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Management of Global Industrialization Projects: two indicators for global standardization in the automotive industry

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STATEMENT OF INTEGRITY

I hereby declare having conducted this academic work with integrity. I confirm that I have not used plagiarism or any form of undue use of information or falsification of results along the process leading to its elaboration.

I further declare that I have fully acknowledged the Code of Ethical Conduct of the University of Minho.

RESUMO

Atualmente, a crescente competitividade dos mercados traduz-se na expansão das empresas para além das suas barreiras nacionais. A internacionalização das empresas impulsionou a produção focada em produtos customizados e com ciclos de vida menores. Esta tendência forçou as empresas de manufaturação a seguirem novas estratégias de negócio, adotando um modelo orientado para os serviços e com foco no cliente. A indústria automóvel passou a integrar a produção em massa de produtos customizados, através de linhas de montagem flexíveis em diferentes locais do mundo que incorporam a diferenciação dos produtos.

A presente dissertação do Mestrado em Engenharia Industrial foi desenvolvida na Bosch Car Multimédia Portugal, S.A., em Braga. Este trabalho de investigação centra-se na gestão de projetos, mais precisamente na gestão do processo de industrialização de um projeto global, com um centro de desenvolvimento comum e três fábricas localizadas em Portugal, na Malásia e na China. Deste modo, de forma a garantir que os produtos finais são iguais, mesmo industrializados em diferentes países, emergiu a necessidade de uniformizar os equipamentos e processos industriais nas três fábricas. Para tal, foram feitas melhorias em relação à gestão da informação do projeto e ainda foi desenvolvida uma Diretiva Central que visa orientar a equipa global durante todo o processo de industrialização em várias fábricas da divisão Car Multimédia em todo o mundo, desde a fase de aquisição do projeto até ao final da série.

Os principais objetivos desta pesquisa centram-se em avaliar e controlar o nível de maturidade industrial atual das diferentes fábricas e verificar a conformidade dos equipamentos e processos com a especificação global predefinida, tendo sido desenvolvidos dois indicadores que permitem identificar o progresso das tarefas pendentes e os equipamentos e processos que necessitam de ser melhorados.

Esta investigação apresenta-se assim como uma mais-valia presente e futura para a gestão de projetos globais de industrialização da Bosch Car Multimédia Portugal, S.A..

PALAVRAS-CHAVE

Indústria Automóvel, Projetos Globais, Projetos de Industrialização, Principais Indicadores de Desempenho, Gestão de Projetos

ABSTRACT

Nowadays, the growing competitiveness of markets means that companies expand beyond their national barriers. The internationalization of the companies boosted the production focused on customized products with shorter life cycles. This trend has forced manufacturing companies to pursue new business strategies by adopting a service-oriented, customer-focused model. The automotive industry has come to integrate mass production of customized products through flexible assembly lines in different locations around the world that incorporate product differentiation.

This dissertation of the Master in Industrial Engineering was developed at Bosch Car Multimedia Portugal, S.A., in Braga. This research work focuses on project management, more precisely on managing the industrialization process of a global project, with a common development center and three factories located in Portugal, Malaysia and China. Thus, in order to ensure that the end products are equal, even industrialized in different countries, the need to standardize industrial equipment and processes across the three factories has emerged. Thereby, improvements have been made to the project information management and a Central Directive has been developed to guide the global team throughout the industrialization process at several Car Multimedia division factories around the world from the acquisition phase of the project to the end of series.

The main objectives for this research is to evaluate and control the current industrial maturity level of the different factories, as well as, to verify the conformity of equipment and processes with the predefined global specification, had been developed two indicators to identify the progress of pending tasks and which equipment and processes need to be improved.

This investigation presents itself as a current and future asset for the management of global industrialization projects at Bosch Car Multimedia Portugal, S.A..

KEYWORDS

Automotive Industry, Global Projects, Industrialization Projects, Key Performance Indicator, Project Management

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ACRONYMS LIST

APL – Assembly Process Leader

ASM – Assembly Synchronization Manager

ASO – Assembly Station Owner

ASR – Assembly Station Representative

BBS – Bosch Business System

BES – Bosch Product Engineering System

BPLM – Bosch Project Lifecycle Model

BrgP – Braga Plant

BrgP/MFE1 – Department of Project Management and Sample Building

CI1 – Connected Information Solutions Business Unit

CM – Car Multimedia Division

CM/MFI – Manufacturing Industrialization Central Department

DAS – Device Assembly Specification

EWAK – Machine specialist support

FPY – First Pass Yield

IPMA – International Project Management Association

IRR – Initial Rejection Rate

ISO – International Organization for Standardization

KPI – Key Performance Indicator

LLP – Lead Line Plant

MAE – Machinery and equipment

MFT-CoC – Manufacturing-Centers of Competence organization

OEE – Overall Equipment Effectiveness

OPL – Open Point List

PAV – Product Test and Alignment Specification for Production

PCR – Process Change Request

PEP – Product Engineering Process

P-FMEA – Process Failure Model and Effects Analysis

PGL – Planning Guideline

PgP1 – Penang Plant

PjM – Project Manager

PMBoK – Project Management Body of Knowledge

PMI – Project Management Institute

PRP – Product Requirements for Production

QGC – Quality Gates of Customer

RTC – Rational Team Concert

SOP – Start of Production

TCO – Total Cost of Ownership

TPL – Testing Process Leader

TSM – Testing Synchronization Manager

TSO – Testing Station Owner

TSR – Testing Station Representative

WBS – Work Breakdown Structure

WhuP – Wuhu Plant

1. Introduction

The present dissertation emerged under the scope of the Master in Industrial Engineering at the University of Minho. It was conducted in the automotive industry at Bosch Car Multimedia Portugal, S.A. company, on the Department of Project Management and Sample Building (BrgP/MFE1). This department is dedicated to industrialization planning and sample production, as well as to update and manage the project information.

In particular, the researcher was part of the MFE-PM3 team which is responsible for the ratio analysis and the project management of global projects.

In this chapter is provided an overview of the research theme and is mentioned the objectives and the motivation of it. Also, is explained in chapter 1.3 the used research methodology and is enlightened a brief description of the dissertation structure on chapter 1.4.

1.1 Framework

Globalization has been the driving force behind the industry that we know today, characterized by the development of technology, the competitiveness of markets, the internationalization of value chains, and the destruction of borders between countries. In parallel with this development, arise a new concept of the global market, a market much more competitive, dynamic, and demanding. This has been the trend of the last decades and will remain in the future, once the expansion beyond-borders performs a primordial character for companies' competitive advantage (Smith & West, 1994).

In the specific case of the automotive sector, these changes also have been felt. In the nineteenth century, Henry Ford quoted: "*the customer can have a car in any color as long as it's black*". The large-scale production of standardized end products was the key factor for the low-cost mass production of Henry Ford's company that almost monopolized the American automobile market (Drucker, 1986). However, the black color became not enough to fulfill the requirements of the customers, outlining a higher consumption and innovation levels of new and better products.

The automotive industry has evolved from a system of repetitive work, rigid labor division and paced assembly lines, to flexible mixed-model assembly lines that produce a large variety of customized products. This modern production is called mass customization and embraces the postponement strategy, which means the delay of product differentiation as long as possible during the product assembly process. This requires a deep analysis of the product variants to understand the number of standardized parts that are possible to assemble in the generic form of the product before start bringing together the diversified parts (Gobetto, 2014).

The industry is being reinvented, now the product market time is reduced and the introduction of new products in the market needs to be faster and more effective (Turner, 2008). The new product development became fundamental for business growth in a sustainable way and to increase the competitiveness of companies in the market (Bai et al., 2017), boosting future opportunities for business (Pons, 2008). Such demanding innovation standards not only implies product modifications but also new industrialization processes to produce different customized products in shared production lines with well-defined and standardized manufacturing processes (Boyer, 1998; Gobetto, 2014).

In this way, with the market constantly changing and becoming more and more competitive, companies need to provide new and innovative products to their customers, with higher quality and lower prices in a shorter time. Project management tools emerge as fundamental strategies for companies to be more effective and flexible considering the market requirements (APOGEP, 2008).

According to Roldão (2010), project management is the process of planning, executing and controlling a project from its acquisition to its closure, in order to achieve a predefined goal through the input of technical and human resources. The same author also stated that the attained final product is restricted by cost, time and quality limitations. In addition, Bryde (2003) considers that project management is a capable tool to manage the wide variety of activities and to deal with all types of change within any organization.

Besner and Hobbs (2008) point out that the adopted project management practices differ according to the organizational project management maturity level, the project size and nature, the project familiarity and similarity, and the level of uncertainty during project definition.

Considering a multinational and multifunctional organization, where projects involve people from different geographical locations and organizations, even become more relevant to have well identified, defined and customized practices for manage projects. To face the growing globalization and to remain competitive in the new global market, adopt more suitable project management techniques has become decisive to handle with innovation (Pinto & Dominguez, 2012). Therefore, the project manager must be able to manage and promote communication between all stakeholders involved in the project to work together in the most efficient way across time and space barriers.

This subchapter contextualizes the research regarding a case study in the Manufacturing and Engineering department of a company that operates in the automotive industry. In this industry, two factors can be identified as the most critical ones: product quality and customer satisfaction (Andaleeb &

Basu, 1994). Accordingly, project management should plan, organize, guide and control the company's resources to achieve success, which Ebert (2009) emphasized that can only be measured, once the goals are set and the work progress is monitored. To do that, a performance measurement system must be used, which is "*a balanced and dynamic system that is able to support the decision-making process by gathering, elaborating and analyzing information*" (Neely et al., 2002 in Garengo, Biazzo, & Bititci, 2005, p. 25).

In short, it is important to be aware that, more than any other time in history, projects are becoming progressively complex and dynamic (Kerzner, 2013). As a result, project management appears as a critical factor for companies' success, driving through fast product development, efficient use of human and financial resources, and better communication (Pinto & Kharbanda, 1996).

1.2 Motivation and Goals

To face the new competitive market, companies gradually expand beyond their national borders (Abele et al., 2008). Therefore, companies began to search for new ways to reduce time-to-market, promoting innovation and applying more efficient strategies.

The globalization of industrialization projects has become a cost-saving opportunity to optimize companies' value chains. The manufacturing process in different countries is mainly driven to reduce production costs or transport costs, so the location of production sites must be strategically chosen to best benefit the company.

A global industrialization project encompasses the production of the same product or similar product variants at different locations around the world. Therefore, it is necessary to ensure the standardization of the equipment and processes among the different manufacturing plants. A higher level of project standardization results in a lower number of mistakes and miscalculations in production on a global scale and, consequently, a higher profit for the company.

Nevertheless, global production has a significant amount of information and resources associated , being more often communications problems in projects with multicultural teams (Ochieng & Price, 2010). To face communication and teamwork challenges, the global project manager should use support tools that provide and simplify the management and monitorization of the entire project.

In this sense, the motivation of this dissertation emerges as a proposal to help the management of global industrialization projects in the automotive industry, assessing the degree of industrial maturity of each manufacturing plant according to the predefined global standard and the degree of standardization between equipment, processes and manufacturing plants distributed worldwide. As a result, the overall status of the project becomes clear to all team members involved in it.

The proposal is directed by the need of transparency regarding the work done and the work that still needs to be done, in order to understand the main equipment, processes, and factories that must be the focus of attention to achieve the desired industrial maturity and efficiency as soon as possible.

Inherent with the study and because of what is presented as motivation and problematic, the following research question arises:

How to measure process standardization between manufacturing plants distributed worldwide?

After raising the research question, it is important to understand the objectives in order to define the progress of the study. Since this study involves several manufacturing plants located in different countries, it must be kept in mind that each factory given its dissimilar characteristics calls for a set of different values, ethics, work methodologies, capacities, and technological level.

In this sense, it is necessary to merge the composition of every production line of the project and bring together the characteristics and parameters of each equipment and process used in order to build a standard profile that must be a reference for the overall production.

To answer the research question, it was created two analysis tools that allow an overview of the project status in a visual and intuitive way. The development of these two indicators aim to accomplish the analysis of the performance index of the different manufacturing plants regarding the desired standard profile.

To support this study, it is possible to compile five goals:

- Study the equipment and processes that compose the industrialization process of a global project on the automotive industry;
- Identify the factors that cause equipment's differentiation between manufacturing plants in a global industrialization project;
- Define an approach to address the difficulties of managing an industrialization project in several countries;
- Develop an analysis tool to measure the degree of standardization of equipment and processes between the manufacturing plants in a global project;
- Develop an analysis tool to measure the degree of industrial implementation of each manufacturing plant in a global project.

1.3 Research methodology

Research methodologies are methods or procedures used to achieve tangible or intangible objectives. Therefore, a research methodology should be the basis of any research in order to guide the researcher through the best way to perform it and validate its procedures and results.

As Saunders et al. (2009) have stated, the researcher must choose the most appropriate methodology or strategy considering the objectives defined for the research. These methodologies are a way of obtaining the necessary knowledge to reach the research goals (Carvalho, 2017).

The chosen research methodology will be explained based on the research "*onion*" (Saunders et al., 2009, p. 106) to understand the philosophies and approaches used in this study. For each layer, will be clarified the choice that best fits this study, starting by the research philosophies, followed by approaches, strategies, choices, time horizons, and techniques and procedures (Figure 1).

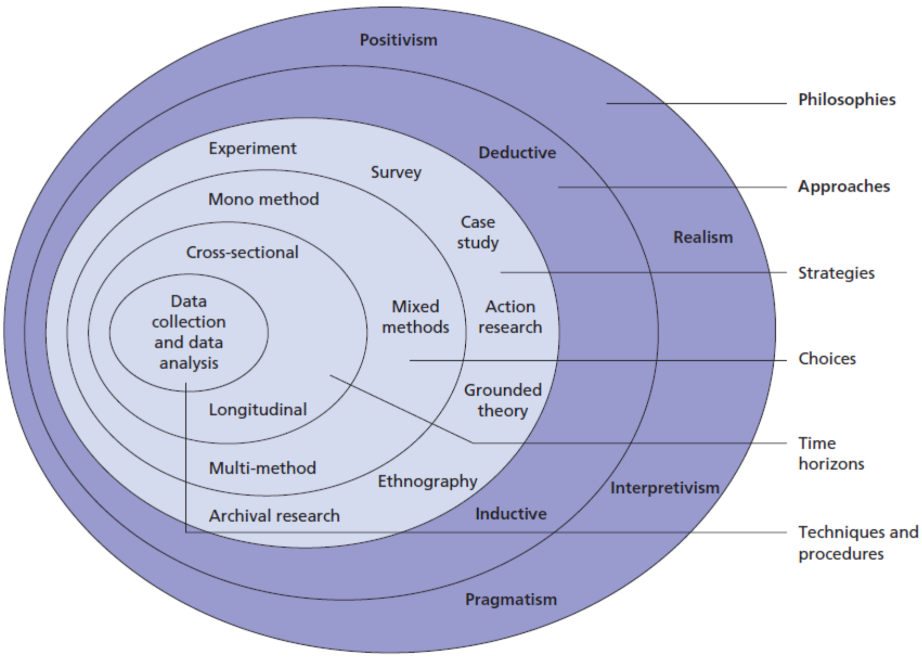

Figure 1 - The Research "Onion" (Source: Saunders, Lewis & Thornhill, 2009, p. 108)

The outermost layer represents the research philosophy that concerns the development and nature of knowledge. The most appropriate philosophy for this study is the pragmatic, as it assumes that the validity of different perspectives is determined by its practical success, according to the research question to be answered (Saunders et al., 2009).

