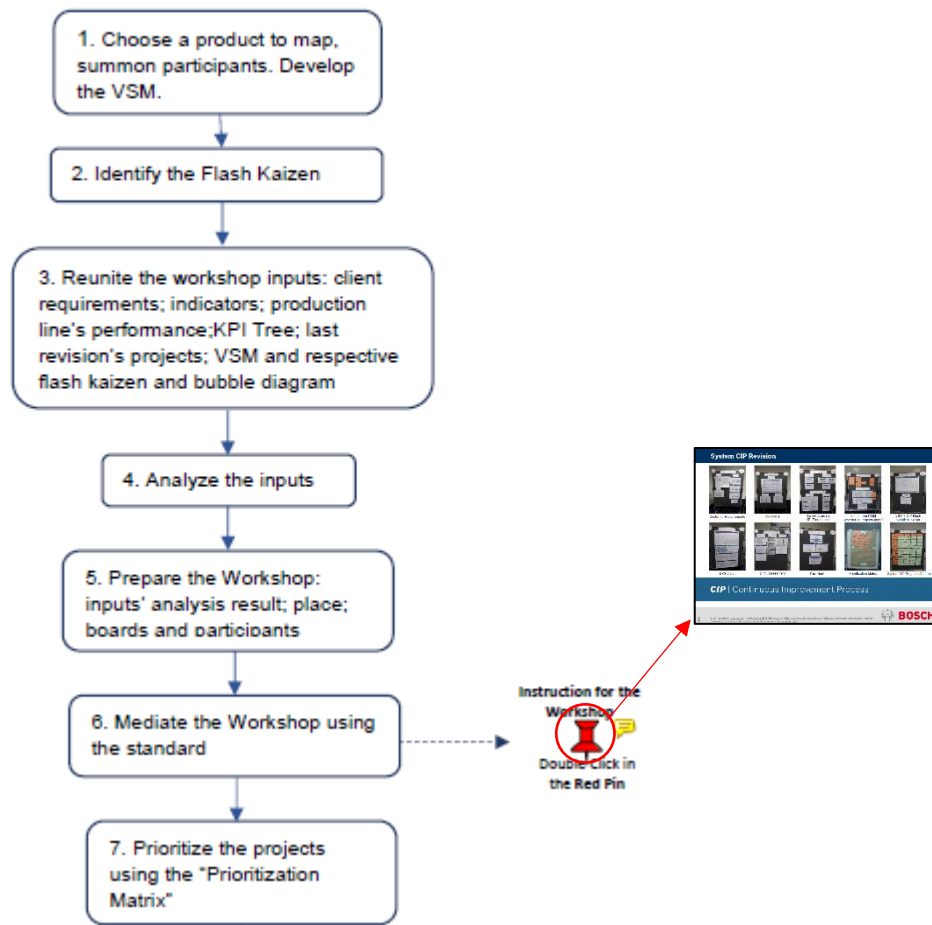


Figure 39 - System CIP Workshop's guide excerpt

Figure 40 shows an excerpt of the guide for the *System CIP Projects*. It starts with standard type and the responsible in this case the *Owner*. The first step is to form the team for the project; next s/he has to arrange a meeting with the minimum frequency of one meeting per week; then the A3 sheet needs to be filled in. Here there is a document attached represented by the red pin and if the user makes a double click in it the instructions for the A3 sheet will appear. After that, the presence in the VS meeting is required and attached there is the RASIC matrix defining the roles and responsibilities for each stage. Then it is asked which phase of the PDCA cycle is the project and the different standard presentations for the SC meeting allocated to it. The *Owner* only needs to double click in the red pin and an edible powerpoint file will open.

Standard: System CIP Projects Responsible: Project Owner

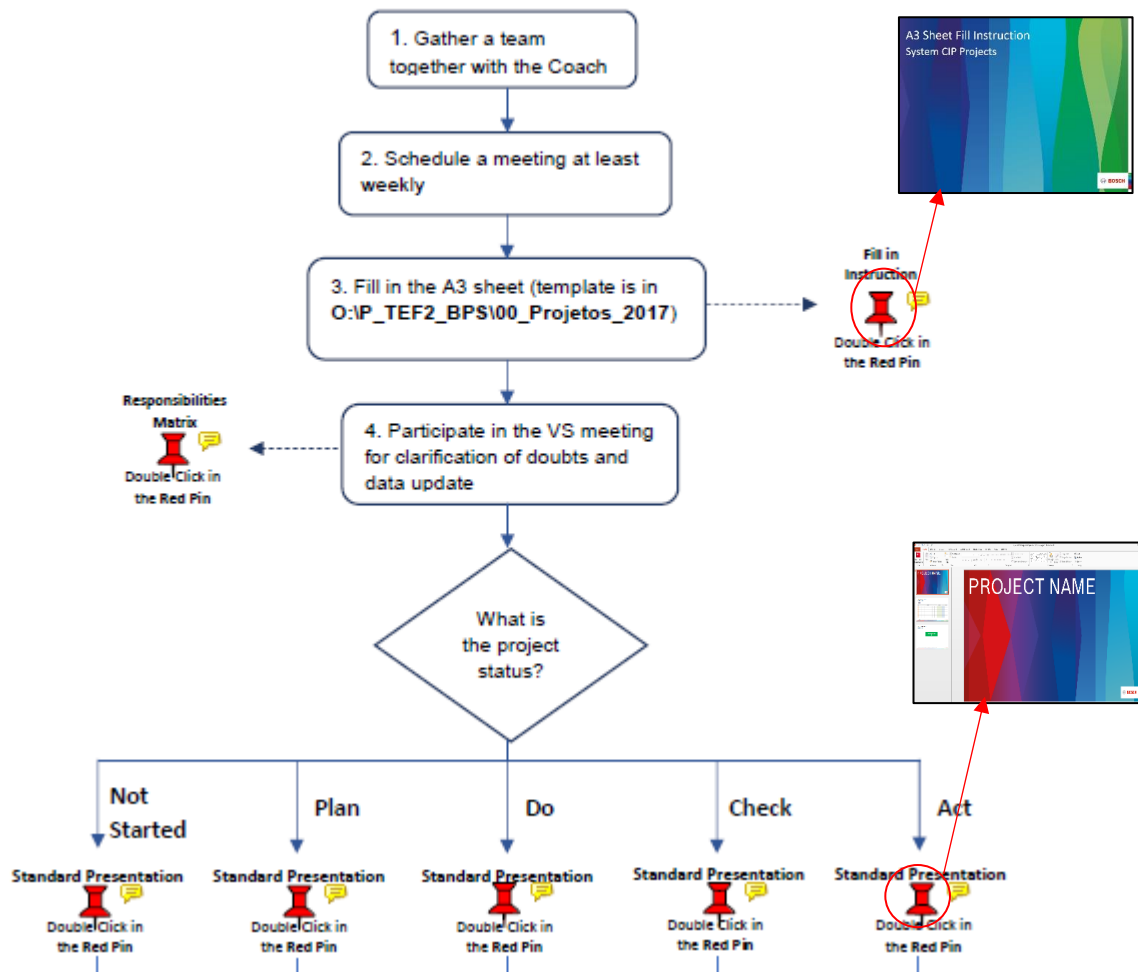


Figure 40 – System CIP Projects' guide excerpt

For the *Point CIP*, although there are templates to be filled-in through this stage, there are no instructions for it. So standards have been created for it and these are attached to the *Point CIP*'s guide, Figure 41. In the first step, the head section must explain the *Point CIP* to the *Team Leader*. Here the instruction for this phase is attached. Then the structured communication needs to be elaborated; for that the instruction is attached; the reaction limits and target condition are defined by reducing the stability criteria. The next step is the process confirmation where the standards are followed and confirmed, the instruction is attached. Then the deviations are monitored; the sheet to be filled-in is the target condition; once again the new document is attached.

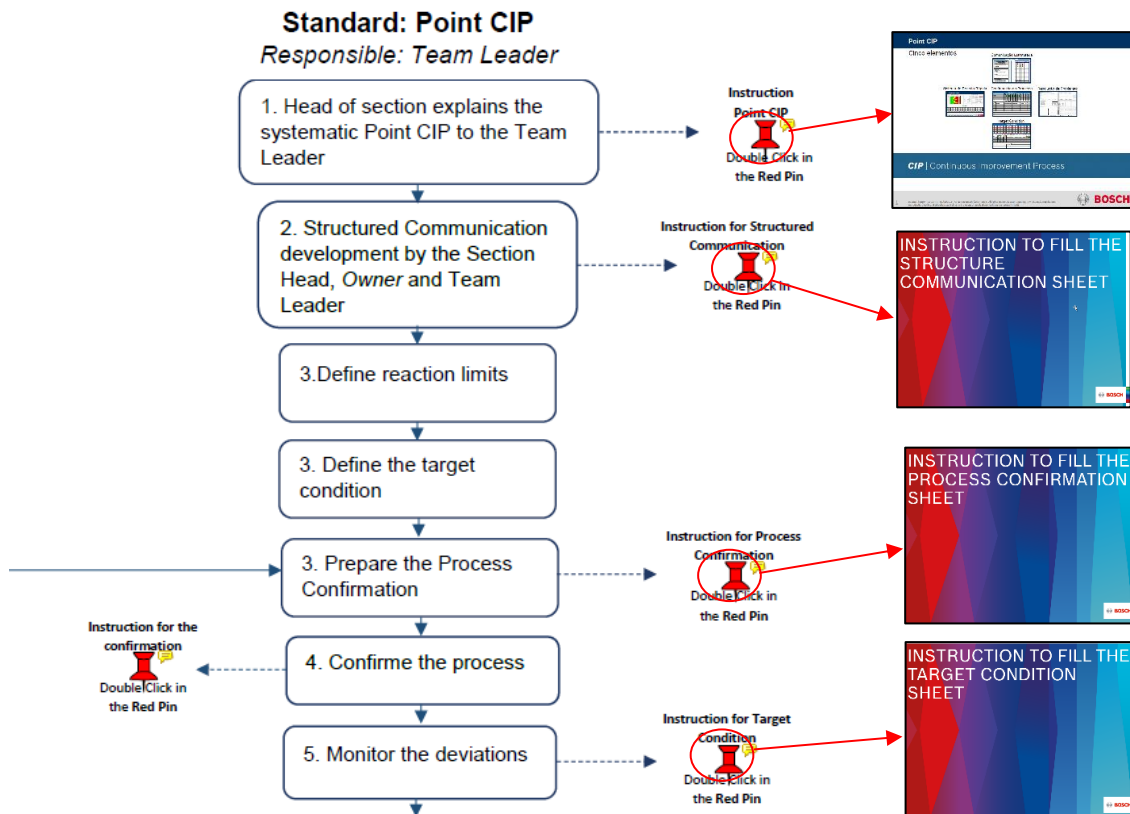


Figure 41 - Point CIP's guide excerpt

Each standard is inside the folder where the project's tools and data are inserted, which makes the standard easy to find and allocated to each step of each phase, Figure 42. The first step is to select the folder of the projects of 2017, a), then click in the folder of the project, b), select instructions and the standards will appear d).

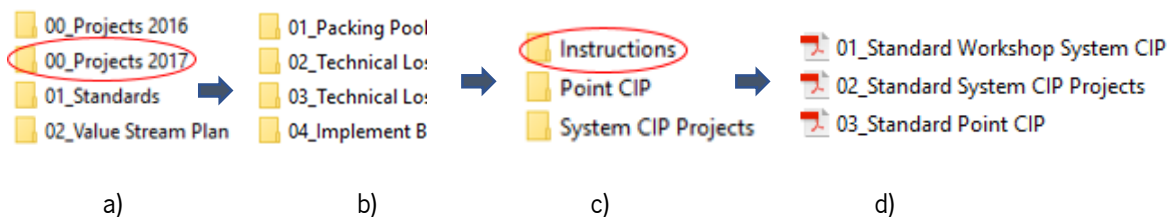


Figure 42 - Folder address for the standards

5.2 VS Meeting is scheduled separately and KPI's stability defined

After the analysis of the current situation it was perceptible that if the *Improvement KPI* had stability criteria defined in the *System CIP Projects* phase, and a more limited range for the *Point CIP*, the project would close faster. To corroborate that theory, this was applied to the B.U. of MS and the results were evident, because the project moved faster to *Point CIP* and the high frequency of the follow-up made the eventual deviations immediately corrected.

The meeting arranged with every *Owner* at the same time was a waste in waiting, so it was told to the *VS Manager* of MS to book a 5 minutes meeting with each *Owner* which resulted in no time wasted and in a more customized support.

5.3 SC Meeting standard presentation is utilized

After attending to every SC meeting, it was identified that although there are standard presentations for each stage of the PDCA cycle, these were not used because, when there were not deliverables, the *Owner* used some information that does not add value to the project to present and hide the lack of evolution in the project's execution. Analyzing the *Owners* that used the standard and the ones that did not, it was concluded that, while the ones that did spent in average 3 minutes and 40 seconds presenting the project status, the ones that did not spent 6 minutes and 48 seconds, approximately the double. This means that if everyone used the standard, the real duration for the SC meeting would be less than the planned duration, Table 9.

Table 9 - Time spent by using the standard's presentation

Time spent per presentation by using the standards	3,69 min
Average of projects per B.U.	17 projects
Average time spent in the KPI and KPR presentation	7 minutes
Total of time for the SC	$7 \text{ min} + (17 \text{ projects} \times 3,69 \text{ min}) = 69,73 \text{ min}$

5.4 PDCA cycle management and task management

This section presents the improvements implemented to achieve the PDCA cycle and task management.

5.4.1 PDCA cycle management

The PDCA was a big lapse in the systematic since the knowledge about its importance and usage was far from the ideal. To fight that, using Excel, it was also created a PDCA for the needed tasks with the respective duration allocated to them, Appendix XI – PDCA Task Management.

The PDCA management was created for the *Owners* to reduce the time spent and help them to organize the work in a time-limited of three months.

The first step is for the *Owners* to choose the project's start date, so when the document opens, the first thing to appear is a calendar for choosing the date, Figure 43.

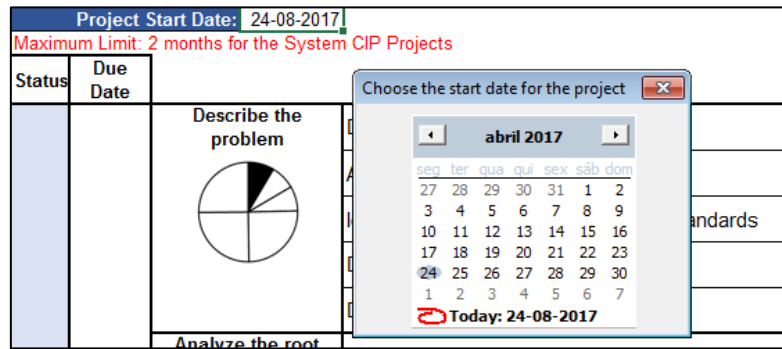


Figure 43 - Calendar from the PDCA task management

After the date chosen, the document will automatically fill-in the due date for each stage of the PDCA, according to the pre-defined duration of three months and work days, the start and end date for the task and the analysis of the comparison between the end date and the due date for the PDCA stage, Figure 44.

Project Start Date: 24-08-2017										
Maximum Limit: 2 months for the System QP Projects										
Status	Due Date			Start Date	Duration (days)	End Date	Days Remaining	Concluded	Delayed Days	Status relation with the due date
Plan	18-09-2017	<div>Describe the problem</div> 	Define the current situation	24-08-2017	1	25-08-2017	1			
			Analyze the existing standards	25-08-2017	1	26-08-2017	2			
			Identify the possible deviation to the standards	26-08-2017	1	27-08-2017	3			
			Describe the problem	27-08-2017	1	28-08-2017	4			
			Define the target condition	28-08-2017	2	30-08-2017	6			
		<div>Analyze the root cause</div> 	Collect and analyze the information	30-08-2017	2	01-09-2017	8			
			Identify the main causes for the problem	01-09-2017	1	02-09-2017	9			
			Compare the collected information with the one gathered in gemba	02-09-2017	1	03-09-2017	10			
			Stablish a cause/effect relationship	03-09-2017	1	04-09-2017	11			
			Determine the root cause	04-09-2017	1	05-09-2017	12			
		<div>Find solutions</div> 	Find solutions for the root cause	05-09-2017	2.5	07-09-2017	15			
			Define actions for each solution	07-09-2017	2.5	10-09-2017	17			

Figure 44 - Automatically filling on the document

When there is only a day remaining for concluding the task, an alert will appear to notify the *Owner* for the urgency of the task, Figure 45.