This study is based on a deductive approach, where the researcher formulates a theory and develops one or several hypotheses that will be tested and validated through the most appropriate research strategy.

Furthermore, this research work followed a case study strategy, which is focused "*on understanding the dynamics present within single settings*" (Eisenhardt, 1989, p. 534). Similarly, Baxter and Jack (2008) declared that a case study is a qualitative methodology that supports the research on studying complex phenomena within their contexts.

This strategy seeks to answer in detail questions as "*why*" and "*how*", being the contextual conditions relevant to understand the phenomenon under study (Baxter & Jack, 2008, p. 545; Yin, 2014). Additionally, Yin (2014) adds that in situations where the researcher has little or no control over behavioral events and the focus is a contemporary phenomenon, the case study will be the most appropriated strategy.

The case study strategy allows the study of a contemporary phenomenon within its real-life context so, this dissertation aims to study the standardization of equipment and processes in global industrialization projects at Bosch Car Multimedia. In this particular case, the study is cross-sectional since the phenomenon could only be studied once due to the limited time of the researcher in the company.

To this end, data were collected mostly through two qualitative methods that together allow understanding the phenomenon under study as a whole.

The first method used was the observation that for Saunders et al. (2009, p. 288) is "*the systematic observation, recording, description, analysis, and interpretation of people's behavior*", where the researcher collects information without resourcing to data previously obtained by others (Kothari, 2004). At the beginning of this study, the researcher was limited to observe the biweekly meeting between all team members from Malaysia, Portugal, and China, and also the work performed by team members located in Braga by being in the same space as the industrialization team from Braga Plant. Patton (2002, p. 262) refers to this type of observation as a direct observation that is intended to "*understand and capture the context within which people interact*". After three months of work, the researcher took on a participative role as an Assembly Synchronization Manager in those same meetings, leading several meetings among all team members from the three manufacturing plants and supporting meetings between the CM team and global suppliers involved in the project under study.

Additionally, through direct observation, the researcher was able to gather information during line walks to production lines carried out at the shop floor in Braga.

The second qualitative method used was document analysis, which includes the analysis of the contents of documentary materials, such as reports, emails, minutes of meetings or even drawings. This method collects information that completes findings based on other data, such as written documents and primary data collected through observation or interviews (Saunders et al., 2009).

In this way, for data gathering, it was used the combination of direct observation, participant observation, and document analysis to obtain both formal/objective and informal/subjective information. All of this not only allowed the researcher to collect an overview of the current work, directly from the team members' experience and daily work but also, all the information associated with the industrial standardization needed in a global project.

After gathering data from documents and observation, the researcher analyzed the collected data that Eisenhardt (1989, p. 539) stated as "*the heart of building theory from case studies*". The researcher could identify the main weaknesses in information management of global industrialization projects and also could apply some improvement actions to facilitate the daily work of all project members across the world and to fill the proposed indicators of the project's global standardization level.

1.4 Dissertation Structure

In addition to this initial chapter, where is contextualized the study and is presented the objectives and the research methodology, this dissertation contains four other chapters.

Chapter 2 is dedicated to the literature review regarding the management of global industrialization projects, including an introduction of project management concepts to a deep explanation of how this area is applied to the increased difficulties experienced in the international context. Also, in this chapter, the reality of the automotive industry in the European and Asian markets is contextualized, given its relevance to the case study.

In chapter 3 is made an introduction of the company where this dissertation was developed, emphasizing milestones of its history, its business units, and its organizational structure. In this chapter is also described the approach of the company to industrialization projects.

After analyzing how the management of industrialization projects works in the company where the study took place, in chapter 4 is explained the work developed in this dissertation regarding global industrialization projects. The researcher restricted the research problem and from there outline an action plan. To answer the raised problem and mitigate identified weaknesses on information management and measure global standardization between manufacturing plants dispersed worldwide, it was applied improvements and tested two analysis tools.

The last chapter addresses the main conclusions of the case study analyzed, highlighting the main contributions and additional future work opportunities.

2. LITERATURE REVIEW

For this study, it was important to highlight studies carried out regarding the scope of this dissertation, to have a clearer view of inputs and results acquired over time, as well as the most relevant difficulties and topics that support in theoretical-scientific terms this study. In this sense, this chapter results from a published literature collection of substantially project management, industrialization projects, and global projects.

This state-of-the-art chapter is divided into three major subchapters. The first subchapter describes the elementary concepts regarding project management, the knowledge associated with the transversal character of project management, and its evolution over time. The second subchapter summarizes the literature review regarding industrialization projects addressing their composition and their management. At last, the third subchapter is related to global projects, particularly in the automotive sector, which will be the basis for the development of the case study.

2.1 Project Management Basics

The project concept has always existed from the earliest times to the present, however this concept has undergone several changes over the years due to the customer's demand for new and customized products and to the increasing competitiveness of the market. In this way, the need to manage projects has become imperative to introduce new products in the market faster and to produce them more efficiently.

Project management as a scientific discipline emerged in the 20th century (Garel, 2013). The growth of the project management discipline has driven organizational entities to standardize the practices associated with project management. One of the best known is the Project Management Institute (PMI), a worldwide leading non-profit professional association in the field of project management, which Bosch Car Multimedia Portugal, S.A. based the standardization of its practices and tools.

Like other subjects, project management has also evolved. The traditional management was considered a closed system that did not allow a vast interaction between the project management and the other functional areas. Once this type of management was focused on getting the job done, it did not generate huge profits for companies.

Over the years, companies have adapted their management style to an open system, named Modern Management. Unlike traditional management, it allows the regular interaction between all the departments of the company, leading to a better organization and communication strategy. Kerzner (2004) had stated that management is translated into better project efficiency, effectiveness, and productivity.

In the mid-1990s, the need to standardized language and structured knowledge about project management led to the creation of the first standards and certification programs, namely in 1996 the PMI launched the first version of Project Management Body of Knowledge (PMBoK), which is already in its sixth edition (2017). Regarding the project manager certifications, the Project Management Professional certification is the best known internationally, also from PMI.

Also, the International Project Management Association (IPMA) must be noticed as one of the other entities that had provided relevant inputs in this field.

For a clear understanding of the research, it is important to define some project management concepts.

2.1.1 Project

In the not too distant past, the occurrence of projects was occasional, and in many situations, it was avoided in the companies, because it disturbs the existing daily work routines. Thus, Dinsmore (1992) refers that projects are engines of change.

According to Dinsmore (1992) and (Atkinson, 1999), a project is a people-driven, definite start-and-finish venture to meet goals set within the cost, time, and quality parameters (Figure 2). For Kerzner (2002) a project, besides having an identifiable objective and consuming resources, is implemented under pressure of deadlines, costs, and quality constrains.

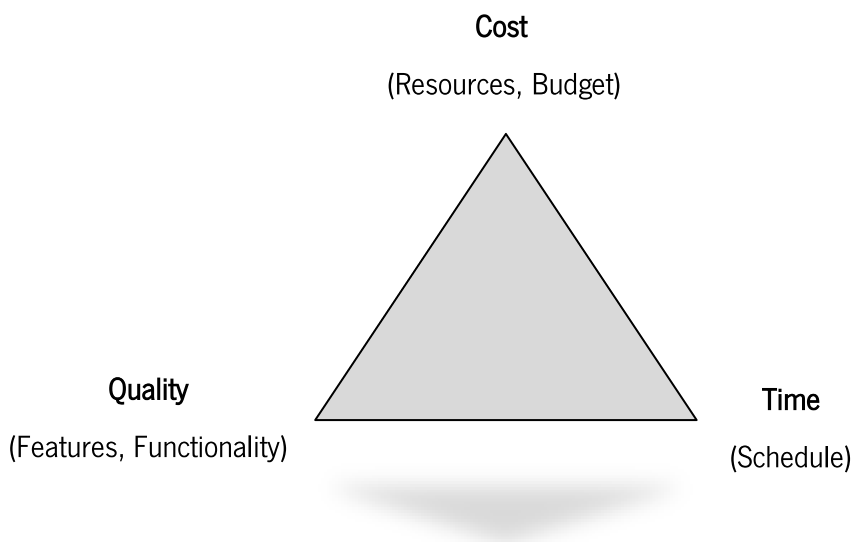

Figure 2 - Iron Triangle (Source: adapted from Atkinson, 1999, p. 338)

Reiss (1993) declared that a project is a human activity that achieves a clear objective against a time constraint, but that is not possible to provide a simple description of how to accomplish it, suggesting that project management is a combination of management, planning, and change management.

For Silva and Gil in 2013, projects were seen as a source of expenses, while the current operation was the main source of profit. However, management by projects has acquired relevance for companies as the market began to change, threatening organizations with mobility, and constantly new customer requirements (Silva & Gil, 2013).

The Project Management Institute introduces a project as a temporary endeavor with clear-cut objectives to create a unique product, service or result. Currently, projects are a common way of work, but each project remains unique (Figure 3), although may have similar deliverables and activities from other projects (PMI, 2013).

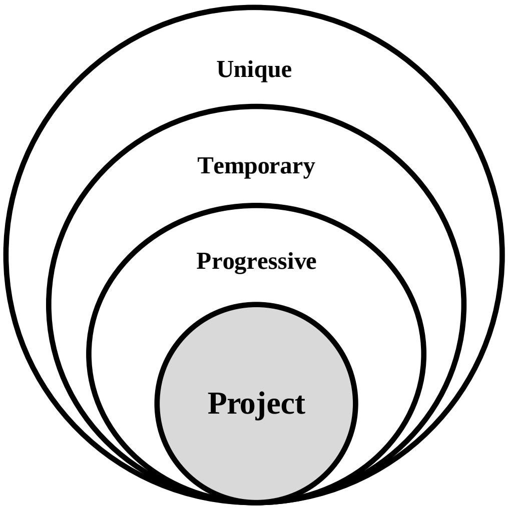

Figure 3 - Characteristics of a project according to PMBoK (Source: own elaboration)

Project can also be defined as "*a unique set of processes consisting of coordinated and controlled activities with start and finish dates, performed to achieve project objectives*" (ISO, 2012, p. 3).

In short, a project has as fundamental features (Kerzner, 2013):

- A specific objective to be completed within certain specifications;
- A time constraint (start and end dates);
- A budget constraint (usually);
- A human and nonhuman resource limit (i.e., money, people, equipment);
- A multifunctional team.

2.1.2 Project Life Cycle

The project life cycle covers various generic phases that the project goes through since its beginning to its completion. Regardless of the size or complexity of the project, they are all divided into phases which can be sequential, iterative or overlapping (PMI, 2017).

At least, a project has an initial stage, one or more intermediate phases, and a final stage. In each phase, the activities are logically related to match the requirements and the deliverables dates (PMI, 2017).

The only way to plan, execute and control the project is by identifying which steps compose it and after having a clear idea of that is necessary to define a logical order for activities and to analyze periodically the actual situation regarding the planned to detect possible deviations (Brand, 1992).

At organizations, the life cycle of projects corresponds to the sequence of activities and decisions that goes from the moment of the idea of the new product or service until that tangible or non-tangible asset turns into a deliverable, becoming available for production and commercialization. The project life cycle depends on the nature of the industry or type of project since it may incorporate the peculiarities of each organization (Silva & Gil, 2013).

An important note regarding this subject is that the life cycle of a project is independent of the life cycle of a product, which can be produced by a project (PMI, 2017). The product life cycle refers to the period since the conception of the new product until the end of product sales (Silva & Gil, 2013).

Under the scope of PMBoK from PMI (2017), all projects can be mapped according to a generic life cycle structure composed of four phases (Figure 4). Each phase is a logical combination of related activities that culminate in one or more deliverables, and that ends with a gate, where the performance of the project is set side by side with the project's documents, and once in conformity, the project proceeds to the next phase.

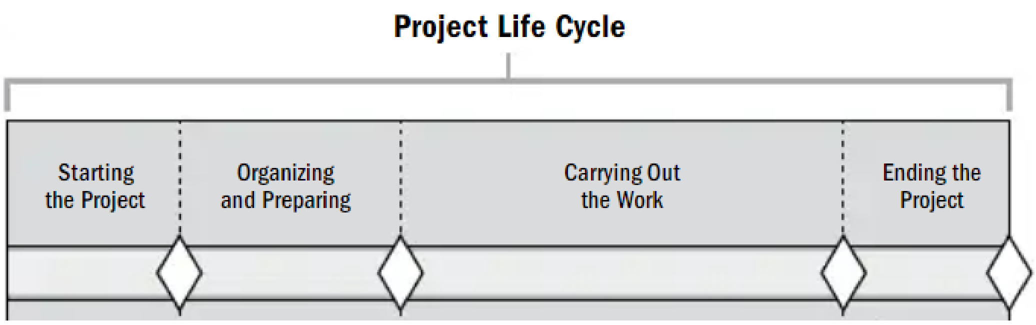

Figure 4 - Generic phases of the Project Life Cycle (Source: PMI, 2017, p. 18)

In the first phase, are identified and selected the projects, and is where is developed the Project Charter that is the document that formally authorizes the existence of a project and gives the project manager the authority to allocate resources to the project's activities.

In the organizing and preparing phase, is made the Project Management Plan, which describes how will be executed the project, monitored, and controlled in terms of scope, resources, activities, budget, and associated risks. In the next phase, is carried out the work, there must be meet all acceptance criteria of the final deliverable and, if necessary, is adjusted the previous plan.

In the last phase of the project is completed all project activities and is pointed out the lessons learned from the project to improve the performance of future projects.

In Figure 5, it is possible to note the project life cycle characteristics concerning cost and staffing levels, which are low at the beginning of the project, growing to a maximum point but with a sharp decrease in the final phase of the project (PMI, 2013). In the same way, the uncertainty, the risk associated with the project, and the ability of stakeholders to influence the final characteristics of the product, decrease over time. Unlike the cost of eventual changes in the project scope that is higher as the project is carried out, once every change from the planned is an unexpected workload.