Project Start Date: 24-08-2017 Maximum Limit: 2 months for the System CIP Projects										
Status	Due Date		Start Date	Duration (days)	End Date	Days Remaining	Concluded	Delayed Days	Status relation with the due date	
Plan	18-09-2017	Describe the problem	Define the current situation	24-08-2017	1	25-08-2017	1			
			Analyze the existing standards	25-08-2017	1	26-08-2017	2			
			Identify the possible deviation to the standards							
		Analyze the root cause	Describe the problem							
			Define the target condition							
			Collect and analyze the information							
			Identify the main causes for the problem							
			Compare the collected information with the one gathered in <i>gemba</i>	02-09-2017	1	03-09-2017	10			
			Establish a cause/effect relationship	03-09-2017	1	04-09-2017	11			
			Determine the root cause	04-09-2017	1	05-09-2017	12			
		Find solutions	Find solutions for the root cause	05-09-2017	2.5	07-09-2017	15			

Figure 45 - One day remaining alert

The *Owner* only has to fill the “Concluded” column with a “1” when the task is finished. After that, the delayed days are summed in the “Delayed Days” column, Figure 46.

Start Date	Duration (days)	End Date	Days Remaining	Concluded	Delayed Days	Status relation with the due date
24-08-2017	1	25-08-2017	0	1	0	

Figure 46 - Task concluded and number of days in arrears

If the end date respects the due date of the PDCA stage, i.e., if the end date is previous to the planned due date for the PDCA stage, the status will return the green color. Otherwise, it will return the red color, Figure 47.

Project Start Date: 09-08-2017 Maximum Limit: 2 months for the System CIP Projects										
Status	Due Date		Start Date	Duration (days)	End Date	Days Remaining	Concluded	Delayed Days	Status relation with the due date	
Plan	01-09-2017	Describe the problem	Define the current situation	09-08-2017	1	10-08-2017	0	1	14	
			Analyze the existing standards	24-08-2017	1	25-08-2017	1			
			Identify the possible deviation to the standards	25-08-2017	1	26-08-2017	2			
		Analyze the root cause	Describe the problem	26-08-2017	1	27-08-2017	3			
			Define the target condition	27-08-2017	2	29-08-2017	5			
			Collect and analyze the information	29-08-2017	2	31-08-2017	7			
			Identify the main causes for the problem	31-08-2017	1	01-09-2017	8			
			Compare the collected information with the one gathered in <i>gemba</i>	01-09-2017	1	02-09-2017	9			
			Establish a cause/effect relationship	02-09-2017	1	03-09-2017	10			

Figure 47 - Status relation with the due date of the PDCA stage

5.4.2 Daily Management Board

One of the biggest problems identified was the lack of training, support and follow-up for the project execution and stabilization, so a board for daily management was developed for the MainTeNance (MTN) department, to test the systematic and stabilize it, Figure 48, always focused on the continuous improvement.



a)

b)

Figure 48 – Daily Management Board a) Initial b) Current

This board is divided in four different parts: competency matrix, personal indicators, daily responsibilities management and PDCA activities and attendance.

This visual management board was supported by a daily meeting with a maximum duration of 5 minutes between the *Coach* and *Owners*.

5.4.2.1 The Paper Prototype

The first step to develop this board was to make sure that everyone that was involved in the systematic participates in its development and improves it. For that, it was created a paper prototype, Figure 49, and it was arranged a meeting that aimed the exchange of ideas.



Figure 49 - Daily management board paper prototype

5.4.2.2 Competency Matrix

The training was a big lapse in this systematic since the *Owners* start the project without having the ability for it. Firstly, it was defined the essential skills needed for an *Owner* to succeed. These were:

- **Basic Principles of BPS:** the principles of *Lean* applied to Bosch; it is necessary a paradigm change to understand the *Lean* culture and apply it to the projects;
- **System CIP Approach:** the different phases and what is needed to successfully conclude a project. This is essential because the *Owner* needs to understand what is required and the reason behind the systematic to execute it properly;
- **KPI and KPR:** key performance indicators and key performance results, since the *Owners* must analyze the project's evolution based on them;
- **A3 sheet:** the main tool for the project execution since it organizes the logical thinking for a structured problem-solving;
- **PDCA Cycle:** There is no A3 sheet without a PDCA behind it; the *Owner* has to master the PDCA cycle to understand the easy steps to solve the problem;
- **Quality tools:** *5Whys*, *Ishikawa Diagram*, *Histogram* and *Pareto Analysis*. These indispensable tools support the systematic.

A competency matrix was developed to trigger a training cycle. Each topic has a square divided into four steps, the four steps of knowledge Figure 50.

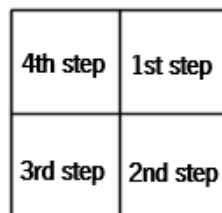


Figure 50 - The four steps of knowledge comprised by the square

- 1st step: Has training: The *Owner* attains this level when he had the training about the topic
- 2nd step: Can do it under supervision: the person is able to do it but under supervision
- 3rd step: Autonomous: is autonomous to put it into practice
- 4th step: Able to give training: is completely autonomous to give training about the topic. After this step the training cycle starts.

The one that gave the training is responsible to check in the planned date if the trainee is fit to move to the next step.

5.4.2.3 The Dot Game

The first training covered the basic principles of BPS, System CIP Approach, KPI and KPR. There was a need for a different and dynamic workshop. For that a game based on the “Dot Game” that highlights the principles of *Lean* and hence BPS was developed.

The goal of the game was to learn by doing the importance of the *5S*, *Poka-Yoke*, *Standard Work*, *One-Piece-Flow* and *Levelling*.

This simulated a factory with six operators that produced paper with different stickers, Figure 51. Operator 1 was responsible for passing the blank pieces of paper; operator 2 was responsible for sticking the blue triangle and operator 3 the yellow triangle; operator 4 was responsible for sticking the red dots carefully to guarantee that these didn't overlapped; operator 5 stuck the green dots in both sides; and operator 6 was responsible for checking the quality and recognize the defects; it was considered a defect when the triangle was backwards, the red dots overlapped and the stickers were close to the edges.

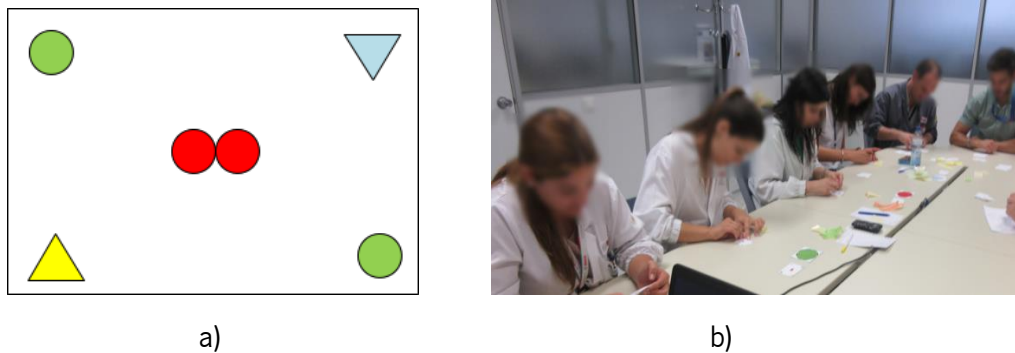


Figure 51 – a) Final product b) The product being produced

This simulation occurs in three different rounds each with 5 minutes. In the first round:

1. It was told verbally to the “operators” their function and how the paper should be;
2. Each station had the different stickers mixed;
3. The lot size was fixed in 6, i.e., the operator passed 6 pieces of paper and only after the 6 pieces accumulated through the station the next “operator” could start.

After each round, some data was gathered to draw some conclusions, as represented in Figure 52. These were the number of completed papers; from that the number that were OK, i.e., the ones that had no defect; then the ones that had a defect. Different times were measured; the time for the first batch to be delivered to the client was timed to compare it to the cycle time, which is the time needed to produce a product, the time between the first process and the last. This calculation was made by dividing the WIP by the throughput justifying the *Little's Law* that says that the cycle time and the stock have a

proportionality relationship (Little & Graves, 2008). The throughput is how many pieces can be produced per minute, which is calculated by dividing the number of pieces without defect by the 5 minutes.



Figure 52 - Discussion at the end of each round

For the first round, the values are represented in Table 10.

Table 10 - Results of the first round

N° of completed papers	N° of Papers OK	N° of papers w/ defect	WIP	Time for the first lot to be delivered to the customer	Throughput (N° papers OK/ 5 min)	Cycle Time (WIP/ Throughput)
6 uni	0	6 uni	36 uni	5 min	0	-

After the data gathered it was asked to the *Owners* the possible improvement measures to increase the output for the client in the limited 5 minutes period. The first suggested to measure the standard work for the paper, since the information got lost and hence the defect rate was high and there was no product delivery to the customer.

The second was the need for *5S*s since there was a high waste of time searching for the right stickers. The last was the lot reduction to decrease the WIP.

For the second round the conditions were:

1. Each station only had the required material;
2. The standard, Figure 51 a), was placed in each station;
3. The lot size was reduced to three; operator 1 passed three pieces of blank paper at a time and the next operator could only continue to work if the three units were assembled by the previous station and so on.

The conclusions for this round are represented in Table 11.

Table 11 - Results of the second round

N° of completed papers	N° of Papers OK	N° of papers w/ defect	WIP	Time for the first lot to be delivered to the customer	Throughput (N° papers OK/ 5 min)	Cycle Time (WIP/ Throughput)
15 uni	9 uni	6 uni	28 uni	2 min 26 sec	1,8 uni/min	23,3 min

Here it was noticeable an increase in the output for the client with 9 units without defects, approximately two units were produced per minute. The WIP decreased and although the time for the first batch to be delivered to the client was done in 2 min and 26 seconds; the cycle time was 23,3 min, which translates the existent problems with the project, for example the high level of WIP.

Once again it was asked to the *Owners* which were their suggestions for the next round. The *Poka-Yoke* was rapidly mentioned, the levelling of the line where the operators were reduced to three:

- Operator 1: yellow triangle and a green dot in the superior left edge;
- Operator 2: blue triangle and the green dot in the bottom right edge;
- Operator 3: the two central red dots.

Here the operator responsible for the quality control was eliminated and that function was executed by each operator, *Jidoka*.

So for this last round:

1. Each station only had the required material;
2. The standard, Figure 51 a) was placed in each station;
3. The blank paper was replaced by a *Poka-Yoke* with each sticker's position identified, Figure 53.

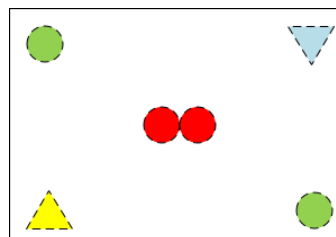


Figure 53- *Poka-Yoke* for the production to avoid defects

4. The lot size was reduced to one, *One-Piece-Flow*.

This last round values are represented in Table 12.

Table 12 - Results for the third round

N° of completed papers	N° of Papers OK	N° of papers w/ defect	WIP	Time for the first lot to be delivered to the customer	Throughput (N° papers OK/ 5 min)	Cycle Time (WIP/ Throughput)
23 uni	23 uni	0	3 uni	27 seconds	4,6 uni/min	39 seconds

The presents were astonished by the results. The WIP was reduced to three units with an output of 23 units, an increase of 53% comparing with the last round. The time for the first batch to be delivered, 27 seconds, was close to the cycle time, which shows the waste reduction.

Comparing the productivity per person from the last round, this increased from 1,5 to 7,7 units p/person. From this game, the message was clearly understood by the *Owners* and the gains by applying *Lean* thinking were shown. After the game, the *System CIP Approach* and *KPI/KPR* were explained.

5.4.2.4 A3 sheet and PDCA Cycle

The next topic was the A3 sheet and PDCA cycle. For this training, the *Owners* were divided in three groups and it was created an imaginary company “Parpel” that produced paper airplanes. The problem for this company was that the clients complained that 60% of the airplanes didn’t fly. After describing the conditions for the plane construction and the type of delivery, the A3 sheet had to be filled in aiming the problem-solving, Figure 54 a). Once again, learning by doing was the key. The difficulties were clarified and in the end the responses were compared and a brief explanation was made, Figure 54 b).



Figure 54 - A3 sheet and PDCA training a) Owners filling-in the A3 sheet b) Brief explanation

The quality tools were left to the responsibility of the human resources department to “push” the *Lean* training in the company.

The *Owners* that were present in these trainings have the first step filled in and have now a planned date for the next step, can do it under supervision. That is represented in Figure 55. Here, the verification of the next step involves giving training to others, that is, they learned the topic and are able to give training

under supervision. Every step of the square has to have a planned date to make sure the cycle will not stop.



Figure 55 - Competency matrix
(In Portuguese)

5.4.2.5 Owners' Performance Indicators

For a daily management is necessary to have personal indicators for each owner to measure the performance. The first indicator is the *Owner's* availability for the project, Figure 56, to guarantee that s/he is not overloaded with tasks. The aim was to induce the *Owners* to define an agenda with time dedicated to the project.

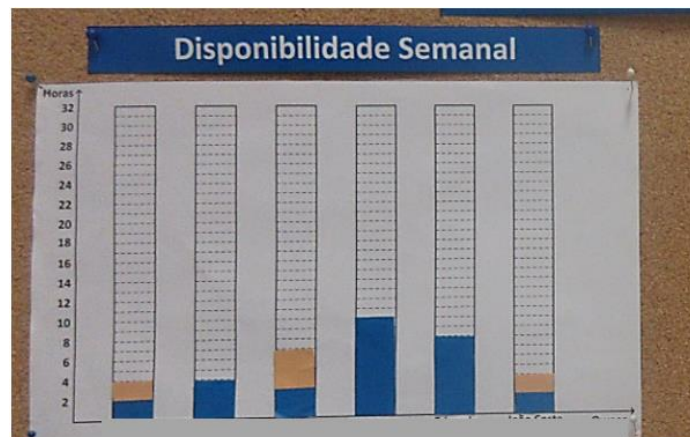


Figure 56 - Personal availability for the project
(In Portuguese)

The overdue tasks were registered and summed each month to give the evolution through time where the different colors represent the different months, Figure 57 a) and b) respectively.

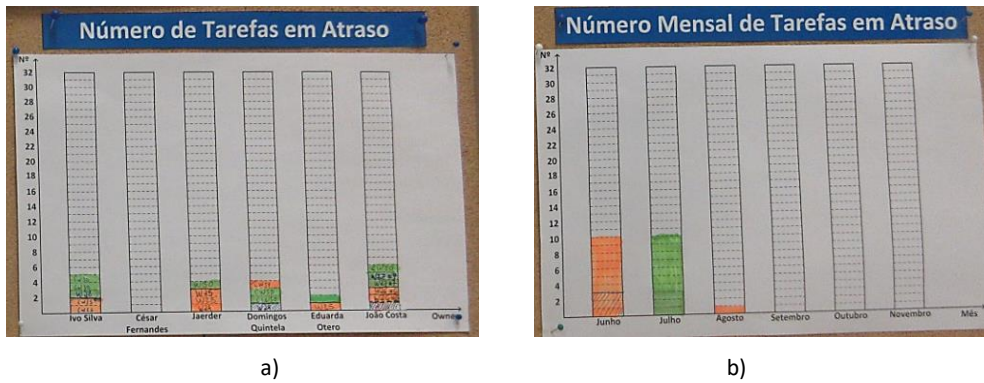


Figure 57 - Overdue tasks a) per owner b) per month
(In Portuguese)

The biggest paradigm's change was for the *Owners* to understand that the count of overdue tasks were not to prejudice him/her but to help the *Coach* notice whom is having difficulties and needs support.

In order to track the reasons behind the delays of the task, it was created a follow-up table with the task number, the reason behind it and proper action to solve it and the planned duration for the task and the real one, Figure 58. This aims to make the barriers for the task conclusion visible and to fight them based in the 7th and 14th principle of TPS to make the problems visible and learn with them.

Figure 58 is a table titled 'Follow-up das Tarefas em Atraso'. The table has 6 columns: Projeto, Nº Tarefa, Responsável, Motivo do Atraso, Ação Corretiva, and Data de Conclusão. The table is empty, with only the header row filled in.

Figure 58 - Follow-up of the overdue tasks
(In Portuguese)

5.4.2.6 Daily Responsibilities' Management

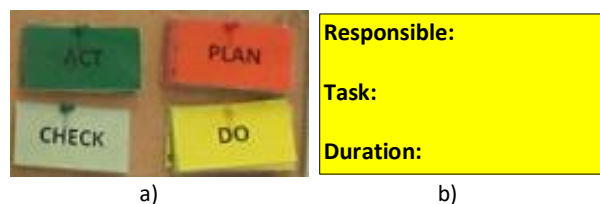
For the daily follow-up of the tasks allocated to a project, the daily responsibilities management was created. Once again and always following a continuous improvement culture, the board evolved Figure 59 a) to b).



a) b)
Figure 59 - Daily responsibilities management a) Initial b) Current

In the daily responsibilities management it's necessary to specify:

- **Owner's name:** the name of the *Owner* that has a project inserted in the *System CIP Approach*;
- **Project's name:** name of the project and respective B.U.; a *Owner* can have more than one project so the color blue and yellow are related to the availability graph in the personal indicators Figure 56;
- **Days of the week:** here is where the tasks are planned; the card is placed in the planned date to conclude the tasks. Each card has one color depending on the phase of the project, *Plan*, *Do*, *Check* or *Act*, Figure 60 a). In this card, every Friday the *Owner* has to plan the next week tasks for that he writes the responsible for the task execution, the task description and its duration, Figure 60 b). This duration, if the *Owner* is responsible for the task, is then compared with the availability graph to guarantee that doesn't exceeds it;



a) b)
Figure 60 - a) Colors for each phase of the PDCA cycle b) Card necessary data

- **Overdue tasks:** if the task's conclusion exceeds the due date, the card moves to the overdue tasks column where it remains until a new date is planned. The overdue tasks graph is updated while the card remains in the overdue tasks column. The reason behind the delay is written down in the follow-up of the overdue tasks, the justification and action are analyzed every Friday;
- **N+1:** the cards are placed in this column when the task is planned for the next week where "N" is the current week and "N+1" the next.

If the project attained its target condition, i.e., if a standard is implemented and the improvement KPI is inside its stability criteria, a green arrow up is placed in the project card; and if the project is in the Point

CIP stage, a green dot is placed Figure 61 a). If the target condition wasn't attained a red arrow is positioned, Figure 61 b). With this is possible to see how the project status is.

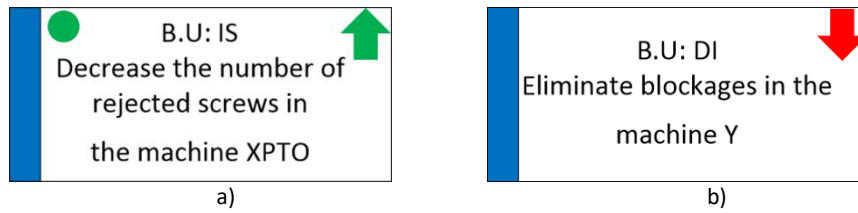


Figure 61 - Project card a) The target condition was attained b) The target condition was not reached

This meeting is mediated by the *Coach* that is responsible for ensuring that the project is being successfully executed. For that it was created a flowchart with the different situation and how the *Coach* should react, Appendix XII – Flowchart Coach.

To clearly understand the needed deliverables for each phase of the *PDCA* cycle, the different activities for each phase were identified, Appendix XIII – PDCA Activities.

To assure the *Owners* and *Coach's* attendance, a presence sheet was placed in the board. After the analysis of the sheet, it was noticed that there were a high percentage of presences, 92%. In average, each member had two absences through the 16 days analyzed.

For this improvement to remain is necessary to create a standard for it. The standard, that is, instructions for the board, can be seen in the Appendix XIV – Standard Daily Management Board, and it is available for every participant in the systematic inside a common folder.

5.4.3 Weekly Management Board

To attain a structured and time-reduced VS meeting, a management systematic was created. This systematic evolve from a task management, Figure 62 a) similar to the daily management board to an one single board containing every point necessary for the project management Figure 62 b).



Figure 62 - Weekly management board a) First Prototype b) Current

This board is divided in three different parts: the weekly task management, project follow-up and project's race.

By the analysis of Figure 62, the evolution is noticeable. In the first try, the tasks were followed and, simultaneously, the project's sheet had to be filled-in, which originated a confusing and unorganized meeting with two focus points, the board and the sheets. This created a longer meeting and the problem with the large number of sheets remained and the board's aim wasn't accomplished, which was to make the meeting organized, the *Owners* motivated, to make sure that the PDCA cycle is followed and the time of the meeting reduced. To attain that, a new version was developed to assure that all of the elements present in the project's sheets were represented in the board.

The first column is the *Owner's* name and the project allocated to her/him. The project card has all the elements present in the project's sheet as shown in Figure 63.

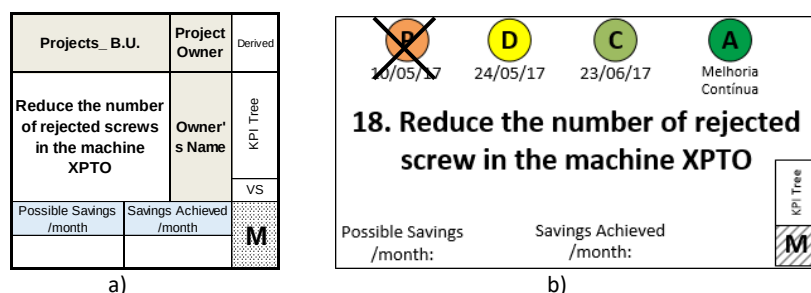


Figure 63 - Header of the project a) Project sheet b) Project card

The new card has, in addition, the due date for each phase of the PDCA cycle; the X means that the due date was outdated according to the time limited by the two months target for the *System CIP Projects* and one month for the *Point CIP*, to incrementally attain the level 3 of the BPS assessment, Figure 64. Although the target for level 3 is one month, the better way to do it is slowly set challenging targets to continually consolidate the improvements achieved.

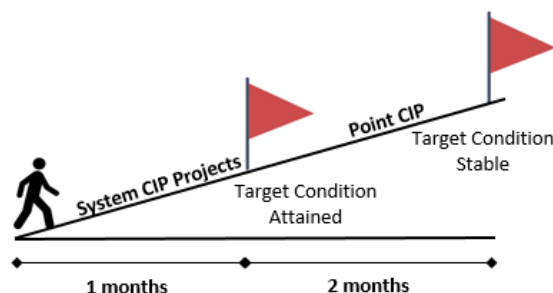


Figure 64 - Level 3 of the BPS assessment for the System CIP Approach

The project header is represented in the card; for the *Improvement* and *Monitoring KPI* two extra columns were inserted in the board with a graph for each KPI, Figure 65, where the green line is the target defined for the KPI and the dashed line is the stability criteria for the KPI. There is only the maximum limit, because in the case of the example, the aim is to reduce the number of screws with defects from 204 to 40, so the 42 is acceptable; the objective of having a minimum limit is because if the *Improvement KPI* is lower than the limit, it is necessary to study why that happen in order to maintain the conditions.

Unfortunately, the culture is not directed for that so it's better to have incremental improvement to slowly consolidate it.

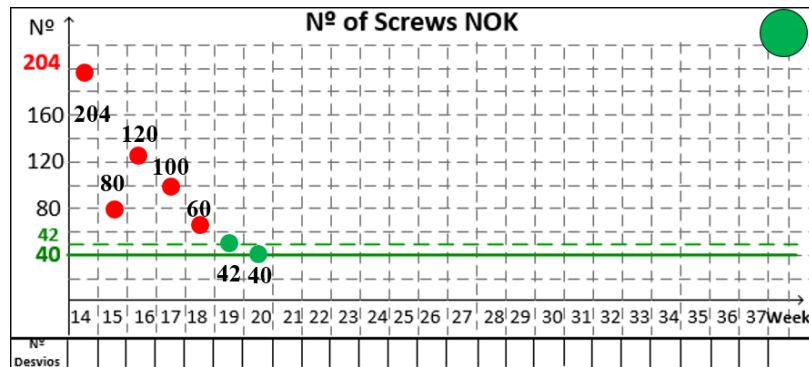


Figure 65 - Improvement KPI in the board

One of the aims of the projects inserted in the *System CIP Approach* is to improve the process and hence the company's *Monitoring KPI*. Different projects with different *Improvement KPI* can contribute for the same *Monitoring KPI* so it's mandatory for the board to translate that direct relationship. If an indicator is inside the target that week, a green dot is stick in the graph, otherwise a red dot is placed. In Figure 66, a section of the board where there are three different projects with respective *Improvement KPI* contributing for the same *Monitoring KPI* is represented. The three *Improvement KPIs* are inside the target as well as the *Monitoring KPI*, a direct relationship between the KPI's.



Figure 66 - Section of the weekly management board

Adding to the KPI's columns, a standard column was created where each action, inserted in the *Do* stage, that had impact in the problem, is described. The responsible for the implementation is identified, the number of the implemented standard placed and the signature, if it is approved by the *VS Manager*, Figure 67.

Task: Change of the screw X for the screw Y
(VS Manager signature)

Due Date: CW22 (João) ①

Figure 67 - Standard's card

By placing every part of the project's sheet in the board, the sheets for the projects and standards are eliminated giving free space in the board as shown in Figure 68. This space can be used, for example, to develop a more detailed KPI Tree with the reasons behind an out-of-target KPI to facilitate the identification and correction of the causes of these deviations.

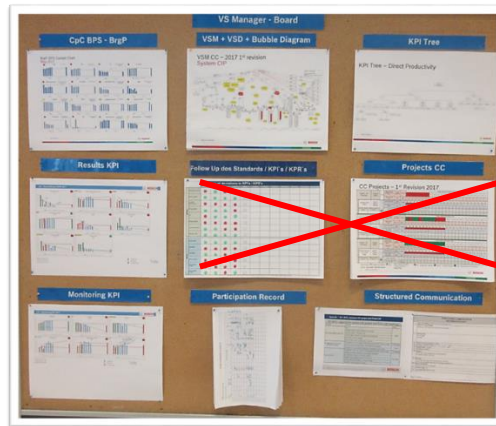


Figure 68 - VS Manager board after the weekly management board

This board was also used for the SC meeting where the follow-up of the projects was simplified. With a board, the evolution of the project is clear and the distinction between who is working in the project and who is not is clear. Make the problems visible, 7th principle of TPS. So, whoever is participating has access to the difficulties of the *Owner* by analyzing the planned and overdue tasks and can give the support needed.

5.4.3.1 Weekly Task Management

There was a clear difficulty to follow the *PDCA* cycle for the project's execution, which originated high lead times to conclude a project since there wasn't a logical path to solve a problem. The "let me try and see what it will happen" attitude originated high monetary and time waste. To fight this, a "Poka-Yoke" was created for the cycle; that is a mechanism to avoid the jumping between phases, to help the *Owners* to remain on track. That "Poka-Yoke" is the weekly task management in which the activities pre-defined are inserted in each phase of the *PDCA* cycle, with the *VS Manager* mediating and guaranteeing that it can only move to the next activity if there are deliverables for the current.

The planning for the week occurs every Wednesday in the VS meeting. The *Owner*, according to the phase where the project is inserted in the *PDCA* cycle, choses a color and defines the activity and respective due date, using the pre-defined activities for the *PDCA*, Figure 69. The *VS Manager* must guarantee that the *Owner* has deliverables every week. If a task is delayed, the planned date is crossed and the new date

is written. This will make the problems visible always having the first planned date to compare and quantify this delay.



Figure 69 - Task's cards according to the PDCA cycle

The first day to appear in the board is Wednesday because, as mentioned, this is the day where the week is planned, so for this task management, the week starts on Wednesday goes on to Thursday, Friday, Monday and Tuesday. So, on Wednesday, the tasks for the next week will be planned and the Monday and Tuesday's task if concluded are removed and a new card for the next week is placed. The tasks planned for the Thursday and Friday can only be verified in the next week. The weekly task management is represented in Figure 70.

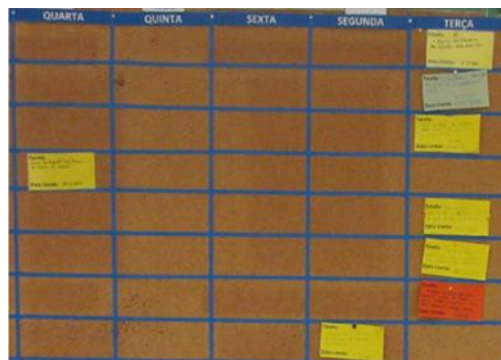


Figure 70 - Weekly task management

5.4.3.2 The Race of projects

The *Owners* are demotivated. One of the best ways to motivate people is to create competitiveness, even if it is a friendly one. For that reason, it was created a race of projects where each car represents a project, Figure 71.



Figure 71 - Project's race

The car can be green, Figure 72 a) or red, Figure 72 b) depending if the project is within the due date for each phase or not, respectively.



Figure 72 – Car with the project's number

The race line represents the different deliverables with the needed duration to attain them inserted in the two months defined. This line is divided in four sub-goals, the first barrier to cross is the target condition definition and the root causes identification. For that, the planned duration is 17 days, then more 13 days to define the actions to fight the root causes. These two barriers are inserted in the *Plan* phase. For the *Do* phase, the requirement to move to the next stage is to have the target condition reached in 10 days, that is, having standards implemented and the *Improvement KPI* within the stability criteria. After this, the car moves on to the stabilization stage, *Point CIP*, where the goal is to stabilize the target condition by following it during 22 events. After the stabilization, the project moves to *DMM. Act* in the PDCA cycle and the continuous improvement will start a new cycle.

5.4.3.3 Weekly Management Board in the SC meeting

The SC meeting projects' follow-up was made using the *VS Manager* board where the sheets were passed and the project status was not immediately visible since the sheets were small and there was not a comparison between the projects because they were represented in different sheets, Figure 73.



Figure 73 - SC meeting before the *Weekly Management Board*

The *Weekly Management Board* supports the meeting, where it is possible to see who is working and who is not, by analyzing the overdue tasks and the *Improvement KPI* status. The visual management is direct and with the project's race, the comparison between the projects is transparent, Figure 74, being possible to give the support needed to those who need it.



Figure 74 - SC meeting being supported by the board

For this improvement to remain is necessary to create a standard for it. The standard, that is, instructions for the board, can be seen in the Appendix XV – Standard Weekly Management Board and it is available for every participant in the systematic inside a common folder.

5.5 Synthesis of the standards implemented

The next step in the A3 sheet, the *Do* stage, is to describe the standards implemented and relate them to the root causes they had impact on, Figure 75.

7. Standards / Actions that had impact					
Nr. Of the root cause	Standard		Standard Description	Application Area	Week
	Proj.	Point CIP			
1	X		Develop a standard work for the VS Manager	All B.U.	CW14
2	X		Guide for System CIP Projects and Point CIP with the standards attached	All B.U.	CW14
3	X		Definition of stability criteria for the Improvement and Monitoring KPI	MS and IS	CW14 and CW28
4	X		Each VS Manager arranges a precise hour with the different Owners	IS and MS	CW14
5	X		PDCA Management, task definition for each stage	All B.U.	CW14
5.1;6.1;7;8 and 9	X		Daily Management Board	MTN department	CW24
7	X		Create a training cycle where everyone involved has the proper formation for it	MTN department	CW28
5 and 6	X		Weekly Management Board	IS	CW23

Figure 75 - A3 sheet: standards implemented related with the root causes found

6. RESULT ANALYSIS AND DISCUSSION

In this chapter, the results obtained or expected are analyzed and discussed. Some of the measures mentioned were implemented, some weren't. Since the PDCA task management was only developed in the week 30, it did not make sense to put it into practice because the revision is almost finished, so it is expected to implement it in the next revision starting in September. The measures implemented throughout the company were the standard work for the *IS Manager*, the PDCA's activities definition and the different guides with the standards attached for the *System CIP Approach*. The *Daily Management Board* and the start for the training cycle were only implemented in the MainTeNance (MTN) department. The IS and MS started to set a specific hour with each *Owner*. The data gathered is from the 1st revision of 2017, that isn't concluded yet; one month is left, so the results can improve meanwhile.