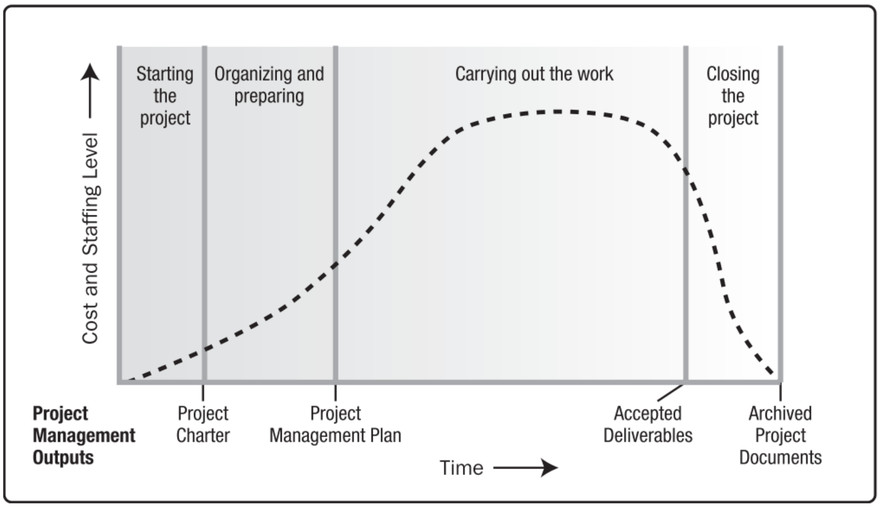

Figure 5 - Generic Project Life Cycle structure (Source: PMI, 2013, p. 39)

Archibald, Filippo, and Filippo (2012) propose a different approach from the Project Management Institute, presenting the Six-Phase Comprehensive Project Life Cycle Model that is not limited to the traditional start-plan-execute-closeout phases, including also the Project Incubation/Feasibility Phase and the Post-Project Evaluation Phase. These changes arise from the need to evaluate the benefits and characteristics of the project before the Project Starting Phase, and the need to determine and improve project success after the current standard Project Close-Out Phase, the proposed Post-Project Evaluation Phase identify weaknesses and threats that can be turned into opportunities for future projects.

The project manager should follow the project life cycle, but at the same time should be aware of the project management phases, which organize and describe how activities must be conducted to meet the project goals (Silva & Gil, 2013). PMI (2013) divides the project management processes into initiating, planning, executing, monitoring, controlling and closing.

In summary, understanding the life cycle is important to project success once each phase must be properly planned and managed concerning significant activities in a logical progression (Silva & Gil, 2013).

2.1.3 Project Management

To face performance, organization, and deadlines issues, companies embrace project management, being increasingly requested and accepted as resources become scarce (Abbasi & Al-Mharmah, 2000). Although it varies with the size and complexity of the project, project management has brought value to companies and, that is why it became an area of interest to them (Zhai, Xin, & Cheng, 2009).

Project management is considered a relatively recent area, but with strong growth in the last decades in the most diverse industries, aiming to control and distribute the existing resources in the best possible way (Kerzner, 2013).

Lester (2006) states that project management is the planning, monitoring, and control of all aspects of a project to achieve project goals, given the time, budget and performance constraints previously set. Besides that, project management is also responsible for managing the motivation of all parts involved. Thus, Turner (1999) claimed that project management should consider the people management for results rather than work management.

According to PMI (2017, p. 10), project management is considered "*the application of knowledge, skills, tools, and techniques to project activities to meet the project requirements*".

Project management appears associated with all work preparation processes, resulting in forty-seven project management processes divided into five logical groups – Initiating, Planning, Monitoring and Controlling, Executing and Closing - that aim to achieve the specific objectives of each project. These process groups are independent of the project life cycle phases (PMI, 2017).

Additionally, project management processes also are categorized by ten knowledge areas in the field of project management. PMI (2013) defines each process inputs and outputs in the different knowledge areas, as well as the most usual practices, tools, and techniques to achieve the desired outcome.

Figure 6 illustrates all knowledge areas from the PMI, as well as all the processes that compose them. Each knowledge area can have processes from several process groups, such as each process group can cover multiple knowledge areas.

Knowledge Areas	Project Management Process Groups				
	Initiating Process Group	**Planning Process Group**	**Executing Process Group**	**Monitoring and Controlling Process Group**	**Closing Process Group**
4. Project Integration Management	4.1 Develop Project Charter	4.2 Develop Project Management Plan	4.3 Direct and Manage Project Work	4.4 Monitor and Control Project Work 4.5 Perform Integrated Change Control	4.6 Close Project or Phase
5. Project Scope Management		5.1 Plan Scope Management 5.2 Collect Requirements 5.3 Define Scope 5.4 Create WBS		5.5 Validate Scope 5.6 Control Scope	
6. Project Time Management		6.1 Plan Schedule Management 6.2 Define Activities 6.3 Sequence Activities 6.4 Estimate Activity Resources 6.5 Estimate Activity Durations 6.6 Develop Schedule		6.7 Control Schedule	
7. Project Cost Management		7.1 Plan Cost Management 7.2 Estimate Costs 7.3 Determine Budget		7.4 Control Costs	
8. Project Quality Management		8.1 Plan Quality Management	8.2 Perform Quality Assurance	8.3 Control Quality	
9. Project Human Resource Management		9.1 Plan Human Resource Management	9.2 Acquire Project Team 9.3 Develop Project Team 9.4 Manage Project Team		
10. Project Communications Management		10.1 Plan Communications Management	10.2 Manage Communications	10.3 Control Communications	
11. Project Risk Management		11.1 Plan Risk Management 11.2 Identify Risks 11.3 Perform Qualitative Risk Analysis 11.4 Perform Quantitative Risk Analysis 11.5 Plan Risk Responses		11.6 Control Risks	
12. Project Procurement Management		12.1 Plan Procurement Management	12.2 Conduct Procurements	12.3 Control Procurements	12.4 Close Procurements
13. Project Stakeholder Management	13.1 Identify Stakeholders	13.2 Plan Stakeholder Management	13.3 Manage Stakeholder Engagement	13.4 Control Stakeholder Engagement	

Figure 6 - Project Management Process Group and Knowledge Area Mapping (Source: PMI, 2017, p. 25)

Fernandes et al. (2013) recognized the top most useful practices that cover the overall project management life cycle since the project conception to its completion. Figure 7 shows the top twenty of the list of the most useful tools and techniques of project management by process group and knowledge areas, highlighting the knowledge areas of scope, time, risk, communication, and integration that have at least three PM practices on the top of the list.

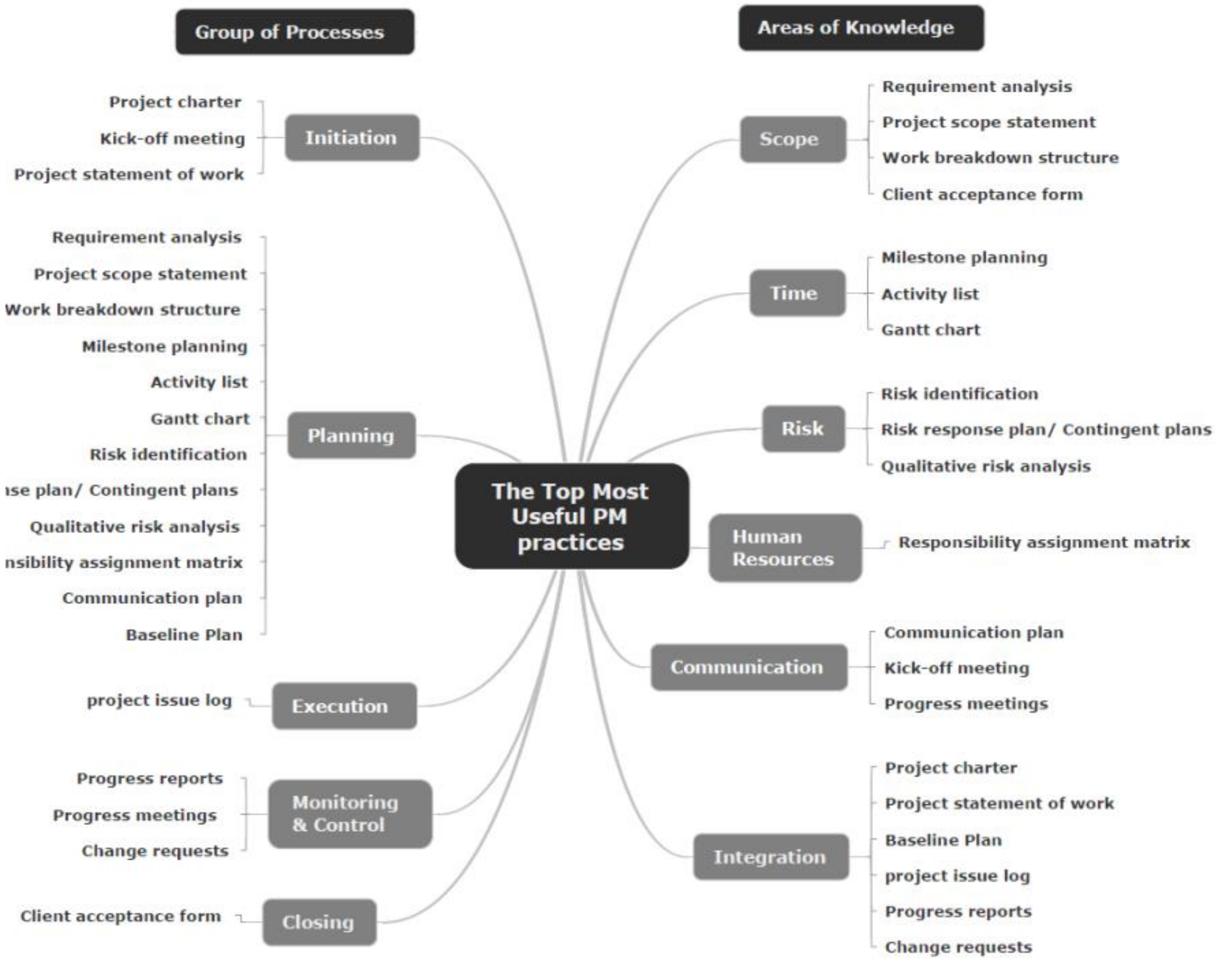

Figure 7 - The top twenty most useful PM practices by group of processes and areas of Knowledge (Source: Fernandes et al., 2013, p. 16)

2.1.4 Project Manager

Such as project management also its central figure, the project manager, has been the subject of many studies that highlight its critical role in project success (Yang, Huang, & Wu, 2011). The performance of the project is directly related to the project manager, once it is the center of communication for all parts of the project, coordinating the project elements to effectively achieve the project goals (Roldão, 2010).

Nowadays, organizations focus on ensuring that project managers acquire the core competencies that need to be successful in their roles. The most relevant competencies of a project manager are the achievement drive, leadership, conflict management, and initiative (Liikamaa, 2015).

The study carried out by Müller and Turner (2010), concluded that to complete the project successfully, the project manager leadership competency profile must differ based on the type of project. In the case of simple projects, the project manager should interact with the team by valuing the sense of duty and establishing a system of rewards or punishments regarding the achievement of the project objectives. On the other hand, in complex projects, the leadership profile adopted by the project manager must be focused on motivating the team to be aligned with the mission and the organization.

In summary, the project manager plays a decisive role in project planning, execution, and control throughout the project life cycle. Considering that the project manager is the person responsible for leading the project, he/she needs to manage the resources associated with it and create clear and achievable objectives to obtain the successful completion of the project (PMI, 2017).

2.2 Industrialization Projects

When it comes to industrialization projects, they are related to the design and development of manufacturing lines to produce a certain product or to industrialize several products with small differences between them (Perrotta et al., 2017). Therefore, this particular type of project precedes and leverages mass production systems, aiming a production at the lowest cost and as efficiently and effectively as possible.

According to Chen (2017, p. 1260), industrialization is considered the manufacture and production at a large-scale that starts on the development of a new product until the production scale process, throughout the "*integration of manufacturing and processing, to promote the extension of the industrial chain, and improve the efficiency of resource applications to create maximum value of output*". This set of processes results in a production system capable of delivering a product taking into account the predefined specifications and the budget and time constraints (Pont, 2013).

Johansson and Kamenjas (2016) stated that the new product development process consists of three phases: design phase, industrialization phase, and production phase. The first phase refers to the creation of ideas, the development of product concept, and product planning. The industrialization phase consists of subprocesses such as product design, system design, and prototyping. Finally, the production phase involves the ramp-up phase and the production of the new product.

In this way, the first step of an industrialization project is understanding all product requirements that will underlie the several developed prototypes, before the conception of the manufacturing line. These prototypes have an increasing maturity level of the product and are usually validated by customers, who will provide feedback and may require changes in the product requirements. This process of building and validating samples allows the improvement of the product concept and functionality, avoiding additional costs when the product is ready to be launched into production (Margineanu, Prostean, & Popa, 2015).

Once the customer satisfied, the development of the manufacturing line begins (Perrotta et al., 2017). The industrialization process is then the bridge between the design and the production (Khedher, Henry, & Bouras, 2010).

Traditionally, across the industrialization process, is performed a product and process assessment through a quality gate system, to verify the conformity of the developed prototypes with the requirements defined by the project stakeholders. Cooper (1990, p. 44) refers to the quality gate system as a "*system (that) is both a conceptual and an operational model for moving a new product for an idea to launch. It is a blueprint for managing the new product process to improve effectiveness and efficiency.*"

The quality gates break down the project into several phases, preventing the project of proceeding to the next phase in case the project fails in accomplishing the requirements defined by the stakeholders (Perrotta et al., 2017).

In the case of the process and product are robust enough to be capable of supporting series production, the ramp-up phase occurs. According to Berg and Säfsten (2006), the ramp-up phase is the period between the production start and the production goal, being a crucial phase to achieve an efficient production from the beginning. The same authors added that time and costs for ramp-up production are minimized when this phase is managed efficiently, which does not always happen due to the lack of knowledge and skills in managing.

To face the market competitiveness and the rapidly decreasing product life cycles, any manufacturer should focus on managing the ramp-up phase successfully, once it is fundamental to successfully launch new products in new or in existing production systems.

Finally, industrialization projects follow the normal life cycle of a project, having as main activity the definition of the manufacturing process of the new product as soon as possible and, at the same time, ensuring the lower cost and the higher quality (Khedher, Henry, & Bouras, 2010).

2.2.1 Key Performance Indicators

A performance measurement system can be defined as "*a balanced and dynamic system that is capable of supporting the decision-making process gathering, elaborating and analyzing information*" (Neely et al., 2002 in Garengo, Biazzo, & Bititci, 2005, p. 25), being considered as an indispensable metric to lead an organization (Krishman, 2008).

The main goal of performance measurement systems is to evaluate and control the current performance of the business and verify its conformity with the predefined targets (Ishaq Bhatti, Awan, & Razaq, 2014). In this way, performance measures should be chosen and monitored over time.

The Key Performance Indicators (KPIs) are the set of measures used with a focus on the main critical activities for the current and future success of the organization (Parmenter, 2015). Traditionally, these indicators are used to evaluate the success of an organization or the success of a specific activity from it (Archibald et al., 2012).

Therefore, performance measures allow a constant and concrete control of the needs and possible improvements in the organization, supporting the decision making to reach the desired objectives, even when they are adjusted. Through the KPIs, managers can identify the progress of activities and the activities that need to be improved, which facilitates the management of tasks in order to achieve the desired performance, always considering the mission and objectives of the organization (Weber, 2005).

In this way, KPIs aim to measure the efficiency and effectiveness of the activities or actions from the production process, either part of it or the entire production system. Key performance indicators then help operators and decision-makers understand if the current performance is following the right path or not and take the necessary actions to make the indicators point the desired outcome (Zhu et al., 2018).

The International Organization for Standardization (ISO) present the ISO 22400 that define the most important measures to evaluate the performance of the manufacturing industry, providing a list of thirty-four KPIs that includes measures such as the overall equipment effectiveness index, machine capability index, production process ratio, first pass yield, among others (Zhu et al., 2018).

At last, the growing competitiveness of markets leads to the acquisition of different strategies by companies to gain an advantage over the other players of the market. Krishman (2008) remarks that globalization boosts a different approach to performance measurement systems. As a result, appears what is called an integrated or multidimensional performance measurement system that considers factors such as environmental uncertainty, organizational strategy, and organizational structure.

2.3 Global Projects

Globalization appears as a consequence of the "*modern client*", a customer with volatile demand, leading companies to offer a more diverse product range in a shorten period (Silva & Gil, 2013, p. 139).

The phenomenon of globalization can be divided into three phases (Abele et al., 2008). The first one occurred before 1930 when the industry was focused on mass production and economies of scale, exporting products from the home location to sales offices around the world. From 1930 to 1980, large companies such as Mercedes or Coca-Cola began to stand out globally. It was during this period that increased the production abroad, developing new sales markets and local just-in-time systems. Finally, the last phase of globalization began in 1980, when the industry identified strategic advantages on international supply chains and cross-functional collaboration.

From the point of view of Lanza et al. (2019), the globalization phases are described from the 1990s when occurred the internationalization of large companies. Since the 2000s, it has increased the competitiveness of markets and driven more and more companies to expand their business limits globally, even small and medium-sized companies, which has allowed them to obtain competitive advantage by adapting products to local needs (Mourtzis, Doukas, & Psarommatis, 2013) and accessing to skilled workforce (International Monetary Fund., 2007).

The internationalization of companies, the reduction of trade barriers between countries, the volatility of global demand and the progress of technology have led companies to adopt new business strategies, emerging the so-called "*global projects*" that, according to Binder (2007, p. 1), are a "*combination of virtual and international projects, which includes people from different organizations working in various countries across the globe*".

In other words, global projects can also be described as a temporary endeavor where through a combination of contractual, hierarchical, and network-based modes of organization, multiple actors aiming to optimize outcomes by combining resources from various sites, organizations, cultures, and geographies (Scott, Levitt, & Orr, 2011). Due to the complex external context, such projects require an additional effort in their management, particularly in relationship management (Aarseth, Rolstadås, & Andersen, 2013), as they involve people from different cultures geographically and temporally dispersed.

Projects that were previously limited to national boundaries, now have a global dimension and with them also work teams. These distributed projects include members who are distributed across space and time, making the communication and alignment of decisions and activities more difficult for the team (Evaristo & Fenema, 1999).

At this time, the overall scenario in the industry is distributed production networks that appear as a way to counter the high costs associated with the rigid and centralized systems that we knew, especially the transportation costs (Matt, Rauch, & Dallasega, 2015).

The global production network is considered a group of geographically dispersed production entities that are interlinked through the material, information, and financial flow (Lanza et al., 2019). This dynamic, open, and overlapping system increases the interconnection between all the interrelated partners and aims to provide direct value-adding activities to the production (Váncza, 2016). However, these global networks have become more vulnerable and dependent on the work of the other actors, making the coordination of inter-organizational relationships a crucial factor in the success of organizations (Moch, Riedel, & Müller, 2014).

In summary, the increasing need of business partnerships and projects across nations led companies embrace distributed projects that comprise a team distributed across space and time (Evaristo & Fenema, 1999), from different geographical locations, organizations and cultural backgrounds (Rad & Levin, 2003). In the next subsection, will be explored the impact of these changes on manufacturing companies and how they shape themselves for the future.

2.3.1 Global Industrialization Projects

Currently, manufacturing companies operate in global production networks (Treber & Lanza, 2018), which means organizational platforms that involve actors geographically dispersed that compete and cooperate for a greater share of value, turning out to be critical to face the fierce competitiveness of this sector (Yeung & Coe, 2015).

The internationalization of companies boosts production focused on customized products, moving from rigid mass production to the production of products highly adapted to local needs. This trend is, by one hand, an opportunity for companies to grow but, on the other hand, represents a challenge in terms of sustainability and efficiency, once product life cycles are getting shorter and shorter what makes the time and resources to develop and industrialize new products even more limited.

Therefore, companies adopted new ways of organizing their entire production system, positioning the production in different locations around the world. Matt et al. (2015) refer to eight different types of distributed manufacturing, since a factory model that manufactures standardized products across the world to a future form of decentralized production with distributed laboratories using generative manufacturing processes, digital data transmission of product data and 3D printers.

So, what drives companies to produce in different locations across the world after all? In *Global Production: A Handbook for Strategy and Implementation* (Abele et al., 2008) is highlighted as the main drivers behind corporate globalization: the cost and growth impact. The several locations of production should be chosen based on the total production and transaction costs for the entire value chain considering the labor costs, once they tend to be higher in affluent economies, while in others, wages tend to be lower. In addition to the cost reduction, also markets outside the highly industrialized world are becoming more attractive to achieve the growth that companies are looking for, and to respond more flexibly and at a lower cost to local needs.

Moreover, global production networks contribute to fulfill customer requirements and achieve a global sustainable supply chain, which would not be possible with the previous centralized production. In this context, production of customized and locally adapted products became a reality, appearing the mass customization that Pine (1999), p. 47) defines as "*developing, producing, marketing and delivering affordable goods and services with enough variety and customization that nearly everyone finds exactly what they want*".

Similarly, Matt et al. (2015) affirmed that the decentralization of production has higher flexibility to local adaptation of products, lower logistic costs and shorter delivery time. On the other side, the same authors mention that investment costs are higher in globally distributed structures and production efficiency is lower since the concept of highly automated central production factories of standardized products has been lost.

The manufacturing facilities should be located considering the criteria that best fit the company's strategy, appointing to locations near consumption areas, areas rich in raw materials, areas with a highly qualified staff, or in low-wage countries (Matt et al., 2015). In this way, the customer proximity and location advantages such as low production and procurement costs, and local knowledge and resources, represent important factors for the decision of production location (Abele et al., 2008).

In the future, as the demand volatility tends to be higher, the product life cycle will be shorter and the produced quantity of each product will be smaller, which forces manufacturing companies to have flexible and reconfigurable production systems to introduce new products into new or existing production systems as soon as possible (Berg & Säfsten, 2006).

In the next subsection is explored the automotive industry in the European and Asian markets since this study is focused on a global industrialization project located in these markets.

2.3.2 Automotive Industry in Europe and Asia

The automotive industry is one of the largest manufacturing sectors worldwide. Thus, due to its large size, all its organizational and management strategies are influencing many other business sectors (Orsato & Wells, 2007).

The evolution of the technological world has led companies to change their business model, including the products and services offered, as was the case of automotive companies (Gao et al., 2016). As a result, the use of new technologies drove the community to work on autonomous driving, Internet-of-Things, and e-mobility. The automotive industry extended its business model for a service-oriented model with a user-focused approach, offering services such as mobility-on-demand, personalized driving experiences, and advanced safety measures (Cohen & Kietzmann, 2014; Lengton, Verzijl, & Dervojeda, 2015).

Focusing on customer satisfaction, it becomes a challenge for companies in this industry to achieve a sustainable and profitable production process and, at the same time, respond to demand volatility and segmented niche market requirements. In this way, companies have adopted new production strategies that complement massification with the diversification desired by the customer. The answer to this challenge is new flexible mixed-model assembly lines that incorporate diversity in a controlled manner, delaying the product differentiation as long as possible during the product assembly, which Gobetto (2014) defined as the postponement strategy. However, this current production has to manage many ramp-ups, once involve multi-variants serial assembly lines (Küber et al., 2016).

To ensure product and process quality, Küber et al. (2016) consider that the degree of automation is the most important part of technical norms in the industrialization process since they are not such vulnerable to human failures and, at the same time, improve working conditions. High-cost countries with a higher wage level tend to have a higher level of automation. As a matter of fact, the same authors also add that construction and planning costs of production lines are reduced with the standardization of the technical requirements of automation, once it is possible to transfer optimized results to identical processes.

For both carmakers and component producers, there has been a growth in the worldwide market in countries characterized by low human costs and big potential markets, like China and India (Gobetto, 2014). This workforce diversity, at first glance, can be seen as an obstacle for production but, once managed correctly, can lead to productivity-increasing through know-how sharing (Saxena, 2014). Huang (2016) concluded in her study that the working method of the European workers, specifically Germans, is to work autonomously based on rigorous project planning, not being very flexible to any change. In opposite, the same author emphasized that the Chinese workforce is receptive to authoritarian leadership and has the advantage of quickly reacting to adversities.

Moreover, carmakers have become involved in social and environmental issues, due to its large size and diversity, the automotive industry has a huge societal impact. The request for the sustainability of automobiles and services related to the mobility sector should start in its development with a holistic approach balancing social, economic and environmental factors (Orsato & Wells, 2007). In the case study of China's automotive production conducted by Liu et al. (2018) is mentioned that companies should opt for strategies such as remanufacturing and direct reuse to increase resource efficiency and reduce environmental impacts.

From the same point of view, the introduction of strategies such as the end-of-life directive of products and development on design for reuse was proposed to the local automotive manufacturers, promoting the reuse components in the Malaysian automotive industry (Amelia et al., 2009). As a developing country, Malaysia promotes economic development, but does not compromise social protection of workers and environmental issues (Zailani et al., 2015).

In Asia there are two emerging economies (China and Vietnam), four competitive economies known as "South Tigers" (Indonesia, Malaysia, Philippines, and Thailand), and two industrialized economies (Japan and Korea) (Burgess & Connell, 2007). The labor markets in Asia have been impacted extensively by the globalization and industrialization phenomenon (Rasiah, McFarlane, & Kuruvilla, 2015), particularly Malaysia has been one of the countries that have experienced a large industrialization since 1970, with the opening of several free trade zones (Wong, 2011).

2.3.3 Management of Global Projects

To face the dynamic market environment that surrounds organizations, they changed the way of working and consequently the way of managing projects. Traditionally, project management was focused exclusively on a single project at a single location (Chen et al., 2003). However, globalization has changed that, now projects are organized and managed worldwide with a different approach, moving from working with people who are in our visual proximity to working with people around the world.

Both small and large companies have projects with a global dimension involving geographically distributed professionals working on cross-functional projects with a common objective. These projects have associated a foreign environment and people from diverse cultures that Huang (2016) highlights as factors that lead to a certain degree of uncertainty about the project due to the different ways of thinking and working.

With this, it has become common to talk about virtual teams, which are groups of geographically, organizationally and/or dispersed workers that complete one or more organization tasks together through information and telecommunication technologies (Powell, Piccoli, & Ives, 2004). These groups who cooperate from internationally distributed sites and different organizations do not share the same physical or temporal space, so it became difficult or even impossible to organize face-to-face meetings in a common office for every person involved in the project.

Therefore, a new approach to project management was required to achieve project success in virtual and international teams, crossing time, space, and cultural boundaries. In the perspective of Binder (2007), the project manager must be aware of the different attitudes, beliefs, behavioral norms, basic assumptions, and values that can affect or influence the collaboration between the team members coming from different countries. At the same time, the leadership style adopted by the project manager must be chosen considering the different cultures present on the project.

The International Project Management Association (2015) emphasizes that a leader must provide direction towards a common goal, driving a group of people and focusing their efforts through an appropriate choice of management style, which varies with project conditions.

Not only the project and team characteristics, but also the challenges that appear adjacent to these global projects are not the same as project managers tend to find in projects at a single location, but their leadership remains a key factor to achieve the project goals (PMI, 2013).

In this way, the project manager's skills are closely related to the success of the project and should include having good communication and leadership competencies to delegate tasks and responsibilities, analyze and solve problems and promote cooperation between the team. When it comes to global projects the harmonious cooperation between all people involved in the project can be compromised through three influencing factors, namely "*industry*", "*people*" and "*culture*" (Huang & Chung, 2014, p. 3). A comprehensive understanding of these three factors will be crucial to know how people who differ culturally will react to the cultural differences that exist and stand out throughout the project development.

Therefore, as Huang (2016, p. 76) stated "*global project management is a highly dynamic domain*" so, the global project manager must be flexible to adjust constantly the project plan to emerging challenges and opportunities. Although there are no equal projects, there are guides like PMBoK that are a reference for any project manager anywhere in the world.

In the particular case of the automotive industry, project management has also been under study and constant improvements, since this industry involves a high-pressure level regarding product innovation and time constraint due to the fierce competition of the market (Margineanu et al., 2015).

3. Case Study

This chapter begins with a brief description of the company where was developed this case study. Firstly, it is provided an overview of the latest results and the presence of the company around the world.

The factory located in Braga is described more closely in subsection 3.2 to understand the manufactured products and the department where was integrated the study.

In subsection 3.3 is provided a deep analysis of an industrialization project at Bosch, including a short introduction of a Central Directive regarding the project management at Bosch and an explanation about the project lifecycle and the Product Engineering Process activities.

3.1 Bosch Group

The present dissertation was developed at Bosch Car Multimedia Portugal, S.A., which belongs to Bosch Group headquartered in Stuttgart, Germany.

The history of Bosch Group begins in November 1886, when Robert Bosch founded the "Workshop for Precision Mechanics and Electrical Engineering" at Stuttgart. Since that time, Bosch has been growing and became a worldwide corporate group. In 2018, Bosch Group was represented in more than 60 countries with roughly 460 subsidiaries and regional companies, which generated sales of 78.5 billion euros, as shown in Figure 8.

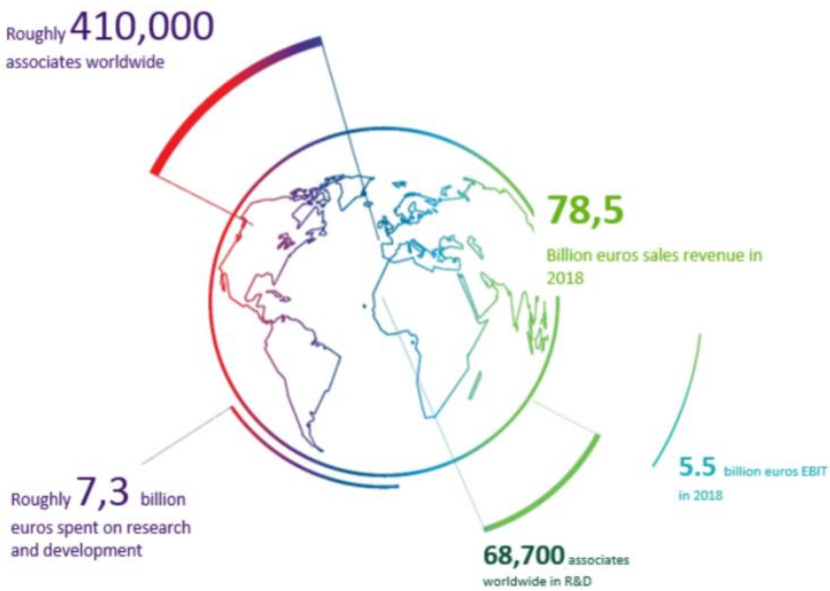

Figure 8 - Bosch Group's values at 2018 (Source: Bosch, 2019)

As a leading global supplier of technology and services, the Bosch Group stands out by its innovative strength and its social commitment. The Group mission statement "We are Bosch" is composed by five tiers – objective, motivation, strategic focal points, strengths and values. Under group's mission, the main motivation is described as the desire to develop products that are "Invented for life". In fact, Bosch's major focus areas for the future include automated driving, electromobility and the internet of things.