6.1 Stakeholders' satisfaction with the improvements

The first and main step was to see whether the people involved felt that the improvements had an impact on the problem or not. For that, it was created satisfaction surveys for the *Daily* and *Weekly Management Board*.

6.1.1 Daily Management Board impact

For the *Daily Management Board*, it was asked to the *Owners*, Appendix XVI – Satisfaction Survey for the Daily Management Board, how they felt that the board impacted the project's execution. For that a questionnaire with different degrees of agreement was created, where the lowest, 1, is when the participant strongly disagrees with the affirmation and the highest, 4, is when the participant completely agrees with the statement.

The results are represented in Figure 76, where the answers of the 6 *Owners* to the 12 questions are gathered.

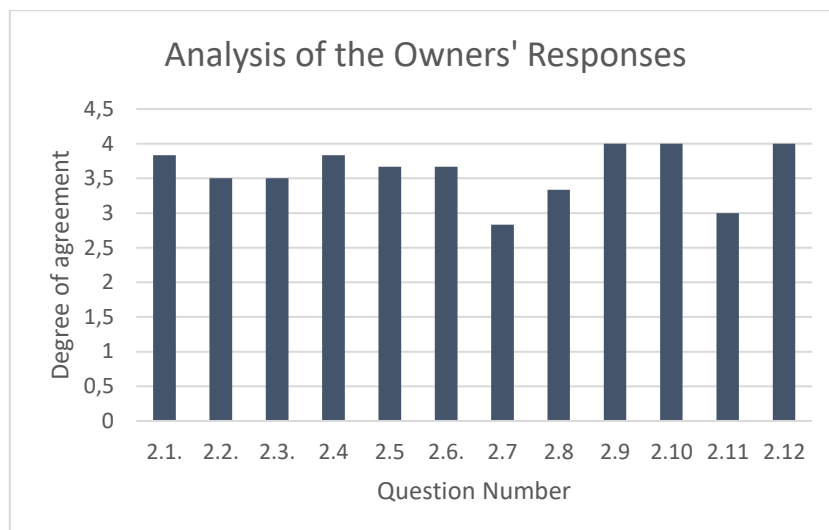


Figure 76 - Analysis of the Owners' responses for the Daily Management Board

By the analysis of the graph, it can be concluded that all *Owners* felt more motivated for the projects' execution. They agree that the visualization of the project's status is simplified and considered it an advantage for their department and that it should be applied to others. Overall, the responses were very positive and translated the *Owners'* satisfaction with the systematic.

A different survey was created for the *Coach*, Appendix XVI – Satisfaction Survey for the Daily Management Board.

The survey's result are in Figure 77 where the *Coach* answered to six different questions about the Daily Management Board.

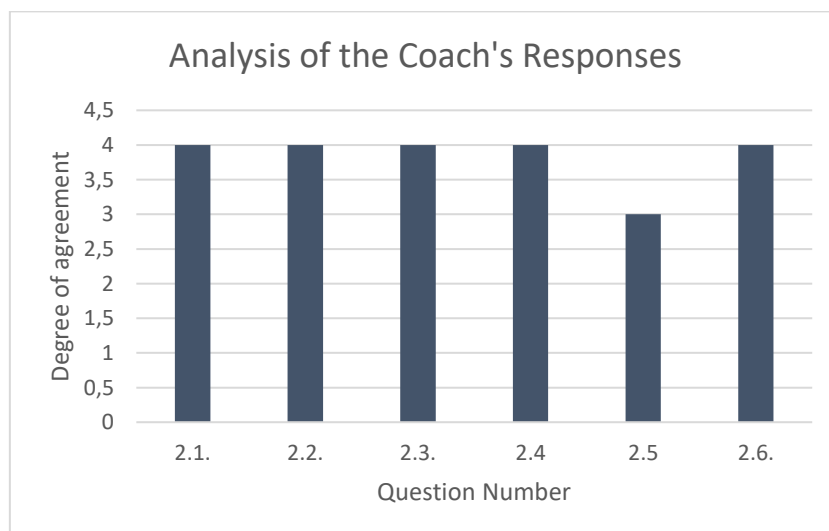


Figure 77 - Analysis of the Coach's responses for the Daily Management Board

When analyzing the graph, it is clear the *Coach's* satisfaction with the systematic, where he notices the *Owners'* motivation. Also that the lead time for the project can be reduced and that the systematic should

be applied to other areas as well. In general, the responses were favorable with the satisfaction echoed in the surveys and the thought of applying the systematic to other areas was common to every answer.

6.1.2 Weekly Management Board impact

To understand how the people were affected by the *Weekly Management Board* it was developed a survey for the *Owners* and the *VS Manager*, Appendix XVII – Satisfaction Survey for the Weekly Management Board.

This survey was made on a sample of 10 *Owners* and the IS's *VS Manager*. The *Owner's* responses are gathered in Figure 78.

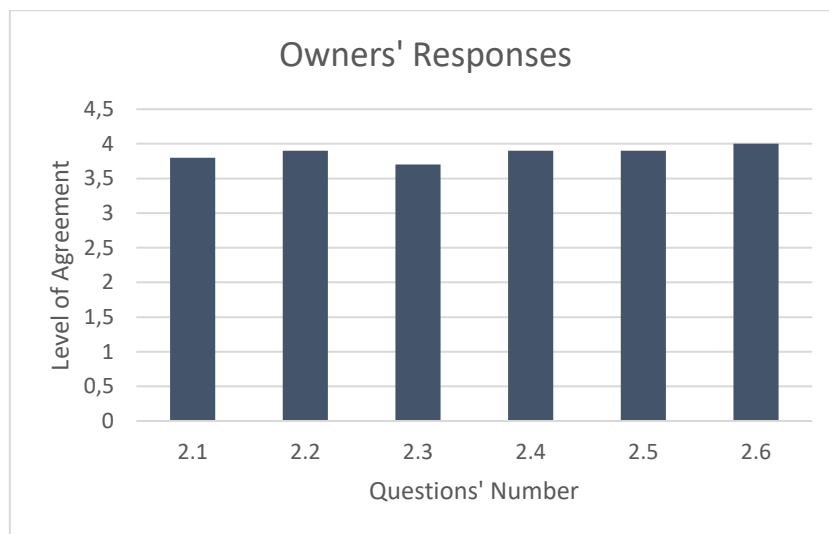


Figure 78 - Analysis of the Owners' responses for the Weekly Management Board

The results are positive, where the gratification with the board is clear with the level of agreement higher than 3,5 in every response.

The other client for the board is the *VS Manager*, so a different survey was developed to follow his perspective, Figure 110.

The VS Manager's responses were gathered and are represented in Figure 79.

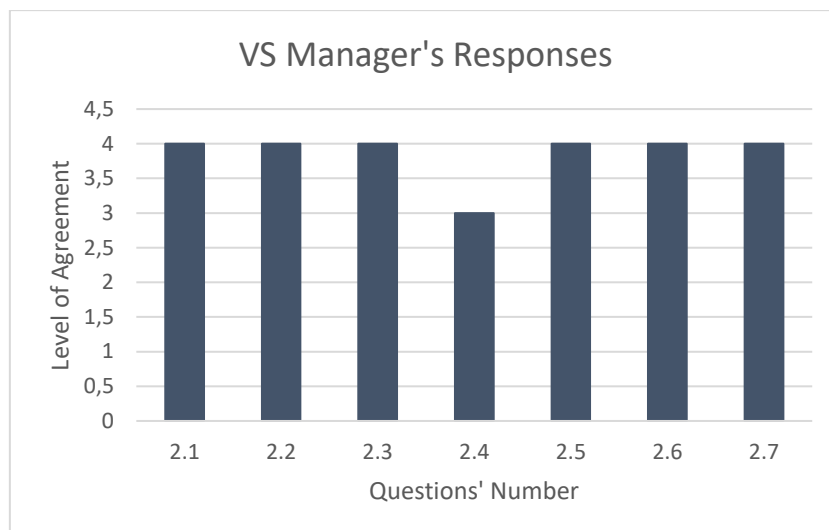


Figure 79 - VS Manager's responses for the Weekly Management Board

The satisfaction is noticeable by the analysis of the VS Manager's responses. The agreement level is in the maximum, 4, for the Owners' motivation, the visual management and meeting management facilitation, the project's lead time and meeting's duration reduction and it's unanimous that this systematic should be applied to other areas. The only question with a lower level is the problems visualization. Although agreed the visualization of the status is easier, the problem behind it is not immediately visible.

6.2 Benefits of the standardized process

There is no improvement without a standard, this can be applied to everything. This systematic is no exception. By creating a sustainable guide for each stage of the *System CIP Approach* with the standards attached and accessible for every participant in the systematic it's guaranteed the longevity of the correct steps to be followed in each phase.

With the RASIC matrix and standard work, the improved, concrete and objective definition of roles and responsibilities clarifies the function of each participant, in each stage, which makes it easier to identify deviations to the expected result.

6.3 Decrease in the number of neglected projects

One of the problems identified were the projects neglected through the System CIP revision, that is, projects that were not started. In Figure 80, there is the relationship between the number of projects neglected from the last revision, 2nd revision of 2016 and the current, 1st revision 2017.

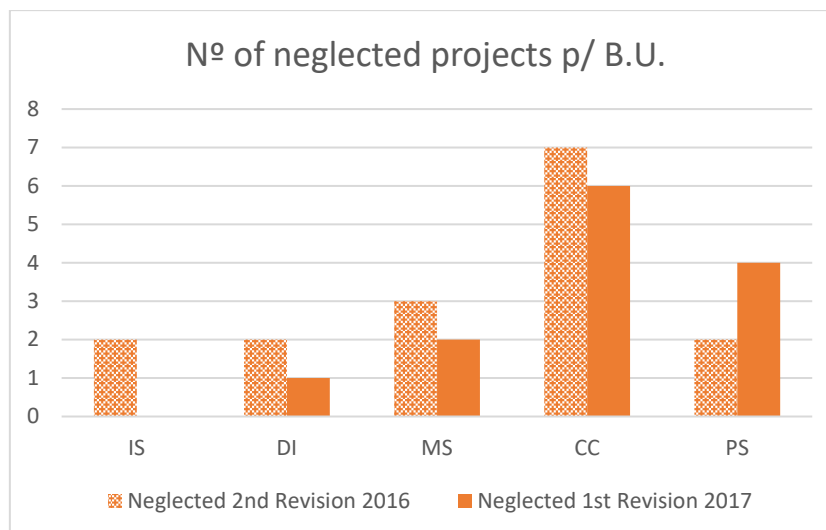


Figure 80 - Number of projects neglected in the last and current revision

By the analysis of the graph, it can be concluded that where the *Weekly Management Board* was implemented, IS, the number of projects neglected was null, which translates the increase on the *Owners'* motivation and perseverance to execute the project. The *Daily Management Board*, was implemented in the MTN department, a systematic between *Owners* of different projects inserted in different B.U. and the *Coach*, i.e., the head of the department of MTN. The projects allocated to this systematic were inserted in different B.U.: five in IS, two in DI and one in PS. The DI was a B.U. that although, indirectly, the board had an impact on the projects concluded.

Despite of the general decrease on the neglected projects, in PS, on the contrary, the number of projects neglected increased. This could be justified because no improvement was made in this B.U., while the rest were like a guinea pig for the measures where the ideas were implemented and stabilized. Only then they were ready for *yokoten*, that is, the transference of the standards to other areas, so PS didn't experience the systematics created. This is important because frequently when a standard is applied to every area possible before its stabilization, the impact turns out to be different from the expected and the money and effort is already spent resulting in monetary and time waste. So, it is essential to first implement a standard in a specific area, analyze the impact and stabilize it and only then implement it in the whole company. The earnings are represented in Table 13.

Table 13 - Improvement on the neglected projects

	Average of neglected projects	Earnings
2 nd revision of 2016	3,2 projects	18,8%
1 st revision of 2017	2,6 projects	

6.4 Shorter Meetings

With the usage of the boards and with the arrangement of a specific hour with the *Owners*, the time spent and wasted at meetings decreased since there was an organized systematic behind the board to limit the time spent with each *Owner* and there was no time spent in waiting, Table 14.

Table 14 - Improvement on the VS meeting

	Meeting's duration <i>IS</i>	Time spent on waiting <i>IS and MS</i>
Initial	45 min.	7 min.
Current	32 min.	0

6.5 Lead Time Reduction

One of the main goals of this dissertation was to reduce the time for the project's conclusion. The results are represented in Table 15.

Table 15 – Lead time analysis

	Initial Situation	Current	Earnings
System CIP Workshop	0,137 days	0,083 days	39,4%
Handover to System CIP Projects	15 days	0,125 days	99,2%
System CIP Projects	60 days	50 days	17%
Point CIP	22 days	22 days	-
Total	97,1 days	72,2 days	25,7%

By the analysis of the table it is clear that the improvements implemented had a positive impact on the *System CIP Approach*. The results of the *System CIP Projects* stage were followed and the earnings' measurement was direct; the time spent on this stage was reduced by 17%. Despite of this reduction, in future it is expected to be higher because, although its implementation, this only occurred in week 23 for the *Weekly Management Board* and in week 24 for the *Daily Management Board*, that is more than one month after the start of the *System CIP Projects* phase started. So, in the next revision, the *Weekly Management Board* will be implemented in the beginning and the results will hopefully be more promising. For *Point CIP*, the stabilization time remains the same since it is the defined time for the correct stabilization of a standard.

For the *System CIP Workshop*, the improvements can't be directly measured because the new revision didn't occur yet, but it is expected with the new improvements on the standards and standard work for the *VS Manager* that the lead time for it will reach the target.

The *Improvement KPI* of the A3 sheet, that monitored the improvements' direct impact, is represented in Figure 81. The target of 62 days was not attained, despite of the reduction of approximately 26%. This can be because the improvements implemented were not put into practice from the beginning of the revision, so if they were implemented in the beginning of the revision, the results were expected to be better.

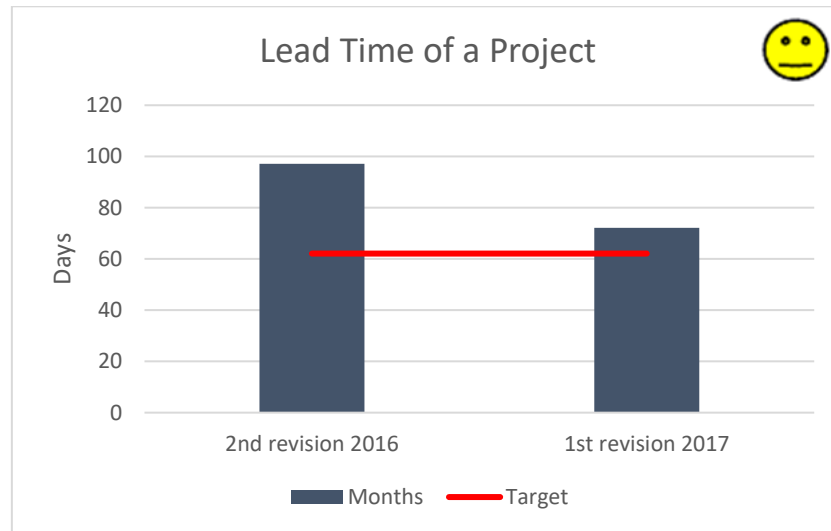


Figure 81 - *Improvement KPI*

6.6 Increase on the percentage of projects concluded

In this case the percentage of projects concluded was measured by dividing the number of projects concluded by the total number of projects. First it was analyzed the number of projects concluded per B.U. comparing it with the last revision to determine the improvement. In Figure 82 there is the number of projects concluded per B.U.