The objective of Bosch Group is to ensure its strong and meaningful development and preserve its financial independence, as wished by its founder, Robert Bosch. To guarantee the sustainability of this global operating company, the Bosch Group prioritizes the focus on customer, in being flexible to change and in striving for excellence to maximize performance.

Nowadays, Bosch operates in four business sectors: mobility solutions, energy and building technology, consumer goods and industrial technology.

This master dissertation analyzes Car Multimedia (CM) division, which is included in the mobility solutions business sector. The CM division has branches in 30 countries, counting with 129 engineering centers, manufacturing and service locations that develop infotainment, connectivity and human-machine interface (HMI) solutions, aiming to be used in passenger cars, commercial vehicles, buses, two-wheelers, and off-highway vehicles.

In case of Portugal, Bosch took the first steps in 1911 with an opening of a sales office. Today, Bosch Portugal is represented by (Figure 9):

- Bosch Thermotecnhology, in Aveiro;
- Bosch Car Multimedia, in Braga;
- Bosch Security Systems, in Ovar;
- BSH household-appliances and a sales office, both in Lisbon.

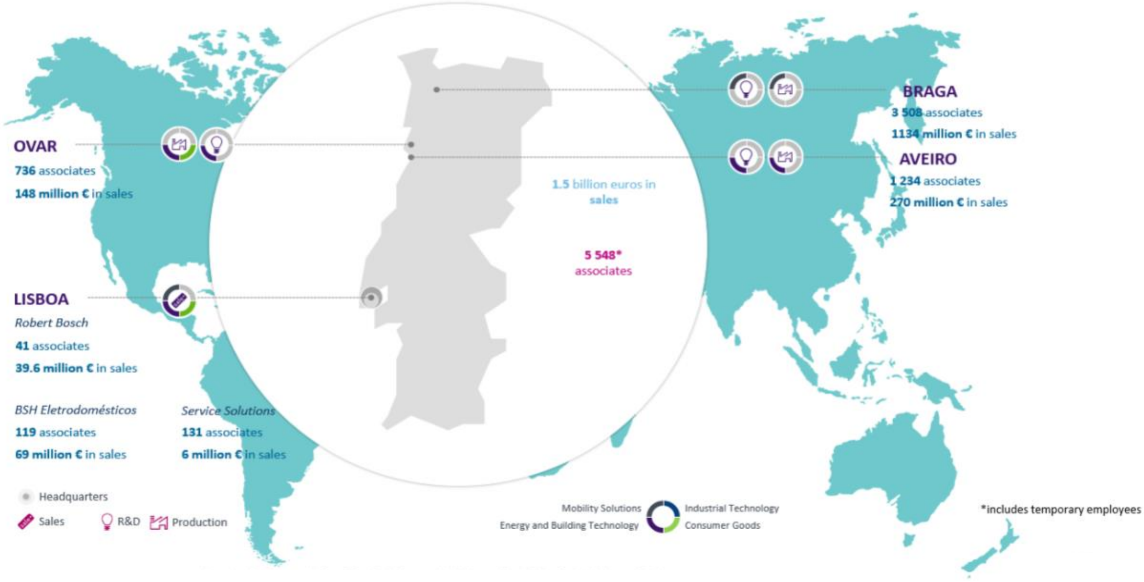

Figure 9 - Bosch Portugal in 2018 (Source: Bosch, 2019)

Braga plant (BrgP) not only is the largest Bosch company in Portugal but also is the main factory of Car Multimedia division of the Group. On the next subsection, an overview of this factory will be provided, by evince its major historical milestones until describe its current organization structure.

3.2 Bosch Car Multimedia Portugal, S.A.

Bosch Car Multimedia Portugal S.A., located in Braga, was founded in 1990 as Blaupunkt Auto-Radio Portugal. In 2009, as consequence of a restructuration on Bosch Group's Car Multimedia division, the Blaupunkt brand was sold and Braga factory reemerged under the name of Bosch Car Multimedia Portugal, S.A..

This company has a strong presence in Braga, being one of the largest employers of the city. Additionally, Bosch Braga has an innovation partnership with University of Minho, resulted of the biggest innovation contract in Portugal in 2016. The company's successful path has been recognized over the years by many awards as Energy Efficiency Award (2011), Bosch Quality Award (2013), EFQM Excellence Award (2015, 2017), Logistics Excellence Award (2016), PSA Supplier Award (2018), CES Innovation Award (2017, 2019) and JLR Quality Award (2019).

Braga factory produces a wide portfolio of innovative and high-tech products (Figure 10), mainly composed by navigation systems and instrumentation systems. Since this factory is one of the most recognized and qualified suppliers in the automotive industry, it presents many customers around the world.

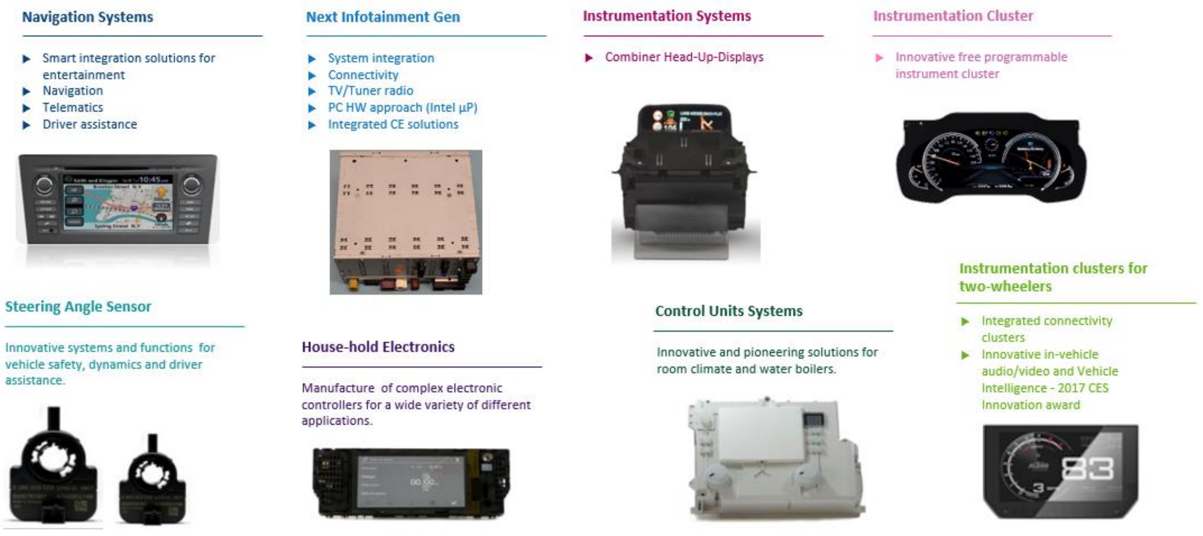

Figure 10 - Product Portfolio of Bosch Car Multimedia Portugal, S.A. (Source: Bosch, 2019)

Braga plant presents the following departments divided between the Commercial area (BrgP/PC) and the Technical area (BrgP/PT). In addition to these two management areas, exists a parallel area associated with the logistics sector that operates worldwide (Figure 11).

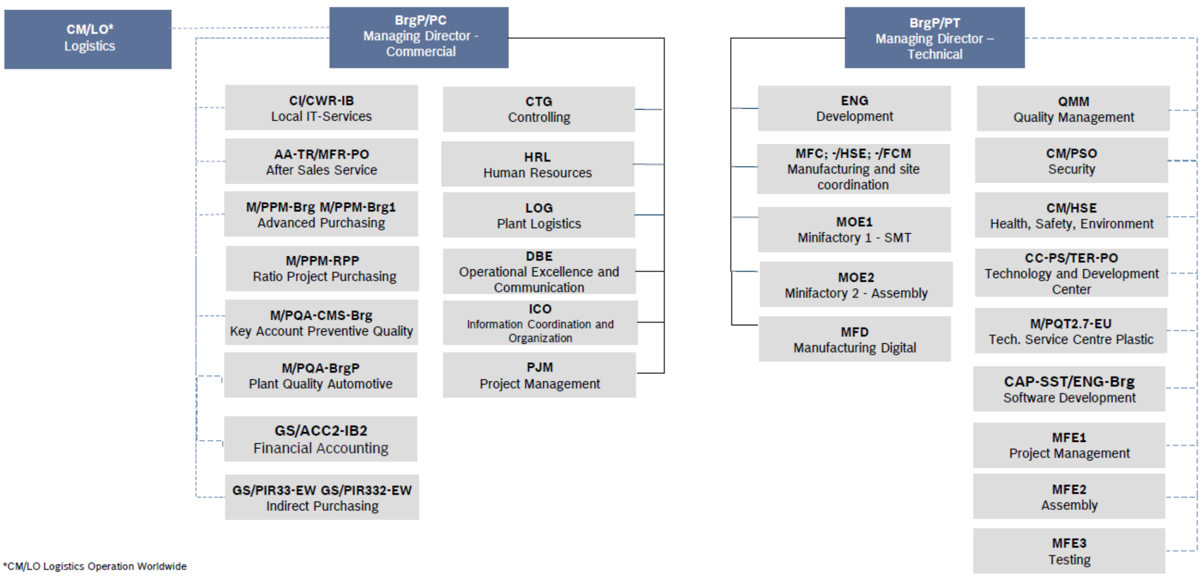

Figure 11 - Organization Chart of Bosch Car Multimedia Portugal, S.A. (Source: Bosch, 2019)

The Manufacturing Engineering (MFE) department is composed of three multifunctional sectors which are Project Management and Samples Building (MFE1), Assembly (MFE2) and Testing (MFE3). To support these sectors, the Maintenance (MFE-MTN) and the Project Office (MFE-PO) provide transversal assistance.

This dissertation was carried out in MFE1 that is responsible for industrialization planning, samples planning for line setup, project schedule available and updated, samples production planning, and POWER tool information updated.

3.3 Industrialization Projects at Bosch

There are several types of projects at Bosch, as software projects, manufacturing projects, purchasing projects, among others. Industrialization projects belong to product development and engineering projects.

The work of an industrialization project embraces two different efforts regarding Product Development, which follows the Product Engineering Process (PEP), and Project Management, which follows the Bosch Project Lifecycle Model (BPLM).

3.3.1 Product Engineering Process

The Bosch Business System (BBS) is a systematic methodology composed by three subsystems based on the three value-creating processes from the market to the customer and also, on the management and support processes of the company (Figure 12).

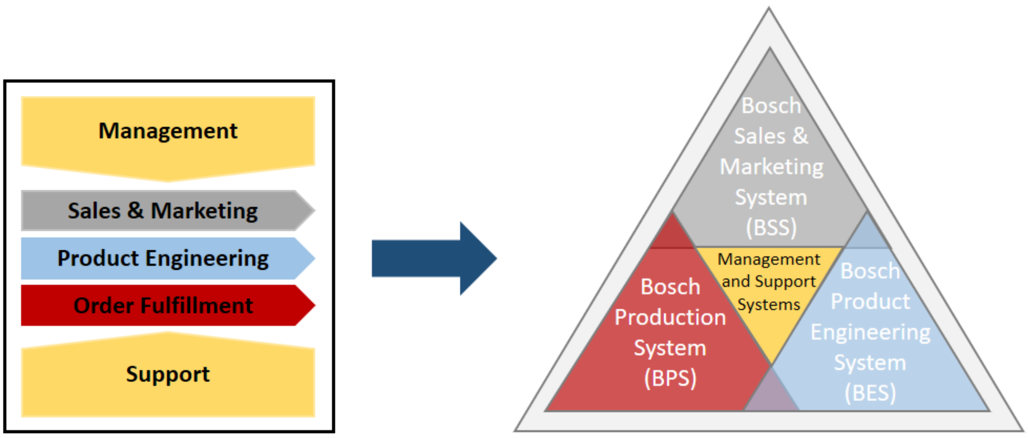

Figure 12 - Bosch Business System (Source: Bosch, 2019)

The Bosch Product Engineering System (BES) is part of BBS and is a system that includes all the activities needed to develop new products, calling for value creation through innovation, a complete understanding of customer requirements and a competitive multifunctional team with agile and lean principles.

Inside BES is integrated the Product Engineering Process that has the main goal of creating "*new products on time, on specification, on budget, with guaranteed outstanding quality*" (Bosch, 2019). The core PEP activities to produce new products are the samples build until the final product is achieved, as well as the line development for mass production.

As is illustrated in Figure 13, the PEP is composed of a five phases sequence, in which are included all product engineering activities from project kick-off to its completion.

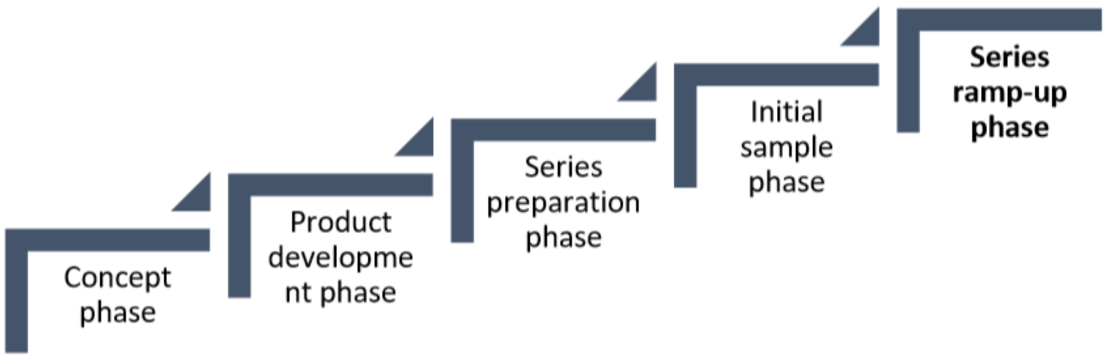

Figure 13 - Product Engineering Process phases (Source: Bosch, 2019)

Based on the Stage-Gate system, each phase identified above ends with a quality gate, where is made a quality control check of the project, product, and process. After each quality gate, a traffic light color is issued that can be green, yellow, and red, as the conformity of the product and manufacturing process with the expected requirements. The obtained rank influences the decision to move forward or not with the project.

The decision of not proceed with the project is a consequence of a red rank in the quality gate assessment, that means that the criteria are not being fulfilled and, at least one of the project goals, will not be achieved. On another hand, when the measured criteria are being completely fulfilled, the "green light" signals and the project can move forward to the next phase. In the case of a yellow rank, are necessary some corrective actions to achieve the project objectives.

In Figure 14, is shown all the quality gates specifically intended for customer-driven projects that any project should follow, named Quality Gates of Customer (QGC).

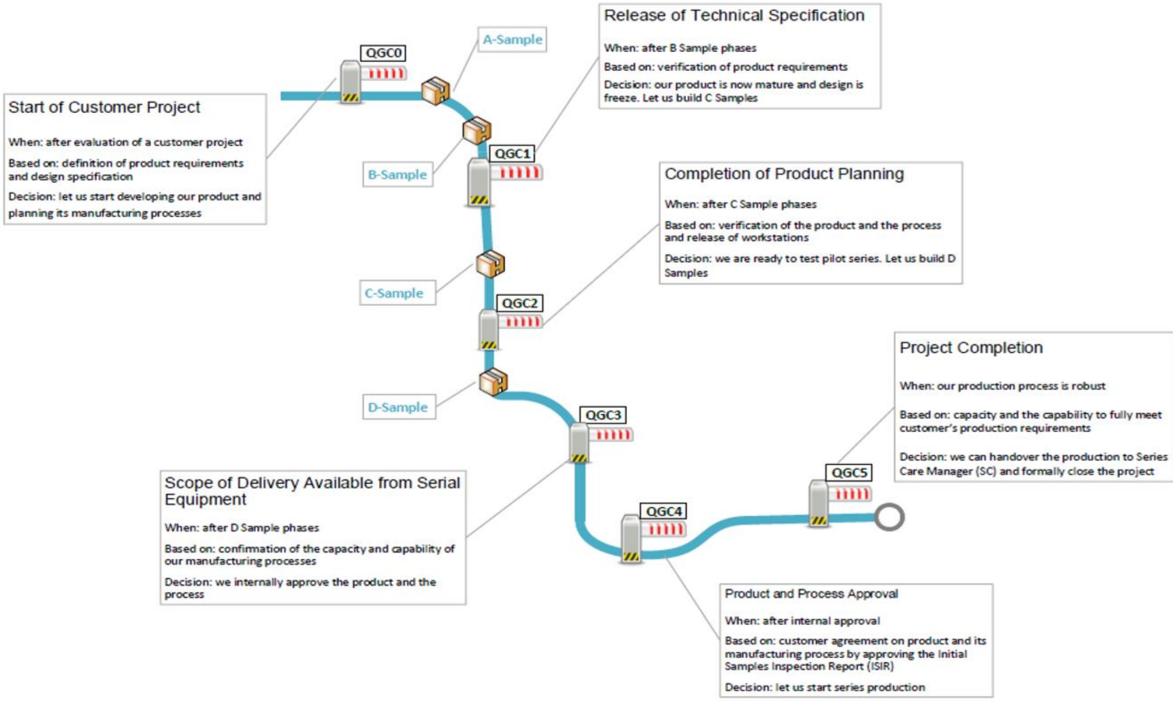

Figure 14 - PEP Quality-Gate System (Source: Bosch, 2019)

The project kick-off is the starting point of the Concept phase, which is characterized by the development of the new product's concept, including the design specification, the software architecture, the mechanical part, the electronic hardware, and the test system. These product's requirements and the defined product's specification are validated on QGC0, indicating the end of the Concept phase.

In the Product development phase, A and B samples are produced in the sample shop to meet the product's specifications, increasing the maturity of products. This phase overs when the QGC1 is approved, where the product is mature, and the design is frozen.

At this moment, the production line setup begins, as well as the sourcing of the necessary tools and equipment for mass-producing the new product. Additionally, the Series preparation phase also comprises the development of C samples that will be validated by the customer. Once the green rank on QCG2 achieved, the Series preparation phase is completed and the product is tested in pilot series, starting the development of D samples on the fourth phase.

The Initial Sample Phase aims to simulate the production process by the development of D samples that will be also subject to the costumer's validation. The simulation enables production resources optimization and problem elimination and, consequently, the improvement of the entire industrialization process. The capacity and capability of manufacturing processes are confirmed on QGC3, where the product and manufacturing processes are internally approved. After is performed an Initial Samples Inspection Report (ISIR), testing an agreed quantity of units to check whether the product is suitable for series production and whether its quality remains consistent once reproduced. In QGC4, when the customer accepted the ISIR, the product and manufacturing processes are externally approved, and the project proceeds to the last phase.

The Series ramp-up phase attends to the optimization of the process efficiency through the production of small series that allow the identification and correction of remaining minor failures and defects. In this way, the production process is improved, becoming a more robust and solid process with the required maturity level to mass production. In QGC5 is measured the production capacity and capability, according to the customer's requirements. In the case of a green traffic light at the last quality gate, the industrialization project is completed and is delivered the project to the Series Care Manager.

Concerning the characteristics associated with each type of sample, in Annex I is summarized the progress of the product over time.

3.3.2 Project Management at Bosch

In 2000, project management was recognized as a core competence to develop and execute Bosch's projects. To elevate PM at this company, the Bosch Group developed "Robert Bosch Project Management Body of Knowledge" (RBPM-BoK), based, on the well-known, PMBoK of PMI. The main purpose of this book is to describe the global PM standards at Bosch and provide an overview of the good practices that should be applied.

In 2009, Bosch created a Central Directive named "Project Management at Bosch". This directive defines the minimum requirements of and for project management for all operating units and intends:

- "*To enhance the alignment of functional organizations by applying professional project management procedures, thus preventing the risk of competitive disadvantages of Bosch;*
- *To ensure effectiveness and efficiency of collaboration especially in projects across operating units by a common process understanding and terminology in project management.*"

The Central Directive introduces the project categorization process to establish the necessary requirements to manage projects from each category. Projects are categorized according to their impact on the operating unit, which can be quantified by the total score obtained from the addition of several criteria.

For industrialization projects, the criteria to take in consideration are:

- Economic impact: calculated according to the required manufacturing plant's investment to the project;

- Process innovation: classifies the degree of process innovation required for the project, ranging from any innovation needed to a new set of required manufacturing and testing processes;
- Industrialization locations: quantifies the number of different locations to set up the project;
- Intercultural setup: measures the cultural diversity of the project;
- Industrialization complexity: lists the number of sample phases/sub-phases or product variants;
- Project duration: measures the project time in months, from kick-off to QGC5.

Table 1 comprises the classification for each criterion, which are rated from 1 to 4 points.

Table 1 - Classification criteria matrix for project category at Bosch (Source: Bosch, 2019)

	1 Point	2 Points	3 Points	4 Points
Economic impact	< 1 M€	< 2 M€	< 3 M€	≥ 3 M€
Process innovation	- Existent processes and test systems (only parameters changes)	- Modified jigs and test systems - SE/test has to update some test processes	- New jigs and test systems - SE/test has to cover all process steps	- New manufacturing processes and testing methods - Involvement of CoC
Industrialization locations	0 locations (only sampling)	1 location (local project)	2 locations	> 2 locations
Intercultural setup	1 culture (local)	2 cultures	3 - 4 cultures	> 4 cultures
Industrialization complexity	1 – 3	4 – 5	6 – 7	≥ 8
Project duration	< 6 months	6 - 12 months	12 - 18 months	≥ 18 months

The project is then evaluated on the above criteria. After the sum of these criteria, the projects are classified by:

- Category D: 6 - 11 points
- Category C: 12 - 17 points
- Category B: 18 - 23 points

- Category A: 24 points

Projects from category A, with a total maximum score of 24 points are more complex and have a significant impact on their operating unit. The project managers that lead category A projects are highly qualified and experienced to do administrate several resources and different cultures.

The "Project Management at Bosch" Directive also specifies what processes, methods, and tools best fit in project management according to the ten areas of knowledge defined by the PMI. The Project Management Process Groups (PMI, 2013) of the same organization is also a reference for the Bosch Project Lifecycle Model, which will be the topic of the next subsection.

3.3.3 Bosch Project Lifecycle Model

The management of industrialization projects at Bosch follows the Bosch Project Lifecycle Model, which is a common project lifecycle aligned with the five management process groups from PMI (2017), as is illustrated in Figure 15.

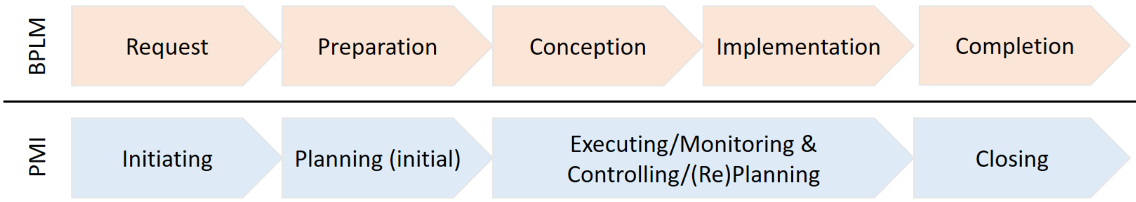

Figure 15 - BPLM phases aligned with the Management Process Groups (Source: own elaboration)

The BPLM is composed by several phases, from project request to project completion, and each one of them is delimited by one milestone, showing the achievement of the outcome defined and signalizing the end of one phase and the beginning of the next (Figure 16).

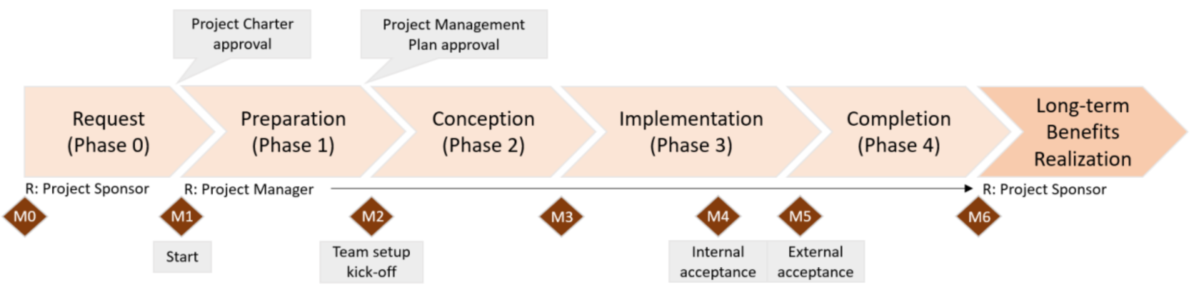

Figure 16 - Project lifecycle of an industrialization project at Bosch (Source: adapted from Bosch, 2019)

A project begins with a request from the customer to either develop a new product or make changes in an existing one. Firstly, it is necessary to collect the customer's requirements for the development of the product's concept, and after the customer's approval of the new concept starts the industrialization project in the manufacturing plant where the new product will be mass-produced.

The industrialization process starts with the request phase, where is nominated a Project Manager (PjM) by the Global Project Manager, located in the development department in Germany.

Milestone 0 is achieved when the project is accepted into the business unit, starting the project setup process. This process is the beginning of phase 0 and includes not only the project category assignment but also other important outputs to the project structuring, such as the conception of the shared folder and the project ID.

The assigned PjM of the project brings together and formalizes the project core team, which includes: a Launch Manager, a Parts Purchase Manager, a Project Quality Manager, and a Sample Build Coordinator. It is also PjM's responsibility to make the project Open Point List (OPL), which comprises all relevant topics to the team. In addition to the OPL, the PjM needs to create the project Organization Breakdown Structure and to develop the Project Charter, which includes all the fundamental aspects of the project, such as the objectives, risks, stakeholders, and constraints.

Once the Project Charter approved, the milestone M1 is completed and consequently begins the first phase of the project. The preparation phase translates the beginning of project execution that carries out the preparation of all details that will belong to the Project Management Plan (PMP). In this sense, the Work Breakdown Structure (WBS) and the project Time Schedule are also developed.

The beginning of the conception phase is manifested by the Project Management Plan approval regarding the milestone M2. In this phase, is refined the PMP, decomposing the WBS through the rolling wave technique1, and are built A and B samples. At the end of the conception phase, is performed the QGC1 to validate the maturity of the project.

In the implementation phase, the main activities are the C and D samples production, which lead to three quality gates that ensure the availability of the required information and prove the maturity of the product and the performance of manufacturing processes. In QGC4, after the validation of ISIR by the customer, it is finished the Product and Delivery Release that formalizes the approval of the series production of the new product. Consequently, the SOP begins, which is aligned with the PEP Series ramp-up phase.

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[1] The rolling wave technique is the process of project planning in waves to become clear the products and processes required for production.

In the last phase of the project, once the desired Initial Rejection Rate (IRR) reached, it is organized the lessons learned meeting with inputs from all team members of the project. After that, it is assumed the end of the project and is transferred all duties of the product to the Follow-Up Manager, who is responsible for the production.

Despite the BPLM milestones and the PEP quality-gates are not aligned but, both models, are related. Figure 17 illustrates this relationship, adding the various sample phases and the quality-gates of PEP with the several BPLM phases.

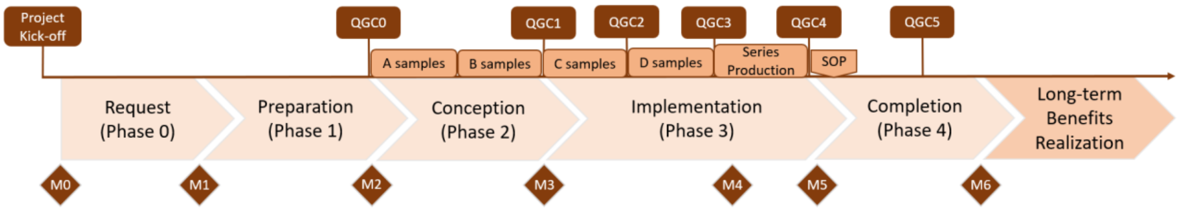

Figure 17 - Life cycle of a Bosch industrialization project aligned with PEP (Source: adapted from Bosch, 2019)

4. Global Industrialization Projects at Bosch

In this chapter, is described the work performed within the case study, i.e., the process of studying a global project, developing a Central Directive, implementing corrective actions in the global project, and analyzing the performance indicators proposed in this dissertation.

Subchapter 4.1 describes the global project studied where a lack of organized information was identified. Therefore, were implemented improvement measures, described in subchapter 4.3, to eliminate the problems previously detected. Additionally, it is presented in subchapter 4.2 the developed Central Directive to standardize processes and establish responsibilities in every global industrialization project at Bosch Car Multimedia.

At last, in subchapter 4.4 is analyzed the application of two indicators to evaluate the global standardization of equipment and processes between different factories distributed worldwide.

4.1 Case Study

During the work developed at Bosch, the researcher integrated a project that belongs to the Connected Information Solutions (CI1) business unit of Bosch Car Multimedia, intended for the production of entertainment and navigation solutions for the automotive industry.

For confidentiality purposes, the name of the project and its adjacent information have been replaced so, from now on, the studied project will be called "Lead Line Project". This project covers the development and production of several navigation systems, being one of them the P32R variant represented in Figure 18.

Figure 18 - Nissan X-Trail (P32R) 8" Navigation System (Source: "www.tcat.com.my", 2019)

The product development phase, A and B samples, takes place in Hildesheim, Germany. Then, comes the implementation phase, where the industrialization process is set up at the manufacturing plants and C and D samples are developed. This process of building and validating samples allows the product and process improvement and, at the same time, avoids additional costs when the product is ready to be launched into series production.

In this project (Figure 19), there are three manufacturing plants, located in Penang, Malaysia (PgP1), Braga, Portugal (BrgP), and Wuhu, China (WhuP).