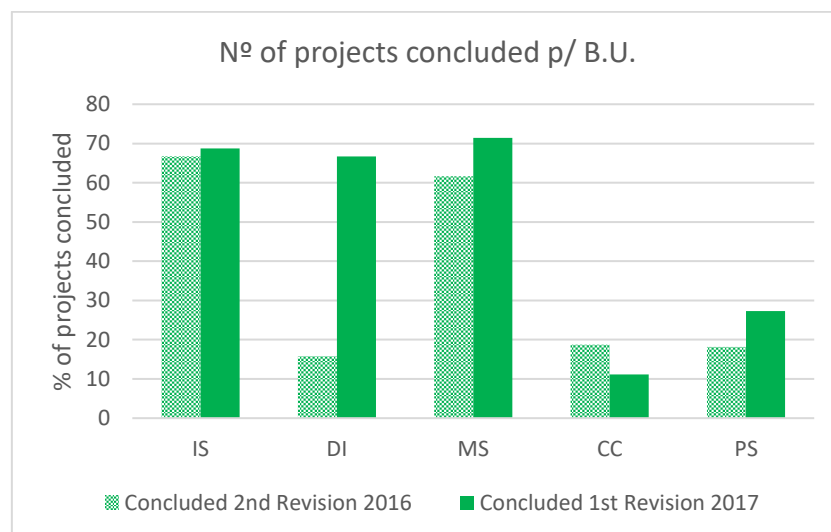


Figure 82 - Number of projects concluded per B.U. in the last and current revision

Once again, the improvement was general in all B.U., except in CC that it was not clearly influenced by the improvements. As mentioned before, the general standards, that is, the standards implemented in the whole company didn't had the immediate action in this B.U.. For the B.U. of IS there was an improvement of 2%. The biggest gain was for the B.U. of DI with 50% more projects concluded and it is to be stressed that it was indirectly influenced by the improvements implemented, because the department of MTN had two projects successfully concluded in this B.U. and the standards created were fully used. For MS, the gain was approximately 10% and for PS 9% more of the projects were concluded in this revision.

For the *Monitoring KPI*, the target of 45% of the projects concluded was attained, Figure 83, but the propose was to be attained in conjunction with the *Improvement KPI*, that is, 45% or more of the projects concluded in 62 days or less. Since the lead time remained in 72 days, the percentage of projects concluded didn't reach the main aim.

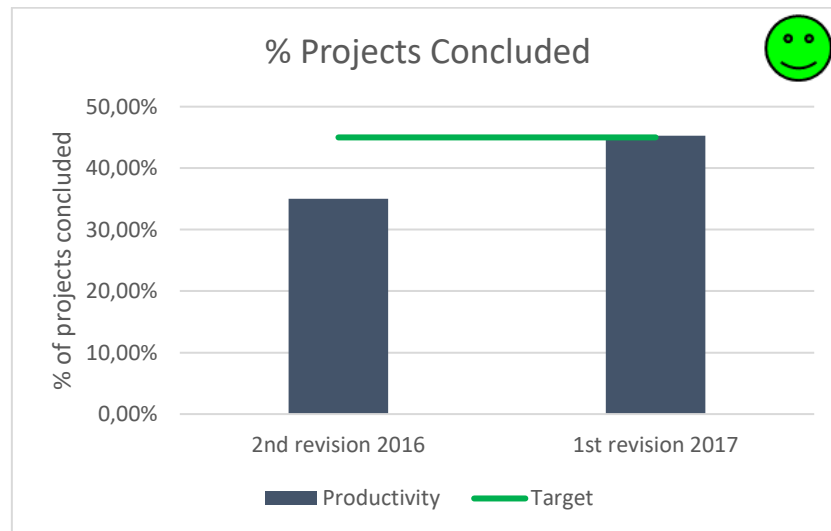


Figure 83 - *Monitoring KPI*

6.7 Increase in the Number of Revisions per Year

By reducing the time to conclude the projects, more time is left to invest in the continuous improvement, that is, to create more projects. For that, a new revision can be executed and hence the monetary savings per year can be increased.

With the improvements, each revision has a reduction of 25 days which results in 72 days for the projects' lead time, one week between them, gives a total of 231 days spent with the *System CIP Approach* almost a full year (250 working days). This is what a continuous improvement culture is, always pursuing perfection.

On the monetary side, with the conclusion of the projects, the wastes and technical flaws are eliminated resulting in savings. Each *System CIP Approach* revision, based on the previous revisions average, saved to the company 833.335,40€. So, with one more revision per year the savings would result in the triple, 2.500.006,20 € saved per year, a gain of 33,3%.

7. CONCLUSIONS AND FUTURE RESEARCH

In this chapter, the different conclusions from this dissertation will be presented. Additionally, the proposals for future work are identified.

7.1 Conclusions

The main goal for this dissertation was to reduce the time spent to conclude the *System CIP Approach* projects and hence increase the *Owners'* motivation, the number of projects concluded and the savings per year.

At the beginning of the study, the lack of interest in the systematic was evident. It was seen as an extra unnecessary work. From the diagnosis stage, different causes for the problem were identified. Among others, the lack of training turned out to be the main cause identified in the systematic. When the knowledge is not at the same level, the practical part of a job cannot be done properly, leading to the demotivation of the *Owners* to execute the projects. The lack of standard work for the *VS Manager* was clear which created a big gap between the different B.U.'s and the *Coach* being an absent figure, which resulted in no support for the *Owner*, which also contributed for his discouragement. Having the task management as basis, new measures were implemented to improve the problems identified.

The first step was to standardize the procedures by creating a clear step-by-step guide, visible for everyone involved, for the *System CIP Workshop*, *System CIP Projects* and *Point CIP*. With this, the process was easier to understand and hence the *Owners*, *VS Manager* and *Team Leader* had the proper information to successfully perform their tasks. One of the problems identified was also the unproductive time spent in the VS meeting and SC meeting. For the first, the *VS Manager* setting, a specific hour with each *Owner* improved the situation because there was no "wait in line" but a more customized supported and hence a more motivated *Owner*. The other improvement in this meeting was the insertion of the task management using the *Weekly Management Board*, where each week the *VS Manager* asked for deliverables according to the PDCA cycle and did a close follow-up on the project's evolution. For the SC meeting, the easy access to the standard presentation and the awareness for its advantages, triggered the usage of the standard resulting in the reduction of the meeting's duration (27%), and the utilization of the board as support of the meeting facilitated the follow-up resulting in a more productive meeting.

These improvements had an impact on the overall systematic reducing the lead time of a project from 97 days to 72 days (26%). The number of projects neglected were also reduced (19%) which led to the increase on the *Owners'* motivation. With the reduction of the lead time, there is time available for a new

revision each year, three revisions per year that will result in an increase of the number of projects concluded and hence an increase in the company savings of 33%, approximately 2.500.000,00€ per year. The number of projects concluded increased (10%), although out of the target of the initial planned 62 days, the rate of completed projects were higher. Despite of the improvements implemented, some were only executed after the beginning of the revision and some will only be implemented in the next revision so it is expected that these results will increase for the next revision where the improvements are implemented from the start.

7.2 Future research

As future work, the first step would be the gathering and management of all the standards created in the *System CIP Approach*. This is a big gap in the systematic because after the standards creation and its impact evaluated, the standards only stay registered on the A3 sheet of the project which causes them to be forgotten. The first activity when a problem is being faced is to check if there are standards, and if there are, check if they are OK or not. The problem here is that to find a standard in the middle of hundreds of projects, divided per year and revision, is hard so an organized sheet for standards management is required.

Another work needed is the measurement of the problem's complexity, because now they are treated as equal and they are not. Some projects required more analysis because the number of variables is higher, so it's necessary to quantify this complexity to give a more customized approach to each project. This would make the prioritization matrix functional because the required effort will be quantified.

One major point missing is the personal indicators, such as, the quantification of the *Owners'* availability, that is, the definition of the *Owners'* time for each activity and the competency matrix where a project was only allocated to whom has competencies and availability for it.

The work is never done when pursuing perfection. The work's revisions must be done frequently always aiming the improvement and the standardization of the best measures to date, reflecting a true *kaizen* culture.

REFERENCES

- Alves, A. C., Kahlen, F. J., Flumerfelt, S., & Manalang, A. B. S. (2014). The Lean Production multidisciplinary: from operations to education. In *7th International Conference on Production Research/Americas*.
- Amaro, A., & Pinto, J. (2007). Criação de valor e eliminação de desperdícios. *Lean Thinking Community*.
- Bilnoski, B. (2011). R.A.S.I.C. Roles, Accountability and Responsibility Matrix. Retrieved May 3, 2017, from https://4good.org/bobbi-bilnoski/r-a-s-i-c-roles-accountability-and-responsibility-matrix#asset_3900
- Bosch. (2013). *BPS - Bosch Production System*.
- Bosch. (2014). *Bosch in the world*.
- Bosch. (2015). *BPS Handbook*.
- Bosch. (2016). *The story of Bosch*.
- Boyle, T. A., Scherrer-Rathje, M., & Stuart, I. (2011). Learning to be lean: the influence of external information sources in lean improvements. *Journal of Manufacturing Technology Management*, 22(5), 587–603.
- Chen, J. C., & Cox, R. A. (2012). Value Stream Management for Lean Office-A Case Study. *American Journal of Industrial and Business Management*, 2(2), 17.
- Cusumano, M. A., & Nobeoka, K. (1998). *Thinking beyond lean: how multi-project management is transforming product development at Toyota and other companies*. Simon and Schuster.
- Dombrowski, U., Crespo, I., & Zahn, T. (2010). *Adaptive configuration of a lean production system in small and medium-sized enterprises*. Production Engineering.
- Dombrowski, U., & Mielke, T. (2013). *Lean Leadership fundamental principles and their application*. Elsevier.
- Flinchbaugh, J. (2005). Beyond lean. *Lean Learning Center*, 1–22.
- Foster, J. (2017). The lean turnaround of the San Diego Zoo Global. Retrieved May 5, 2017, from <http://planet-lean.com/the-lean-turnaround-of-the-san-diego-zoo-global>
- Hall, R. W. (1987). *Attaining Manufacturing Excellence – Just in Time, Total Quality, Total People Involvement*.
- Hindle, T. (2009). Genchi genbutsu. *The Economist Guide to Management Ideas and Gurus*.
- Hines, P., Riccardo, S., & Bartolini, M. (2002). *Lean profit potential*. Lean Enterprise Research Centre.
- Imai, M. (1986). *Kaizen*. New York: Random House Business Division.
- Imai, M. (2005). *Praise for Gemba Kaizen*.
- Kotnour, T. (2000). Organizational learning practices in the project management environment. *International Journal of Quality & Reliability Management*, 17(4/5), 393–406.
- Kumiega, A., & Van Vliet, B. (2008). *Quality money management*. Academic Press.
- Lago, N., Carvalho, D., & Ribeiro, L. (2008). 2008_Lago_et_al.pdf.
- Lahote, D. (2005). A3 St Story B Boards d, 1–9.
- Lareau. (2003). *Office Kaizen: transforming office operations into a strategic competitive advantage*. ASQ Quality Press.
- Liker, Jeffrey K. Meier, D. (2006). *The Toyota Way Fieldbook*. McGraw Hill.
- Liker, J. K. (2004). *The Toyota Way: 14 Management Principles from the World's Greatest Manufacturer*.
- Liker, J. K., & Morgan, J. M. (2006). The Toyota Way in Services: The Case of Lean Product Development. *Academy of Management Perspectives*, 20(2), 5–20. <https://doi.org/10.5465/AMP.2006.20591002>
- Likert, R. (1961). *New Patterns of Management*. McGraw-Hill.
- Little, J. D., & Graves, S. C. (2008). Little's law. *Building Intuition*, 81–100.

- Mann, D. (2005). *Creating a lean culture*.
- McKellen, D. (2005). The lean office. *MWP- Metalworking Production*, 149, 12–12.
- Mehta, M. B. (2015). Targeting administration. *Institute of Industrial Engineers*.
- Monteiro, M. F., Pacheco, C. C., Dinis-Carvalho, J., & Paiva, F. C. (2015). Implementing lean office: A successful case in public sector. *FME Transactions*, 43(4), 303–310.
- Munns, A. K., & Bjeirmi, B. F. (1996). The role of project management in achieving project success. *International Journal of Project Management*, 14(2), 81–87.
- O'Brien, R. (2002). An Overview of the Methodological Approach of Action Research. Retrieved February 20, 2017, from <http://www.web.ca/~robrien/papers/arfinal.html>
- Ohno, T. (1988). *Toyota production system: beyond large-scale production*. crc Press.
- Ortiz, C. A. (2006). *Kaizen assembly: designing, constructing, and managing a lean assembly line*. CRC Press.
- Parry, G. C., & Turner, C. E. (2006). Application of lean visual process management tools. *Production Planning & Control*, 17(1), 77–86.
- Pereira, R. (2008). Guide to lean manufacturing.
- Pinto, J. P. (2008). Lean Thinking: Introdução ao Pensamento Magro.
- Rose, P., Schabos, M., Sheldan, T., Zettergren, P., Hines, P., Found, P., ... Harrison, R. (2008). Staying Lean : thriving , not just surviving.
- Rother, M. (2010). *Toyota kata*.
- Shingo, S. (1989). *A Study of the Toyota Production System From Industrial Engineering Viewpoint*. Portland: Productivity Press.
- Shingo, S. (2007). *Kaizen and the art of creative thinking: the scientific thinking mechanism*. Enna Products Corporation.
- Shook, J. (2008). *Managing to Learn: using the A3 management process to solve problems, gain agreement, mentor and lead*. Lean Enterprise Institute.
- Spear, S. J. (2004). Learning to Lead at Toyota. *Harvard Business Review*, 78–87.
- Sugimori, Y., Kusunoki, K., Cho, F., & Uchikawa, S. (1977). Toyota production system and Kanban system Materialization of just-in-time and respect-for-human system. *International Journal of Production Research*, 15(6), 553–564. <https://doi.org/10.1080/00207547708943149>
- Suikki, R., Tromstedt, R., & Haapasalo, H. (2006). Project management competence development framework in turbulent business environment. *Technovation*, 26(5), 723–738.
- Susman, G. I.; Evered, R. D. (1978). An assessment of the scientific merits of action research. *Administrative Science Quarterly*, 582–603.
- Suzaki, K. (1993). *New Shop Floor Management: Empowering People for Continuous Improvement*. Simon and Schuster.
- Van Amelsvoort, P., & Benders, J. (1996). Team time: a model for developing self-directed work teams. *International Journal of Operations & Production Management*, 16(2), 159–170.
- Wilson, L. (2009). *How to implement lean manufacturing*. McGraw Hill Professional.
- Womack, J. P., & Jones, D. T. (2010). *Lean thinking: banish waste and create wealth in your corporation*. Simon and Schuster.
- Womack, J. P., Jones, D. T., & Roos, D. (1996). *The machine that changed the world*. Simon and Schuster.

APPENDICES

APPENDIX I – A3 SHEET FOR THE DISSERTATION

A3 SHEET: "Improvement on the project's elaboration processes using Lean tools in an electronic components company"																																																																																																	
1. Why this project? (Justify) The low number of projects concluded, that is, in six months 35% and the high lead time to conclude it approximately 97 days.																																																																																																	
2. Current situation (Describe) SYSTEM CIP WORKSHOP Poor project's definition: owners, KPI and the project itself Long unproductive workshops Long time to handover the project to the Owner, approximately 15 days SYSTEM CIP PROJECT Lack of formation about the System CIP Approach, Lean and Lean tools Lack of Standard Work for the VS Managers Coach is a non-existent figure resulting in the lack of support of the Owner PDCA cycle is not followed Long and tiring SC meetings Unproductive VS meeting where there are 63% of absences and average of 30 min. waste in waiting by the Owners and an unorganized environment due to the high number of paper sheets in the small gemba table POINT CIP AND DMM The five elements of Point CIP and DMM are not followed The Team Leader doesn't participate in the improvement processes																																																																																																	
3. Objectives (SMART : Specific, Measurable, Achievable, Relevant, Time-limited) The objective of this dissertation is to reduce the lead time of the System CIP Approach from 97 days to 62 days or less and to increase the number of projects concluded from 35% to 45% or more and hence move from the level 2 of the BPS assement to the level 3 in one year																																																																																																	
4. Condition (Future state) Every participant in the systematic has the proper formation for it, creation of a formation cycle There is task management to manage the Owners Arrange a precise hour to the meeting of VS with each Owner The PDCA cycle is understood and followed All the VS Managers know their function and put it into practice according to the standard Eliminate the high amount of paper in the Systematic Create a standard for the project's handover for each phase All Owners use the standard presentation for the SC meeting Arrange the logical path of the System CIP Workshop, reducing the duration BASIC elaboration for the System CIP Approach Standard with the steps for each phase of the System CIP Approach Stability limits definition for the Improvement KPI																																																																																																	
5. Key Performance Indicators <div> <div>Monitoring KPI</div> </div> <div> <div>Improvement KPI</div> </div>																																																																																																	
6. What are the Problems Exactly? Root Cause Analysis <table border="1"> <thead> <tr> <th>Man</th> <th>Machine</th> <th>Material</th> <th>Method</th> <th>Environment</th> <th>Other</th> <th>N°</th> <th>Root Cause</th> </tr> </thead> <tbody> <tr> <td></td> <td></td> <td></td> <td>X</td> <td></td> <td></td> <td>1</td> <td>Lack of Standard work for the VS Manager</td> </tr> <tr> <td></td> <td></td> <td></td> <td>X</td> <td></td> <td></td> <td>2</td> <td>The parties involved find it difficult to find the standards</td> </tr> <tr> <td></td> <td></td> <td></td> <td>X</td> <td></td> <td></td> <td>3</td> <td>There are no stability limits for the projects KPIs</td> </tr> <tr> <td></td> <td></td> <td></td> <td>X</td> <td></td> <td></td> <td>4</td> <td>VS meeting is scheduled with all Owners at the same time</td> </tr> <tr> <td>X</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td>5</td> <td>The PDCA cycle is not followed</td> </tr> <tr> <td></td> <td></td> <td></td> <td>X</td> <td></td> <td></td> <td>6</td> <td>Lack of task management</td> </tr> <tr> <td>X</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td>7</td> <td>Lack of a competency matrix</td> </tr> <tr> <td></td> <td></td> <td></td> <td>X</td> <td></td> <td></td> <td>8</td> <td>Lack of a competency matrix</td> </tr> <tr> <td></td> <td></td> <td></td> <td>X</td> <td></td> <td></td> <td>9</td> <td>In the System CIP Workshop the present don't the availability of the Owners for the project</td> </tr> <tr> <td></td> <td></td> <td></td> <td>X</td> <td></td> <td></td> <td>10</td> <td>Team Leader is not involved from the beginning of the projects, projects complexity is not quantified</td> </tr> </tbody> </table>										Man	Machine	Material	Method	Environment	Other	N°	Root Cause				X			1	Lack of Standard work for the VS Manager				X			2	The parties involved find it difficult to find the standards				X			3	There are no stability limits for the projects KPIs				X			4	VS meeting is scheduled with all Owners at the same time	X						5	The PDCA cycle is not followed				X			6	Lack of task management	X						7	Lack of a competency matrix				X			8	Lack of a competency matrix				X			9	In the System CIP Workshop the present don't the availability of the Owners for the project				X			10	Team Leader is not involved from the beginning of the projects, projects complexity is not quantified
Man	Machine	Material	Method	Environment	Other	N°	Root Cause																																																																																										
			X			1	Lack of Standard work for the VS Manager																																																																																										
			X			2	The parties involved find it difficult to find the standards																																																																																										
			X			3	There are no stability limits for the projects KPIs																																																																																										
			X			4	VS meeting is scheduled with all Owners at the same time																																																																																										
X						5	The PDCA cycle is not followed																																																																																										
			X			6	Lack of task management																																																																																										
X						7	Lack of a competency matrix																																																																																										
			X			8	Lack of a competency matrix																																																																																										
			X			9	In the System CIP Workshop the present don't the availability of the Owners for the project																																																																																										
			X			10	Team Leader is not involved from the beginning of the projects, projects complexity is not quantified																																																																																										
7. Standards / Actions that had impact <table border="1"> <thead> <tr> <th rowspan="2">Nr. of the root cause</th> <th colspan="2">Standard</th> <th rowspan="2">Standard Description</th> <th rowspan="2">Application Area</th> <th rowspan="2">Week</th> </tr> <tr> <th>Proj</th> <th>Point CIP</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>X</td> <td></td> <td>Develop a standard work for the VS Manager</td> <td>All B.U.</td> <td>CW14</td> </tr> <tr> <td>2</td> <td>X</td> <td></td> <td>Guide for System CIP Projects and Point CIP with the standards attached</td> <td>All B.U.</td> <td>CW14</td> </tr> <tr> <td>3</td> <td>X</td> <td></td> <td>Definition of stability criteria for the Improvement and Monitoring KPI</td> <td>MS and IS</td> <td>CW14 and CW28</td> </tr> <tr> <td>4</td> <td>X</td> <td></td> <td>Each VS Manager arranges a precise hour with the different Owners</td> <td>IS and MS</td> <td>CW14</td> </tr> <tr> <td>5</td> <td>X</td> <td></td> <td>PDCA Management, task definition for each stage</td> <td>All B.U.</td> <td>CW14</td> </tr> <tr> <td>5, 6, 7, 8 and 9</td> <td>X</td> <td></td> <td>Daily Management Board</td> <td>MTN department</td> <td>CW24</td> </tr> <tr> <td>7</td> <td>X</td> <td></td> <td>Create a formation cycle where everyone involved has the proper formation for it</td> <td>MTN department</td> <td>CW28</td> </tr> <tr> <td>5 and 6</td> <td>X</td> <td></td> <td>Weekly Management Board</td> <td>IS</td> <td>CW23</td> </tr> </tbody> </table>										Nr. of the root cause	Standard		Standard Description	Application Area	Week	Proj	Point CIP	1	X		Develop a standard work for the VS Manager	All B.U.	CW14	2	X		Guide for System CIP Projects and Point CIP with the standards attached	All B.U.	CW14	3	X		Definition of stability criteria for the Improvement and Monitoring KPI	MS and IS	CW14 and CW28	4	X		Each VS Manager arranges a precise hour with the different Owners	IS and MS	CW14	5	X		PDCA Management, task definition for each stage	All B.U.	CW14	5, 6, 7, 8 and 9	X		Daily Management Board	MTN department	CW24	7	X		Create a formation cycle where everyone involved has the proper formation for it	MTN department	CW28	5 and 6	X		Weekly Management Board	IS	CW23																																
Nr. of the root cause	Standard		Standard Description	Application Area	Week																																																																																												
	Proj	Point CIP																																																																																															
1	X		Develop a standard work for the VS Manager	All B.U.	CW14																																																																																												
2	X		Guide for System CIP Projects and Point CIP with the standards attached	All B.U.	CW14																																																																																												
3	X		Definition of stability criteria for the Improvement and Monitoring KPI	MS and IS	CW14 and CW28																																																																																												
4	X		Each VS Manager arranges a precise hour with the different Owners	IS and MS	CW14																																																																																												
5	X		PDCA Management, task definition for each stage	All B.U.	CW14																																																																																												
5, 6, 7, 8 and 9	X		Daily Management Board	MTN department	CW24																																																																																												
7	X		Create a formation cycle where everyone involved has the proper formation for it	MTN department	CW28																																																																																												
5 and 6	X		Weekly Management Board	IS	CW23																																																																																												

Figure 84 - A3 sheet used for this dissertation

APPENDIX II – CURRENT RASIC MATRIX

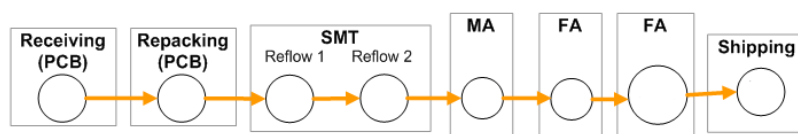
Roles& Responsibilities of a Value Stream Manager													
R: Responsible A: Approval S: Support	I: Inform C: Cooperation	Plant manager	VS Manager	MOEx-P	MOE1,2	LOG	QMM	TEF	TEF2 BPS	Plant VS manager	Project owners	Section Manager	Team leader
Collect business requirements based on CM and plant strategy, plant vision, Business plan, customer and market demand....		S	R	I	S	S	S	S	C	I			
Derive targets for the value stream (VS-KPR) according to the business requirements		S	C	I	S	S	S	I	I	R			
Leading the value stream planning (VSM, VSD, bubble diagram, incl. reviews)		C	R	I	C	C	C	C	C	C			
Organization of system CIP workshops,		C	R	I	C	C	C	C	C	S			
Define focus area		R	S	I	C	C	C	C	C	S			
Prioritization of focus areas		R	S	I	C	C	C	C	C	S			
Define System CIP projects		C	R	I	C	C	C	C	C	C			
Definition of target conditions (KPI target, standard, stability crit., incl. recourses)			A	C	I	I	I	I	C	I	R		
Implement System CIP project and validate target condition			A	C	I	I	I	I	C	I	R		

Roles& Responsibilities of a Value Stream Manager													
R: Responsible A: Approval S: Support	I: Inform C: Cooperation	Plant manager	VS Manager	MOEx-P	MOE1,2	LOG	QMM	TEF	TEF2 BPS	Plant VS manager	Project owners	Section Manager	Team leader
Target conditions yokoten			I	I	I	I	I	I	S	I	R	I	
Follow up of the VS-KPR		I	R	C	I	I	I	I	S		C		
Follow-up of System CIP projects		I	R	C	I	I	I	I	S		C		
Point CIP – stabilization of the target conditions			I	I					S		I	S	R
Define qualification requirements for the value stream team (source , make, deliver)		I	R	I	I	I	I	I	C	C		I	I

Figure 85 - Current RASIC Matrix

Bubble Diagram System CIP

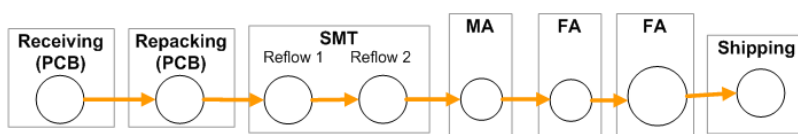
Current



Flow relation between Processes

Other	1 - 1	1 - 2	2 - 1
0	7	0	0

Future



Flow relation between Processes

Other	1 - 1	1 - 2	2 - 1
0	7	0	0

1

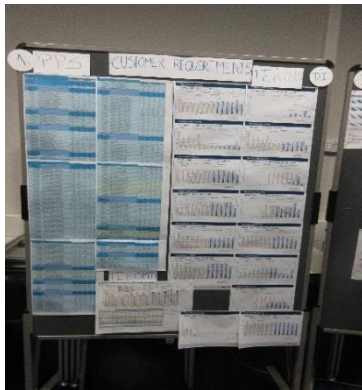
BrGP/TEF2 | 3/16/2016

© Robert Bosch GmbH 2016. All rights reserved, also regarding any disposal, exploitation, reproduction, editing, distribution, as well as in the event of applications for industrial property rights.



Figure 86 - Bubble Diagram template

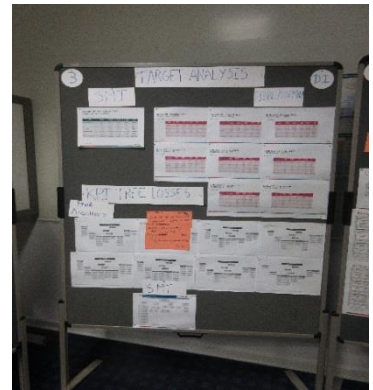
APPENDIX IV – WORKSHOP SYSTEM CIP



a)

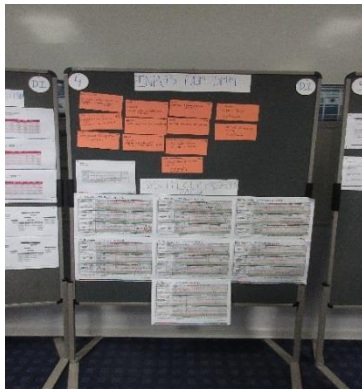


b)

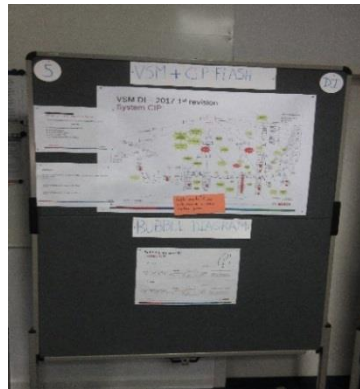


c)

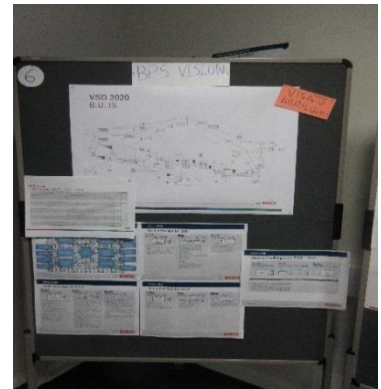
Figure 87 - a) Board 1: Customer Requirements b) Board 2: KPI's c) Board 3: Target Analysis



a)

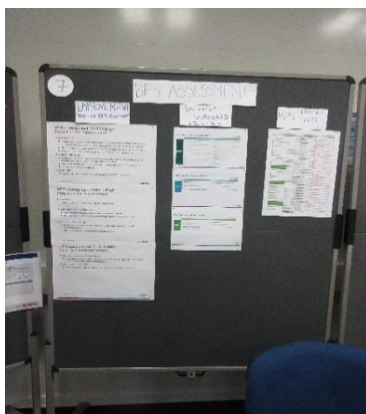


b)



c)

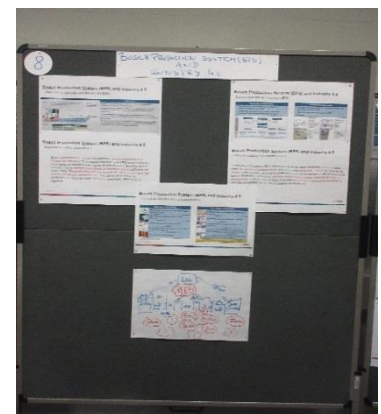
Figure 88 - a) Board 4: Inputs from DMM and last revision projects b) Board 5: VSM and Bubble Diagram c) Board 6: BPS Vision



a)

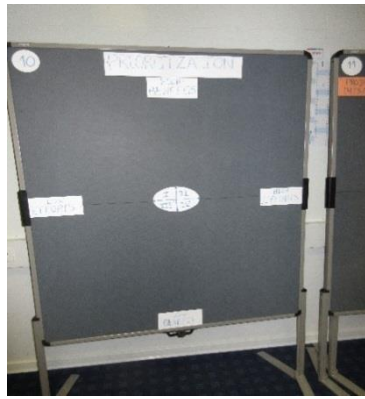


b)



c)

Figure 89 - a) Board 7: BPS Assessment b) Industry 4.0 c) True North



a)



b)

Figure 90 – a) Board 10: Prioritization Matrix b) Board 11: Projects defined for the System CIP Projects

APPENDIX V – A3 SHEET

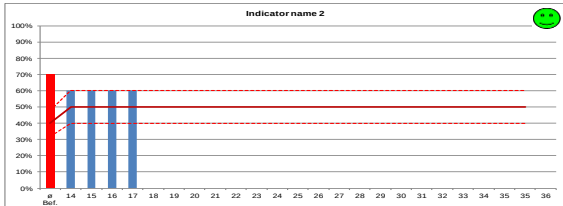
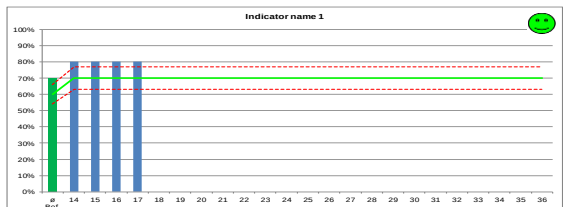
 BOSCH	Plant:	Date:	Project Name:	Project Owner:	Team Members:	Costs:	Savings:												
				Coach:															
1. Why this Project (Current state / Justify)				5. What are the Problems Exactly? Root Cause Analysis															
				Man	Machine	Material	Method	Environment	Other	N°	Root Cause								
											1								
											2								
											3								
											4								
											5								
											6								
2. Objectives (SMART - Specific, Measurable, Achievable, Relevant, Time -limited)																			
										7									
3. Condition (Future state)				6. Standards / Actions that had impact															
				Nr.	Standard	Proj.	Point CIP	Standard Description	Application Area	Week	Impact (%)	Approval (VS Manager)							
4. Key Performance Indicators				7. Yokoten															
<div>Monitoring KPI</div> <div>Indicator name 2</div>  <div>Improvement KPI</div> <div>Indicator name 1</div> 				Standard				Application Areas				Responsible	Follow-Up Location	Resp. Signature					
8. Project closure approval																			
PT / PC				Head of Department				Head of Section				Line Leader				Worker of the area			
Date:				Date:				Date:				Date:				Date:			