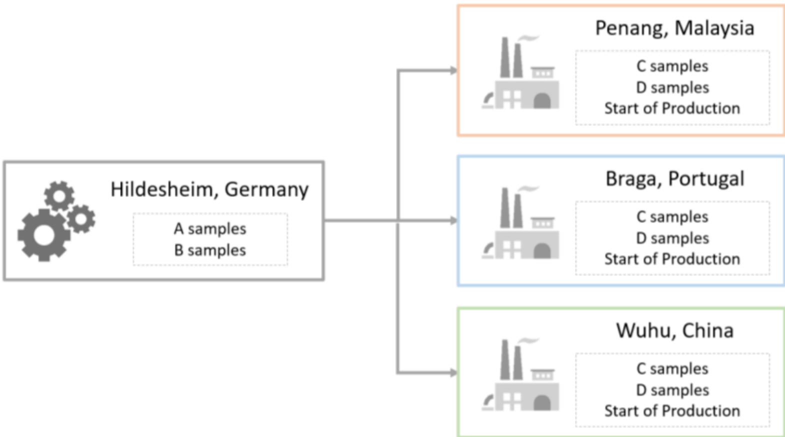

Figure 19 - Lead Line Project (Source: own elaboration)

As the product represented in Figure 18, also other products are industrialized in those three factories through a distributed manufacturing system, where a similar industrialization model is used in different locations to produce multi-variants in flexible assembly lines.

The industrialization process has adaptable assembly and testing lines, which allow the adjustment of production to different product variants with similar manufacturing steps and with different ramp-up dates. All product variants of the project were analyzed at the component level to understand which are the standardized parts that can be assembled before the differentiation of the product.

Considering the different assembly configuration of each variant was programmed the industrialization process, always postponing the differentiation process as much as possible. Therefore, the assembly lines were designed for a defined number of product variants derived from the same architecture, balancing and optimizing the production of multi-variants in shared assembly lines.

In summary, the Lead Line Project began in 2016 with a common development center and three manufacturing plants. This global project aims to produce several product variants worldwide, industrializing each product variant in one, two, or even the three factories of the project.

To ensure that final products are the same, even being industrialized in different countries, emerged the need for processes standardizing across manufacturing plants distributed worldwide. To do that, the researcher, along with Bosch coordinator, developed a Central Directive, explained in the next subsection, to apply in Lead Line Project and future global industrialization projects at Bosch Car Multimedia.

For the directive developing, it was necessary to understand all the decision-making of a global industrialization project at Bosch. For that, the Lead Line Project was analyzed to study a global project in real-life context.

The focus of the study was the implementation phase of the Lead Line Project in Braga, Penang, and Wuhu. In this phase is developed C and D samples and is approved the final product and its manufacturing processes for series production in all factories. However, there were product variants developed at the Lead Line Project that were already implemented and, consequently, were in series production. Nonetheless, the same product variant may be in a different phase according to the maturity of the manufacturing process in the factory, for instance, a variant in BrgP can be in D samples but, in PgP1, that same variant may already be in the SOP.

During this study, the researcher had an active role in the assembly synchronization meetings of the Lead Line Project that were intended to ensure the standardization of equipment and manufacturing processes in BrgP, PgP1 and WhuP. These assembly synchronization meetings included meetings between the CM team members from all factories and also, between the CM team and global suppliers, having the researcher performed the global role of assembly synchronization manager.

Additionally, the researcher was able to gather information during line walks to production lines of the Lead Line Project at the shop floor in Braga.

Through the participant observation in the synchronization meetings and the direct observation in line walks, the researcher identified some weaknesses in the Lead Line Project in terms of information management which, together with document analysis, can be described as:

- The lack of clarification about the stations and processes of each manufacturing plant;
- The lack of definition of roles and responsibilities;
- The difficulty in sharing information and know-how;
- The difficulty in planning and tracking activities;
- The lack of standardization in the problem-solving process;
- The insufficient collaboration and communication between the team members and suppliers;
- The poor transparency of the work done and the pending tasks of each manufacturing plant;
- The difficulty in having a visual overview of the status of each manufacturing plant in global terms.

Crossing the detected problems with the central question of this dissertation - *how to measure process standardization between manufacturing plants distributed worldwide?* - it was necessary to improve the way how information was organized to answer the question raised. Thus, simultaneously with the development of the central directive, several improvement measures were implemented in the Lead Line Project that were taken into consideration and integrated into the Directive.

4.2 "Lead Line Plant Process" Directive

This subchapter describes the "Lead Line Plant Process" Directive that is intended for global industrialization projects at Bosch Car Multimedia, providing a coordination guideline for the industrialization process in several CM manufacturing plants across the world, since the acquisition phase of the project until the end of series.

Based on a Global Production Network, the main goal of this directive is to achieve a high level of process standardization between manufacturing plants to accomplish the same quality performance and customer perception worldwide. To do that, it describes the global production strategy, the structure of factories, as well as the tasks and responsibilities of each member involved in the project.

Each project has to pursue the most optimized value stream so, the manufacturing strategy must be decided between in-house manufacturing and outsourcing the necessary material or semi-finished parts, based on the Total Cost of Ownership (TCO)[2] and the Made and/or Buy analysis[3]. Nonetheless, the several manufacturing plants of the global industrialization project may have different manufacturing strategies, once the most profitable policy depends on the existing worldwide capabilities. In other words, while for one factory of the global project can be more beneficial to build the entire product in-house for another manufacturing plant, it may be more advantageous to purchase parts of the product already made up by a supplier.

After having an idea of what the Directive is and what it is for, it is time to understand all the work done. In the "Lead Line Plant Process" Directive was identified the essential steps for any global industrialization project at Bosch Car Multimedia, which resulted in a four-step proposal represented in Figure 20.

[2] Total Cost of Ownership is a financial estimate that determine the direct and indirect costs of a product or a system.

[3] The Make and/or Buy analysis influences the decision to manufacture a product in-house or purchase it from a third party, the option chosen must be the one that maximizes the long-term financial outcome of the company.

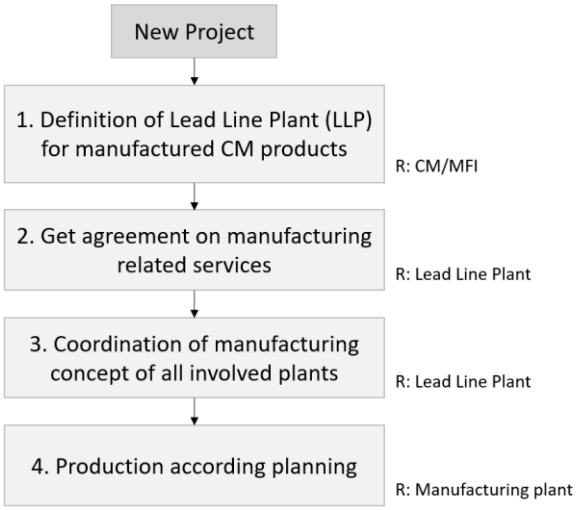

Figure 20 - Steps of a global industrialization project (Source: adapted from Bosch, 2019)

4.2.1 Definition of Lead Line Plant

In a new global industrialization project, the first step is the definition of the Lead Line Plant (LLP) which is one of the manufacturing plants of the project that has additional responsibilities regarding the global synchronization of the project. In a particular project, the LLP has a worldwide technical and organizational responsibility for the central coordination and continuous standardization of the manufacturing processes in the assembly and testing technology.

As illustrated in Figure 21, the LLP is responsible for coordinating the information between the manufacturing plants and for monitoring the progress of the industrialization process, from the product development phase to its production in the different manufacturing plants.

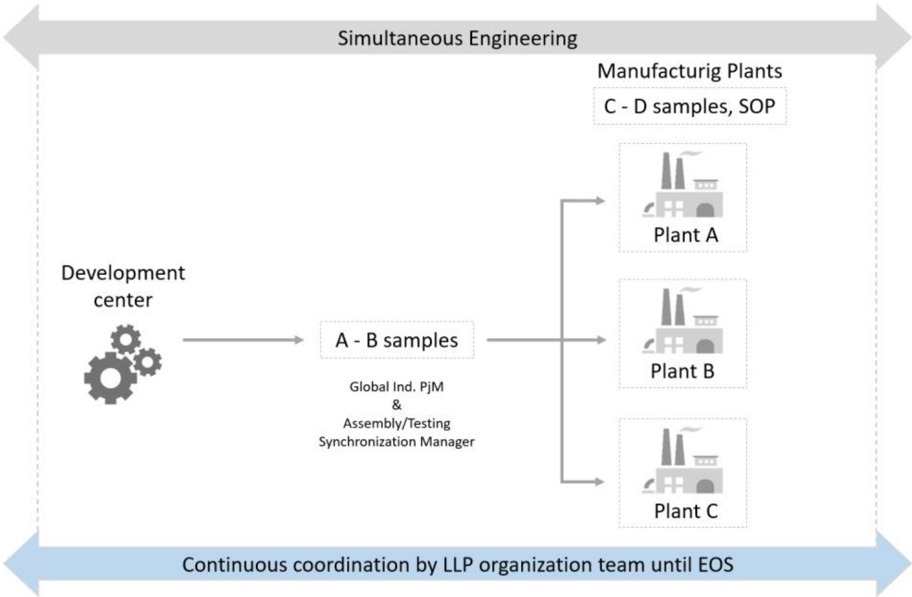

Figure 21 - Working mode of a global industrialization project (Source: own elaboration)

The nomination of the LLP organization is from the responsibility of the Manufacturing Industrialization Central Department (CM/MFI) of the Car Multimedia Division and, the recommended criteria for this decision are the plant with the first SOP or the plant with the higher number of industrialized product variants.

4.2.2 Get agreement on manufacturing related services

The second step is to get agreement on manufacturing related services by naming the work team and defining the responsibility of each team member. This requires an understand of what services are needed for develop a common product and industrialize it in different factories around the world, ensuring the final product is the same, even not being industrialized on the same site.

Figure 22 shows the overview of the team from a global industrialization project at Bosch, which consists of a product development team, an industrialization team, and a central purchasing department.

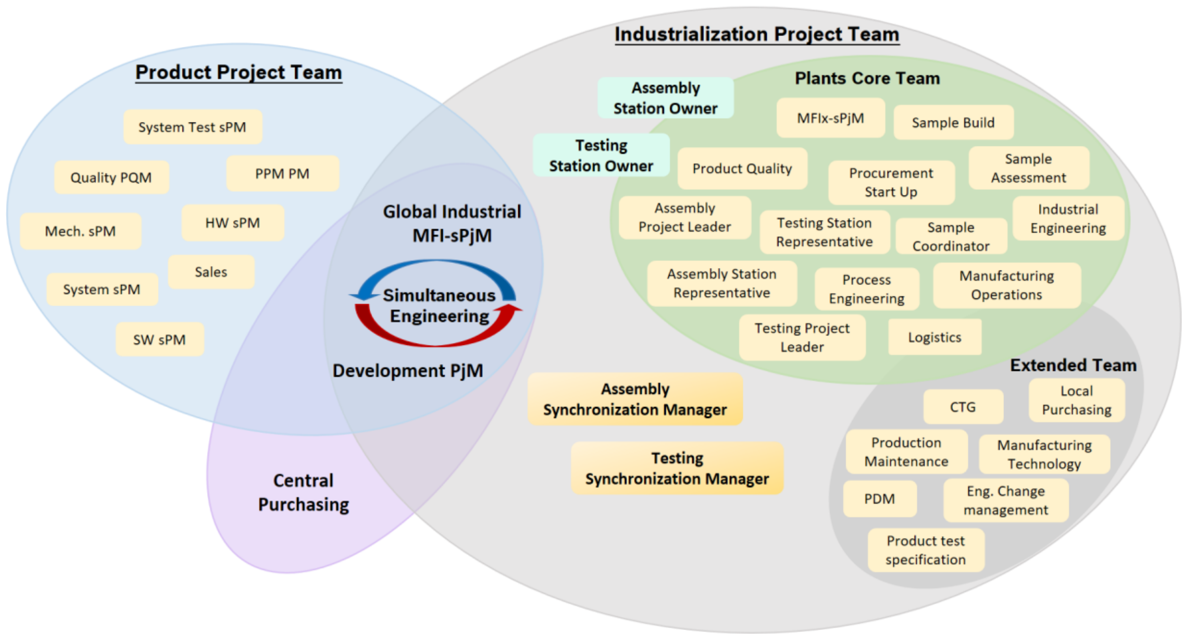

Figure 22 - Global Team Overview in a Global Industrialization Project at Bosch (Source: own elaboration)

The Product Project Team is responsible for developing the product, considering the specifications and expectations of the customer and is coordinated by the Development Project Manager.

In the early stages of product development, the Product Project Team works together with the Industrialization Project Team to obtain an integrated design and process planning of the new product. This iterative process of a multidisciplinary team is called Simultaneous Engineering and aims to decrease the time between the conception of the product and its launch on the market, to reduce development and manufacturing costs, and to improve products' quality (Eversheim et al., 1997). The LLP is responsible for promoting the contact between all simultaneous engineering teams involved in the project.

After the design release, the Industrialization Project Team translates the idealized design by the development team into a physical product through the development of production systems.

In a global industrialization project, the industrialization process takes place in more than one factory dispersed around the world, so it requires additional standardization and coordination between all manufacturing plants. In this sense, five new global functions emerged under the responsibility of these tasks, namely the Global Industrialization Project Manager (Global Ind. PjM), the Assembly Synchronization Manager (ASM), the Testing Synchronization Manager (TSM), the Assembly Station Owner (ASO) and the Testing Station Owner (TSO).

The Global Ind. PjM leads the core team of the industrialization project and ensures the achievement of the project goals. The Global Ind. PjM responsibilities are: establish the global project management plan, be the main interface between the development team and the manufacturing plants, track the global investment budget, coordinate A and B samples build, ensure the handover to the plants, among others.

The Assembly and Testing Synchronization Managers are responsible mainly for ensuring the same level of equipment's industrialization in all manufacturing plants based on a global specification, leading the alignment meetings with Plant Process Engineers from the different manufacturing plants, tracking sample builds line problems, and also coordinating the transfer of process change requests and lessons learned to the other manufacturing plants.

The Global Ind. PjM, the ASM, and the TSM are nominated by CM/MFI and must be in the LLP organization or, as an alternative, make short-term assignments and business trips there.

Assembly/Testing Station Owners (ASO/TSO) are responsible for a specific workstation across the world, being in charge for the workstation specification and for support the ASM and TSM on controlling the equipment's bugs, the necessary new requirements and process change requests in all manufacturing plants and with external suppliers.

The ASM and the TSM must get an agreement with the project team about the person that will perform the role of Station Owner, considering the expertise and station know-how. However, until the new manufacturing technology is installed in the plants, the Manufacturing-Centers of Competence organization (MFT-CoC) might be responsible for the role of ASO/TSO. The MFT-CoC is a commission of experts for specific manufacturing processes and test concepts in manufacturing. Once the new manufacturing technology installed, the MFT-CoC supports the designed ASO/TSO until the release of the new process. In the case of End of Series, this function should be assured by someone from the manufacturing plants that still use the workstation to produce.

In addition to the functions described above, each manufacturing plant has a Project Manager to coordinate the industrialization process, who is supported by the project synchronization managers and is under the supervision of the Global Industrialization Project Manager.