Figure 91 - A3 Sheet Bosch's template

APPENDIX VI – ISHIKAWA DIAGRAM

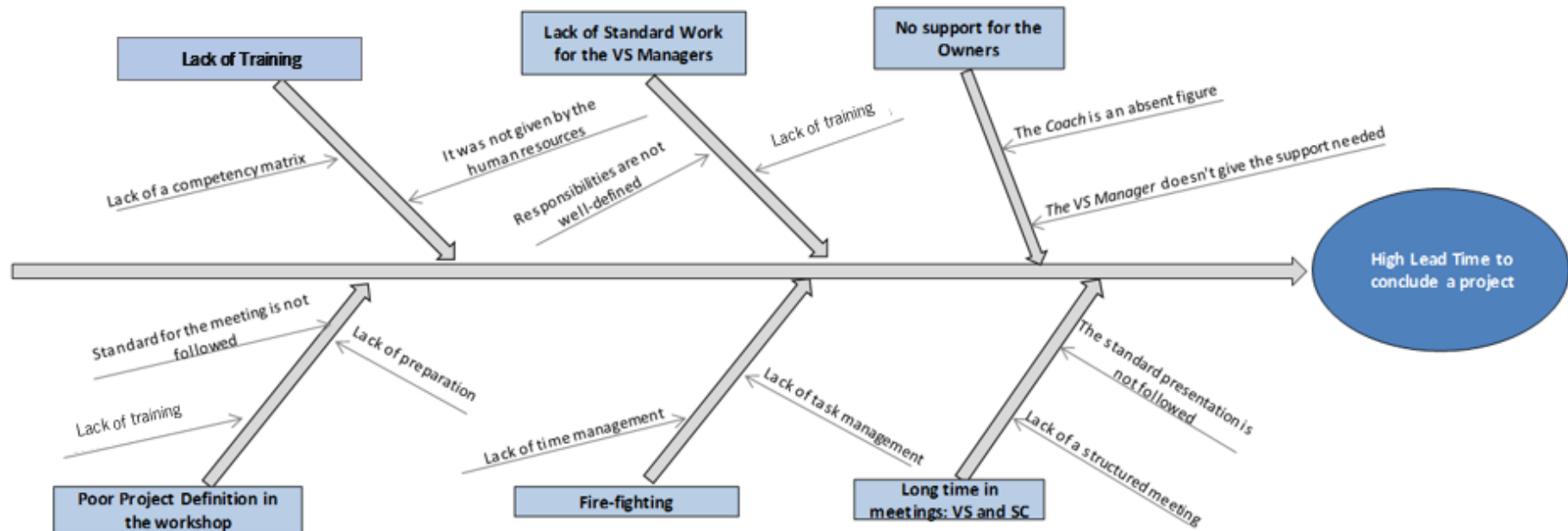


Figure 92 - Ishikawa Diagram for the high lead time for the project conclusion

APPENDIX VII – IMPROVED RASIC MATRIX

		Roles & Responsibilities															
		R: Responsible A: Approval S: Support	I: Inform C: Cooperation	Plant manager PT/PC	VS Manager	MOEx-P	MOE1,2	LOG	QMM	MFE	MFC BPS	Plant VS manager	Project owners	Team Members	Coach	Team leader	Worker
System CIP Workshop	Preparation	Arrange the meeting	I	R	I	I	I	I	I	S	I				I		
		Gather the inputs		R							S						
		Prepare the boards		R							S						
	Workshop	Mediate the meeting		R							S						
		Define new projects		R							S						
		Prioritize the projects		R							S						
		Determine the KPI's and Owner for the project	C	R	C	C	C	C	C	S	C						

Figure 93 - RASIC matrix for the System CIP Workshop

		Roles & Responsibilities															
		R: Responsible A: Approval S: Support	I: Inform C: Cooperation	Plant manager PT/PC	VS Manager	MOEx-P	MOE1,2	LOG	QMM	MFE	MFC BPS	Plant VS manager	Project owners	Team Members	Coach	Team leader	Worker
System CIP Projects	Preparation	Team formation		I									R		C		
		Arrange weekly meeting: VS		R							S	I	I		I		
		Arrange monthly meeting: SC	I	R	I	I	I	I	I	S	I	I	I	I	I	I	
		Notify the parties involved about the meetings	I	R	I	I	I	I	I	I	I	I	I	I	I	I	
	VS Meeting	VS Board: Participation Record		R							S						
		Ensure the owners presence		R							S				C		
		Update project KPI's data		S							S		R				
		Write weekly data in the project sheet		R							S		C				
		Verify that the deliverables for each phase of the PDCA cycle are completed before moving to the next		R							S						
		Define new standards		A							S		R				
		Give feedback		R							S						
	Steering Committee	Elaborate the presentation using the available standard powerpoint		S							S		R				
		SC meeting preparation: Place for the meeting; VS Board in place;		R							S						
		Introduce the meeting and analyze the root causes of Monitoring KPI and KPRs outside target		R							S						
		Present the project evolution		S							S		R				
		Discussion about the presentations	C	C	C	C	C	C	C	C	S	C	C	C	C	C	
		Conclude the meeting		R													

Figure 94 - RASIC matrix System CIP Projects

		Roles & Responsibilities															
		R: Responsible A: Approval S: Support	I: Inform C: Cooperation	Plant manager PT/PC	VS Manager	MOEx-P	MOE1.2	LOG	QMM	MFE	MFC BPS	Plant VS manager	Project owners	Team Members	Coach	Team leader	Worker
Point CIP	Preparation	Print the needed documents for Point CIP: Structured Communication; Target Condition; Process Confirmation; Fast Reaction System and Problem Solving								S		R					
		Explain the systematic Point CIP to the Team Leader		R						S							
		Arrange weekly meeting with the parties involved: Team Leader, Owner, VS Manager and Worker		I						S		R					
	Process Confirmation	Fill-in the standards description		S						S		R					
		Check for the standards applicability to the process confirmation, if not applicable justify how to guarantee that there is no deviations		S						S		R					
		Follow-up of the deviations		S						S		S			R	C	
		Corrective actions		C						S		C			R	C	
	Target Condition	Fill the Improvement KPI value throughout the events		S						S		S			R	C	
		Check for deviations		S						S		S			R	C	
		If there are deviations, check if the standards are OK		S						S		C			R		
		If NOK check the root cause and develop a corrective action for it		S						S		C			C		
		If OK open the problem solving according with the type of problem		S						S		C			R		
	Fast Reaction System	Develop a Fast Reaction System								S		C			C		
		Define a reaction limits that when achieved activate alerts to initiate a problem solving cycle								S		R					
		Give the alert															R
		Analyze the problem and decide the corrective action													R		

Figure 95 - RASIC Matrix Point CIP

Standard: System CIP Workshop Responsible: VS Manager

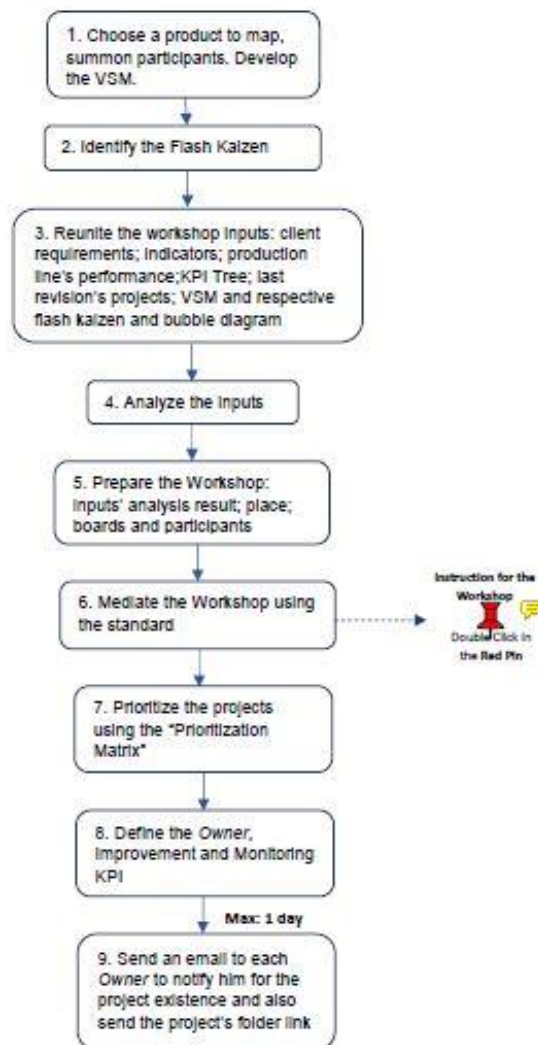


Figure 96 - Standard: System CIP Workshop



115

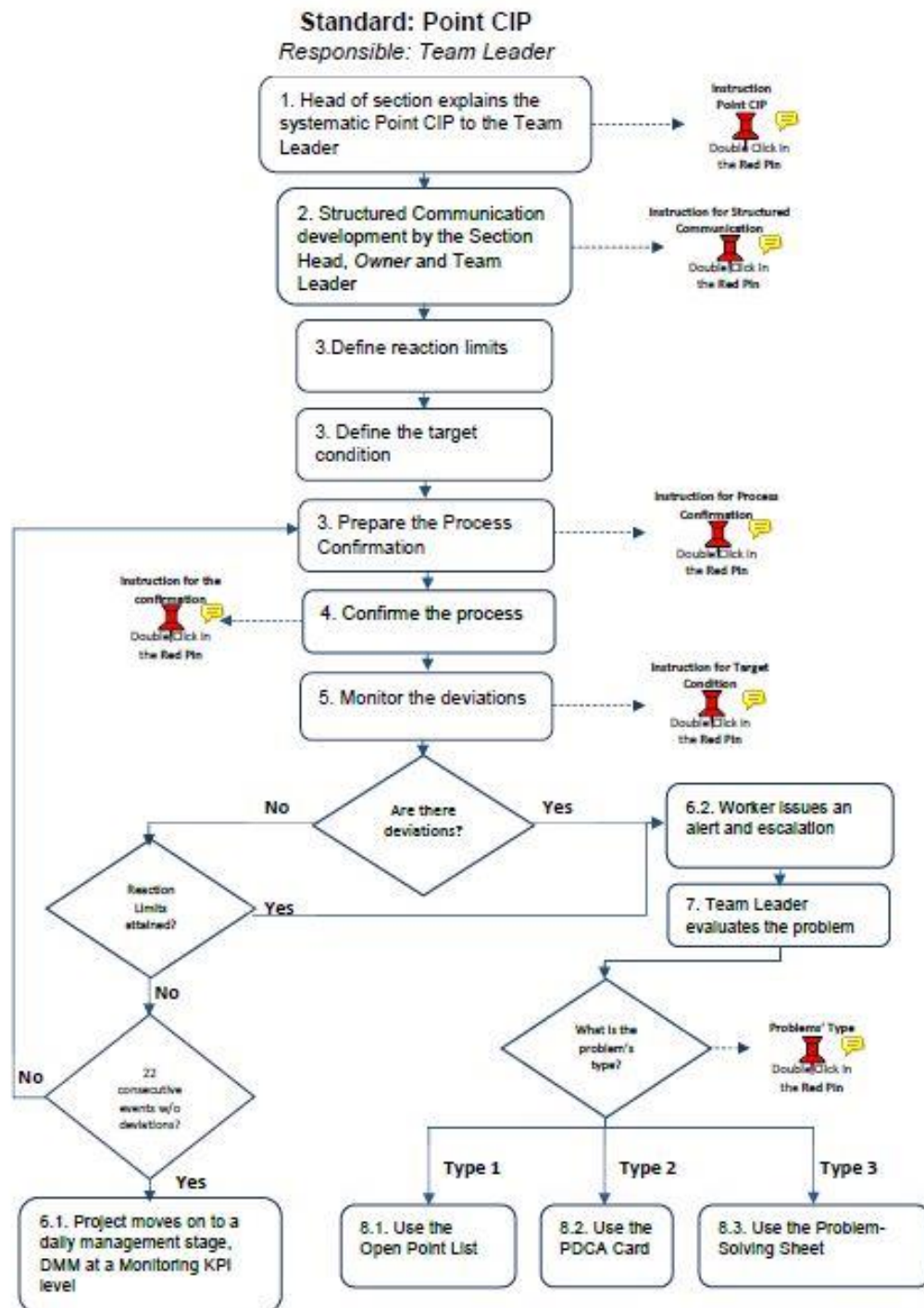


Figure 98 - Standard: Point CIP

APPENDIX XI – PDCA TASK MANAGEMENT

Project Start Date:

Maximum Limit: 2 months for the System CIP Projects

Status	Due Date		Start Date	Duration (day\$	End Date	Days Remaining	Concluded	Delayed Days	Status relation with the due date
Plan		<div>Describe the problem</div> <div></div>	Define the current situation	1					
			Analyze the existing standards	1					
			Identify the possible deviation to the standards	1					
			Describe the problem	1					
			Define the target condition	2					
		<div>Analyze the root cause</div> <div></div>	Collect and analyze the information	2					
			Identify the main causes for the problem	1					
			Compare the collected information with the one gathered in <i>gemba</i>	1					
			Stablish a cause/effect relationship	1					
			Determine the root cause	1					
		<div>Find solutions</div> <div></div>	Find solutions for the root cause	2,5					
			Define actions for each solution	2,5					
Do		<div>Implement actions</div> <div></div>	Prioritize the actions	2					
			Define an action plan for the implementation	2					
			Distribute the tasks by the team	2					
			Execute the action plan	4					
Check		<div>Stabilize the Target Condition</div> <div></div>	Stabilize the standard at an Improvement KPI level (Point CIP)	22					
Act		<div>Standardize and transfer information</div> <div></div>	Evaluate the results	2					
			Standardize the actions to avoid recurrences	1					
			Yokoten	2					
			Follow-up of the implemented actions	1					
			Daily follow-up at a Monitoring KPI level, DMM	1					
			Check for opportunities for improvement	1					

Figure 99 - PDCA task management document

```
Private Sub Calendario_DateClick(ByVal DateClicked As Date)

On Error Resume Next
Dim cell As Object
Sheet1.Range("D1").Value = DateClicked
Unload Me

End Sub
```

Figure 100 - VBA code for inserting the calendar in the document

```
Private Sub Worksheet_SelectionChange(ByVal Target As Range)

ActiveSheet.Unprotect Password:="t"
If Not Intersect(Target, Range("D1")) Is Nothing Then
InicioProjeto.Show
End If
ActiveSheet.Unprotect Password:="t"
End Sub
```

Figure 101 - VBA code for the calendar to show up when start date cell is selected

```

Private Sub Worksheet_Change(ByVal Target As Excel.Range)
Dim rCell As Range
Dim rChange As Range
ActiveSheet.Unprotect Password:="t"

On Error GoTo ErrHandler
Set rChange = Intersect(Target, Range("N4:N26"))
If Not rChange Is Nothing Then
    Application.EnableEvents = False
    For Each rCell In rChange
        If rCell > "" Then
            With rCell.Offset(0, 3)
                .Value = Now
                .NumberFormat = "dd-mm-yyyy"
            End With
        Else
            rCell.Offset(0, 3).Clear
        End If
    Next
End If
Range("Q4:Q26").Font.Color = vbWhite

```

Figure 102 - VBA code that returns the date when the task was concluded

APPENDIX XII – FLOWCHART COACH

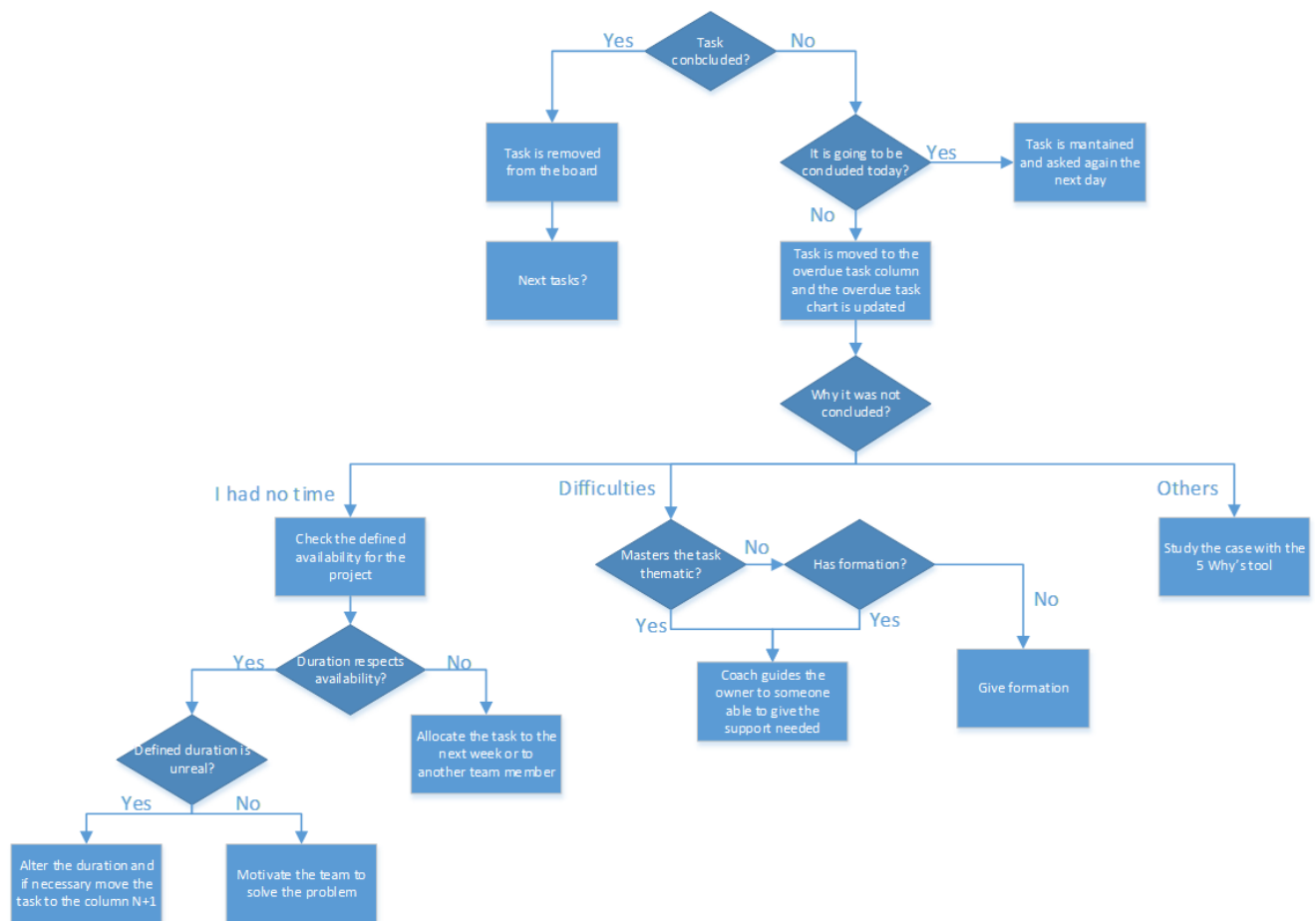


Figure 103 - Flowchart guide for the Daily Management Board for the Coach

APPENDIX XIII – PDCA ACTIVITIES

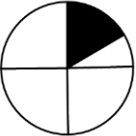
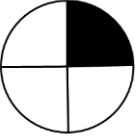
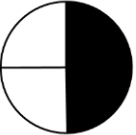
Plan	Describe the Problem 	Define the current situation
		Analyze the existent standards
		Identify, if exist, deviations to the standards
		Describe the problem
	Analyze the root cause 	Gather and analyze the information
		Identify the main causes for the problem
		Compare the gathered data with the one gathered in the gemba
		Stabilize the cause/effect relationship
		Determine the root cause
	Find the solutions 	Find solution for the root cause
		Define actions for each solution
Do	Implement actions 	Prioritize the actions
		Develop the action plan for the implementation
		Distribute the task by the team
		Execute the action plan
		Target Condition (Standard+ Improvement KPI+ Stability Criteria) attained
Check	Check the results 	Stabilize the target condition (Point CIP)
Act	Standardize and transfer the information 	Evaluate the results
		Standardize the actions
		Yokoten
		Follow-up of the implemented actions
		Daily follow-up at a Monitoring KPI level
		Check for improvement opportunities

Figure 104 - PDCA Activities

APPENDIX XIV – STANDARD DAILY MANAGEMENT BOARD

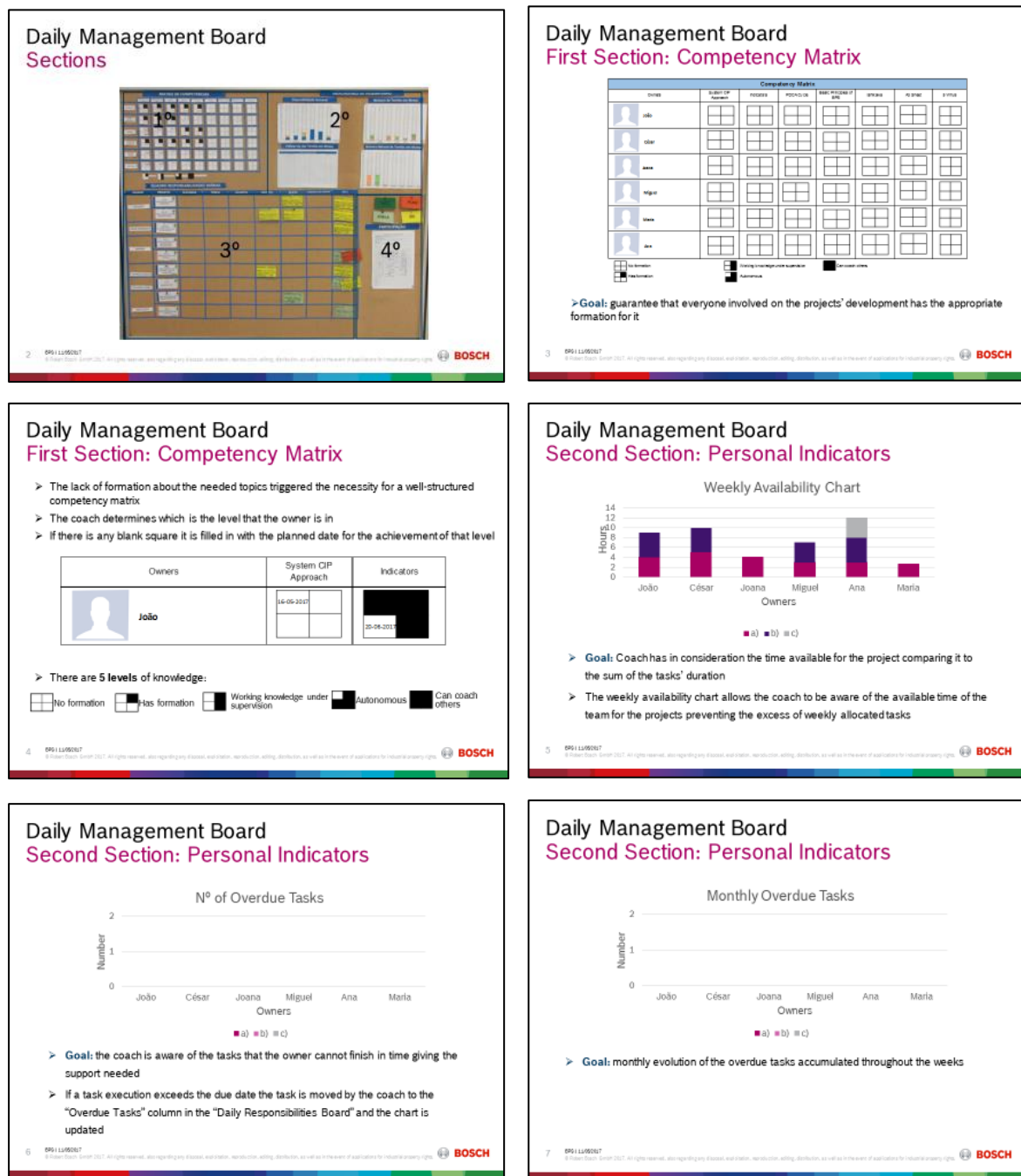


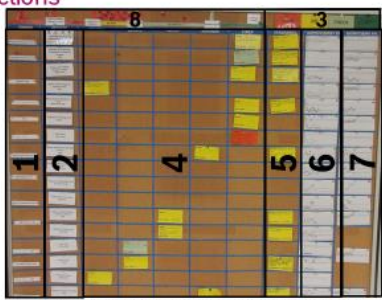
Figure 105 - Exerpt of the standard for the Daily Management Board

APPENDIX XV – STANDARD WEEKLY MANAGEMENT BOARD

WEEKLY MANAGEMENT BOARD INSTRUCTIONS



Weekly Management Board Sections



Objectives: Reduce the execution time for the projects; Sistematize the weekly follow-up and the development of a follow-up focused on the PDCA cycle



Weekly Management Board Sections 1 e 2: Owner and Project's Name

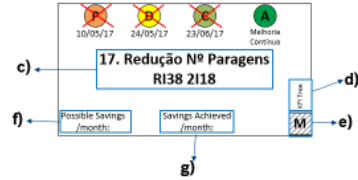
> In **Section 1** the Owner has to be identified with name and department
 > In **Section 2** the project's name is described in the card represented in the figure below



a) PDCA (Plan-Do-Check-Act) cycle status
 b) Limit date for the conclusion of each phase



Weekly Management Board Sections 1 e 2: Owner and Project's Name

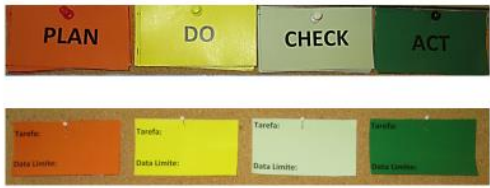


c) Project's number
 d) Derived from
 e) Value stream step where the project is inserted
 f) Possible Savings
 g) Savings Achieved



Weekly Management Board Section 3: Task Cards

> The cards for each stage
 > The color represents the PDCA cycle phase




Weekly Management Board Section 4: Weekly Planning

> If the task was planned for:

- Monday or Tuesday:** The tasks card is removed if the task is concluded and new ones are planned for the next week
- Thursday or Friday:** Como it's not possible to see if they are concluded so these remain in the columns and the next week are checked

If the task is delayed the new date is written and the previous scratched




Figure 106 - Excerpt of the standard for the Weekly Management Board

APPENDIX XVI – SATISFACTION SURVEY FOR THE DAILY MANAGEMENT BOARD

Satisfaction Survey - Daily Management Board					Owner
1. Do you considered that this systematic brought advantages?					Yes ☐ No ☐
1.1. If the answer was "No", why?					
2. Mark with an X the degree of agreement with the statements (1- Strongly Disagree; 2- Disagree; 3- Agree; 4- Completely Agree)					
	1	2	3	4	
2.1. I feel more motivated for the project with this systematic of daily follow-up					
2.2. The <i>Coach</i> started to be an active figure in the systematic CIP					
2.3. The project can be concluded faster					
2.4. With the board, the project's status visualization and the necessity for support is easier. Problems are quickly identified.					
2.5. Now I have a structured tasks' planning following the PDCA cycle					
2.6. I have the needed support by the <i>Coach</i>					
2.7. There is a clear connection between this board and the <i>Weekly</i>					
2.8. This systematic motivated the formation about the thematic, facilitating the projects' execution					
2.9. This systematic was na advantage for our department					
2.10. I see the graph of overdue tasks as a positive analysis since is easier to see when I need support					
2.11. It was hard to define a weekly availability for the projects					
2.12. I am pleased with the systematic and should be applied to other areas					
3. Observations					

Figure 107 – Satisfaction Survey: Daily Management Board - Owner

Satisfaction Survey - Daily Management Board		Coach																																						
<p>1. Do you considered that this systematic brought advantages? Yes ☐ No ☐</p> <p>1.1. If the answer was "No", why? _____</p> <p>2. Mark with an X the degree of agreement with the statements (1- Strongly Disagree; 2- Disagree; 3- Agree; 4- Completely Agree)</p> <table border="1"> <thead> <tr> <th></th> <th>1</th> <th>2</th> <th>3</th> <th>4</th> </tr> </thead> <tbody> <tr> <td>2.1. With this systematic is easier to give the needed support</td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>2.2. With the board, the project's status visualization and the necessity for support is easier. Problems are quickly identified.</td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>2.3. The project can be concluded faster</td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>2.4. I feel that the <i>Owners</i> are more motivated</td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>2.5. I can do a direct follow-up of the activities</td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>2.6. I am pleased with the systematic and should be applied to other areas</td> <td></td> <td></td> <td></td> <td></td> </tr> </tbody> </table> <p>3. Observations</p> <div style="border: 1px solid black; height: 150px; width: 100%;"></div>							1	2	3	4	2.1. With this systematic is easier to give the needed support					2.2. With the board, the project's status visualization and the necessity for support is easier. Problems are quickly identified.					2.3. The project can be concluded faster					2.4. I feel that the <i>Owners</i> are more motivated					2.5. I can do a direct follow-up of the activities					2.6. I am pleased with the systematic and should be applied to other areas				
	1	2	3	4																																				
2.1. With this systematic is easier to give the needed support																																								
2.2. With the board, the project's status visualization and the necessity for support is easier. Problems are quickly identified.																																								
2.3. The project can be concluded faster																																								
2.4. I feel that the <i>Owners</i> are more motivated																																								
2.5. I can do a direct follow-up of the activities																																								
2.6. I am pleased with the systematic and should be applied to other areas																																								

Figure 108 - Satisfaction Survey: Daily Management Board – Coach

APPENDIX XVII – SATISFACTION SURVEY FOR THE WEEKLY MANAGEMENT BOARD

Satisfaction Survey - Weekly Management Board				Owner
1. Do you consider the Weekly Management Board brought advantaged? Yes ☐ No ☐				
1.1. If "No", why? <input type="text"/>				
2. Assinale com um X o grau de concordância com as afirmações (1- Discordo Completamente; 2- Discordo; 3- Concordo; 4- Concordo Completamente)				
	1	2	3	4
2.1. I feel more motivated with the this weekly follow-up				
2.2. I can easily see the status of the projects				
2.3. The meeting management is easier				
2.4. The problems are identified faster				
2.5. This systematic reduces the project lead time				
2.6. I feel pleased with the systematic and should be applied to other areas				
3. Observations				

Figure 109- Satisfaction Survey: Weekly Management Board – Owners

Satisfaction Survey - Weekly Management Board		VS Manager	
1. Do you consider the Weekly Management Board brought advantaged? Yes ☐ No ☐			
1.1. If "No", why?		<input type="text"/>	
2. Assinale com um X o grau de concordância com as afirmações (1- Discordo Completamente; 2- Discordo; 3- Concordo; 4- Concordo Completamente)			
		1	2
2.1. I feel the <i>Owners</i> motivated with the this weekly follow-up			
2.2. I can easily see the status of the projects			
2.3. The meeting management is easier			
2.4. The problems are identified faster			
2.5. This systematic reduces the project lead time			
2.6. The time of the VS meeting was reduced			
2.7. I feel pleased with the systematic and should be applied to other areas			
3. Observations			
<input type="text"/>			

Figure 110 -Satisfaction Survey: Weekly Management Board - VS Manager