Figure 23 illustrates the global industrialization team chart, where each manufacturing plant has an Assembly Process Leader (APL), a Testing Process Leader (TPL), an Assembly Station Representative (ASR) and a Testing Station Representative (TSR). The nomination and the responsibilities assigned to these functions depend on the plant's team roles of each manufacturing plant.

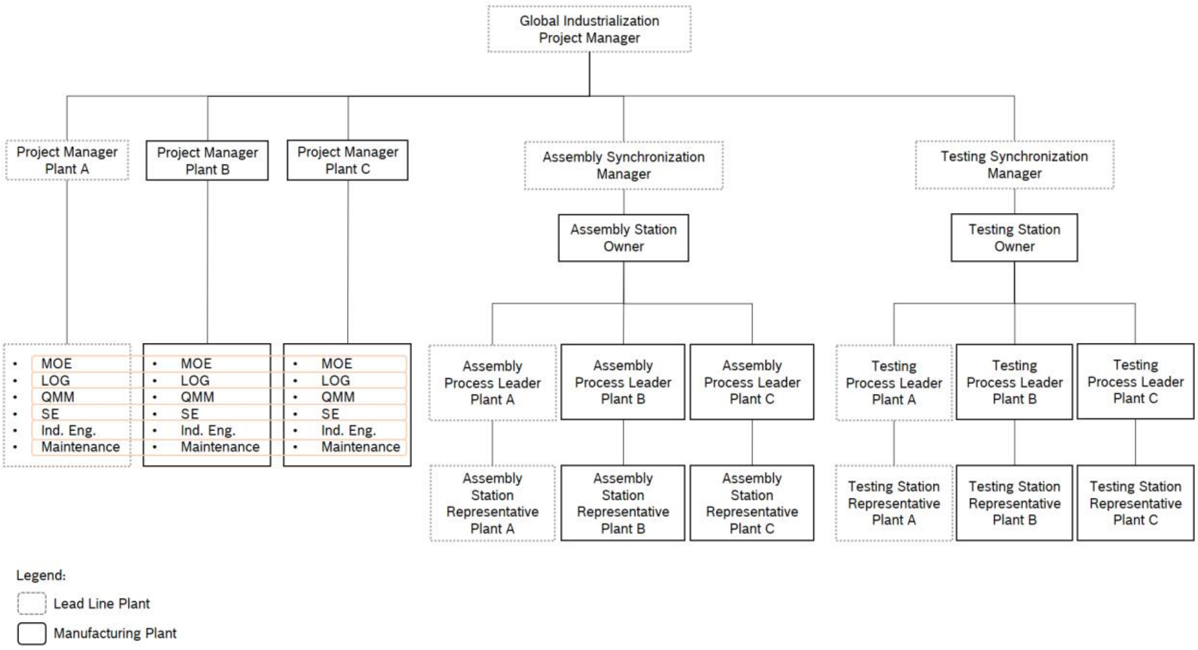

Figure 23 - Global industrialization team chart (Source: own elaboration)

The Global Ind. PjM must promote the synchronization with the department managers from other functional areas of each factory, such as maintenance, quality, logistics, among others.

According to project size and requirements complexity more than one role can be combined, whichever best fits the project conditions, e.g. the Assembly Synchronization Manager and the Testing Synchronization roles can be assured by the same person, making the synchronization of both assembly and testing processes.

4.2.3 Coordination of manufacturing concept

After defining the Lead Line Plant and getting the agreement on the manufactured-related services, it becomes relevant to talk about the manufacturing concept.

Traditionally, the industrialization process consists in two different moments: assembly parts and test them. In both cases, the assembly line and testing line, are composed of several workstations assigned to different production steps. Each workstation has a Machinery and equipment (MAE) and may have more than one Machine specialist support (EWAK), depending on the product variants produced on that flexible assembly line. Moreover, the MAE is the workbench that supports EWAK, which in turn is the support equipment of the product during the assembly and the testing process.

The manufacturing concept can be translated into several steps which are illustrated in Figure 24.

Figure 24 - Milestones of Manufacturing Concept of a global industrialization project (Source: own elaboration)

Firstly, the manufacturing concept starts with the Planning Guideline (PGL) that includes a series of workshop activities, which should be coordinated by the Global Ind. PjM and in which one expert team member from each manufacturing plant should participate and contribute with relevant inputs to the project planning.

PGL activities are aligned with PEP activities and include the definition of product design using the Design for Manufacturing and Assembly[4], the clarification of objectives with their continuous improvement through the System CIP[5], the study of planning and investment alternatives of Production planning as Production Life Cycle Planning, and the planning of the value chain and production process using Value Stream Design[6], Scaling[7] and Lean Line Design[8].

Bosch Production System principles (pull system, process orientation, perfect quality, flexibility, standardization, transparency, continuous improvement, waste elimination, and associate involvement and empowerment) have to be considered during the manufacturing concept definition of any project, improving the quality, costs, and delivery performance.

After the Global PGL roll-out, it is time to define the workstations specification that include the MAE and EWAK requirements, process flows, and technical details for each workstation. In the case of a global project, the workstation specification is transversal to all manufacturing plants, so the global team must be involved in the specification design, review, and approval of all workstations.

The equipment's standardization is defined by the CoC or during lead line workshops, as PGL activities.

The CoC is responsible to specify the standard requirements for manufacturing processes and test concepts in the equipment's specification catalog, designed as Product Requirements for Production

4 The Design for Manufacturing and Assembly is a methodology that through simultaneous engineering aims to reduce the costs of design and manufacture of products.

5 The System CIP is a methodology that promotes the knowledge of all project cause-effect interactions to respond as soon as possible to deviations from standards.

6 The Value Stream Design identifies wastes and their causes across the value chain.

7 The Scaling systematically analyzes possible assembly alternatives to promote the manual process at the beginning of the process.

8 The Lean Line Design verifies the use of Lean principles, balancing the operator's work with the equipment's work, and minimizing the stoppage time.

(PRP). The standard defined in PRP is applicable for all manufacturing plants involved in the project and must be ensured by the LLP.

Once all global workstation specifications defined, it should be filed in a shared project folder and updated by ASO/TSO when necessary.

In this way, it was imperative to analyze all manufacturing concept requirements that must be met for the same product to be manufactured in different locations across the world. In the "Lead Line Plant Process" Directive, was described as premises for the manufacturing concept in all factories:

- Same process, considering that is possible to have equipment with different automation level (e.g. manual and automatic screwing);
- Same production sequence;
- Identical workbench MAE, according to automation level;
- Identical EWAK for identical processes, according to automation level;
- Same process parameter setup, according to the Product Requirements for Production, the Device Assembly Specification (DAS), and the Product Test and Alignment Specification for Production (PAV);
- Same product testing, including the same software base, the same testing coverage and an identical testing time;
- Identical Process Failure Model and Effects Analysis (P-FMEA) and Control Plan, using the same structure with regular alignments;
- Same workbench software base with local parameterization due to environmental influences;
- Adapted degree of automation level for each location according to the best possible commercial solution conferring the TCO, using the PRP as reference;
- The equipment's reuse must be considered and promoted.

All process deviations between the manufacturing plants must be approved by the Synchronization Manager of the project and documented into the deviation list (Annex II) with a proper description of the reason to the deviation and the associated risk analysis.

The "Lead Line Plant Process" Directive does not consider as mandatory to global standardization the following parameters of manufacturing concept:

- Surface-Mount Technology process[9];
- Plant facilities (e.g. building's environment conditions, signals generators, illumination system);
- Production line layouts, support bases work in progress, MAE scanners quantity and position, MAE acrylic covers, MAE support bars dimension and position, screw feeders position, buttons location, cables dress (e.g. in case of different variants);
- Manufacturing plants' standards (ex: logistics' standards as shelves, trays and repacking boxes, and products packaging);
- Product and material handling (e.g. using different handling systems);
- Plant off-line standards (e.g. printing pool, product parts reworks, and outsourcings).

Once the manufacturing concept is defined, the next step is the selection of equipment's sourcing strategy that can differ between purchasing the MAE and EWAK from a global supplier or a local supplier.

In the case of a global supplier, the equipment's global procurement is based on the defined specification and is performed, for each manufacturing plant, a negotiation protocol according to the agreed automation level. Since the equipment is developed and implemented by the same supplier in all manufacturing plants, this option makes the equipment's standardization between factories easier. However, when it comes to the equipment's implementation, a global supplier tends to take longer than local suppliers, even if the global supplier may have several branches around the world.

On the other hand, the local supplier sourcing applies the "Local for Local strategy", which uses a common global specification that will be the basis for equipment's development in the different local suppliers of the factories dispersed worldwide. Under these circumstances, the LLP is responsible for the equipment's design standardization and coordination, considering the degree of automation and local facilities of each manufacturing plant. When the same automation level is applicable among factories is nominated one local supplier to develop the workstation and to fill the necessary documentation for the duplication by the local suppliers from the other manufacturing plants.

The global manufacturing strategy should be chosen considering that manufacturing plants must ensure the standardization of industrialization equipment and processes between them but, at the same time, strive for the efficient use of worldwide structures and search for the optimization of local resources, as in the case of reuse of equipment.

[9] The Surface-Mount Technology process is a method to assemble electronic circuits, mounting and placing electronic components directly into the surface of printed circuit boards.

After aligning the manufacturing concept and choosing the best strategy to purchase the required equipment, it begins the implementation of production lines that involve at an early stage the pre-acceptance of stations by the customer, then the integration of equipment in CM manufacturing plants and, at last, the final acceptance of equipment. These phases will be explained in the next step, production according planning.

4.2.4 Production according planning

The last step of a global industrialization project is to implement the planned production in each manufacturing plant of the project.

The first installation of a new line, new manufacturing concept, and new equipment in each manufacturing plant must be coordinated by the Global Industrialization PjM. Moreover, the setup of the new EWAK or MAE must be organized by the LLP and the CM global team.

The duplication of a line or equipment must be ensured by each manufacturing plant organization according to the plant's production planning, which must request the support of the LLP organization, if necessary.

During the industrialization process of several product variants in multiple manufacturing plants of a global project, any deviation from the requirements defined in the equipment's specification or any possible improvement on the equipment results in open points that are tasks that need to be completed to ensure the proper operation of the equipment and to be able to support series production.

The Open Point List is a tool used to create and manage all open points recognized during the industrialization process, i.e., from the pre-acceptance process until the line release. Once all open tasks are completed, the production system is available to successfully mass-produce.

Every new production line approval starts with the pre-acceptance process, which is the requirements check by the customer, usually on the supplier site. The supplier is responsible for providing the equipment according to the predefined specification, once detected a deviation during the pre-acceptance process is performed an immediate evaluation and an action plan to ensure the equipment's conformity before the delivery and installation on CM manufacturing plants.

After the pre-acceptance of the equipment is the commissioning process, that means the line installation on Bosch facilities where the supplier is responsible to perform the setup of new production lines, manufacturing concepts, and equipment at the CM manufacturing plants. In addition to the installation process, the supplier must also provide a demonstration of the equipment's operating to the plant's project team responsible and maintenance team.

During the commissioning process, in case of any problem or any possible improvement on the equipment being recognized by the Assembly/Testing Station Representative, the necessary actions must be aligned with the Station Owner and the Synchronization Manager.

The final acceptance is the last approval before the line release to mass production, so it occurs after the implementation of all required actions from the open points. In the case of missing the previous standard agreement, it must be agreed between the CM team and the supplier, due dates for the corrective actions.

In short, the manufacturing equipment is improved until achieving the maturity level and robustness required to support mass production. In the case of global projects, to ensure the equipment's standardization and reach a high level of worldwide efficiency, it is important to align common solutions and transfer relevant know-how to the other manufacturing plants of the project. In this way, in the "Lead Line Plant Process" Directive was differentiated two communication flows, depending on whether the change in equipment or process is local or global.

The process flow A is related to global issues, which means that are changes that affect more than one manufacturing plant and can be:

- Process Change Request (PCR) - Open points from CM global team whenever is necessary to make process changes against the latest MAE and EWAK specification index (e.g. new assembly step, different assembly sequence, product design change);
- New requirement – Open points from CM global team regarding new requests not specified into the original specification of the workstation;
- New variant kick-off – Open points from CM global team due to a new product or new variant(s) to be produced in the existing production line or equipment;
- Lessons learned – Open points from CM global team acquired from experiences concerning quality, performance, costs, and safety. In this way, the yokoten process of horizontal transferring of knowledge across an organization must be applied to the other manufacturing plants to replicate improvements and prevent the reoccurrence of mistakes.

The identification of a global problem or a possible improvement into the manufacturing process begins with the communication between the Assembly/Testing Station Representative of the plant where the issue was detected and the Assembly/Testing Process Leader (Figure 25).

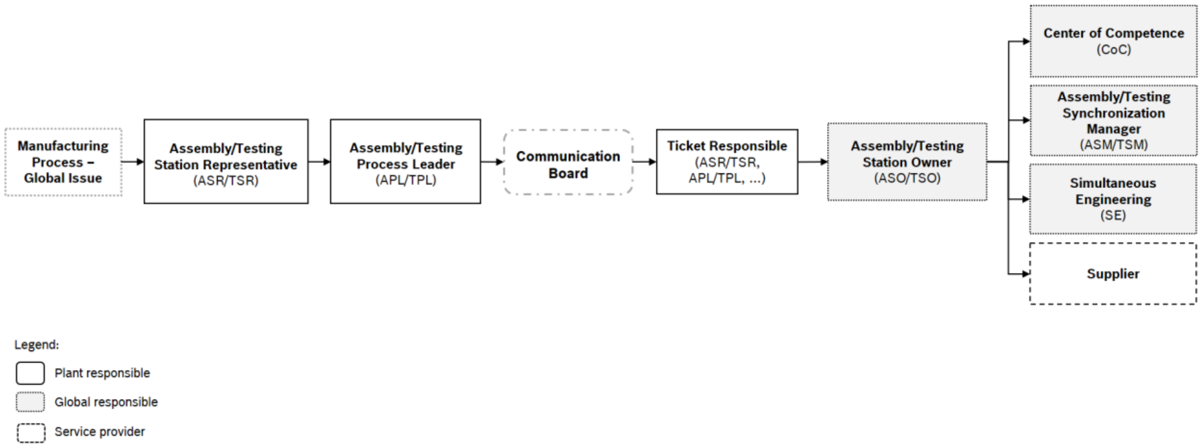

Figure 25 - Communication regarding global issues (Source: own elaboration)

Once it is a global issue, the information is shared with the other manufacturing plants of the project through the communication board, where is stored the Open Point List of the project.

The communication board is essential to manage the significant amount of data and information regarding the manufacturing changes in all plants of the project. In this way, the support tool for communication and issues tracking, as Rational Team Concert (RTC) and Jira, must be used for all members involved in the project.

On the OPL, each ticket refers to an identified problem or an improvement suggestion and is individually shared by the issuer of the new point, and the Assembly Station Owner until is achieved a viable course of action to reach the desired solution for all plants (Figure 26). The necessary actions to close the point can include the input of the CoC for standard process definition, the Synchronization Manager for eventual necessary alignment, the supplier for service execution, and the Simultaneous Engineering team for support the product assembly and testing (Figure 25).

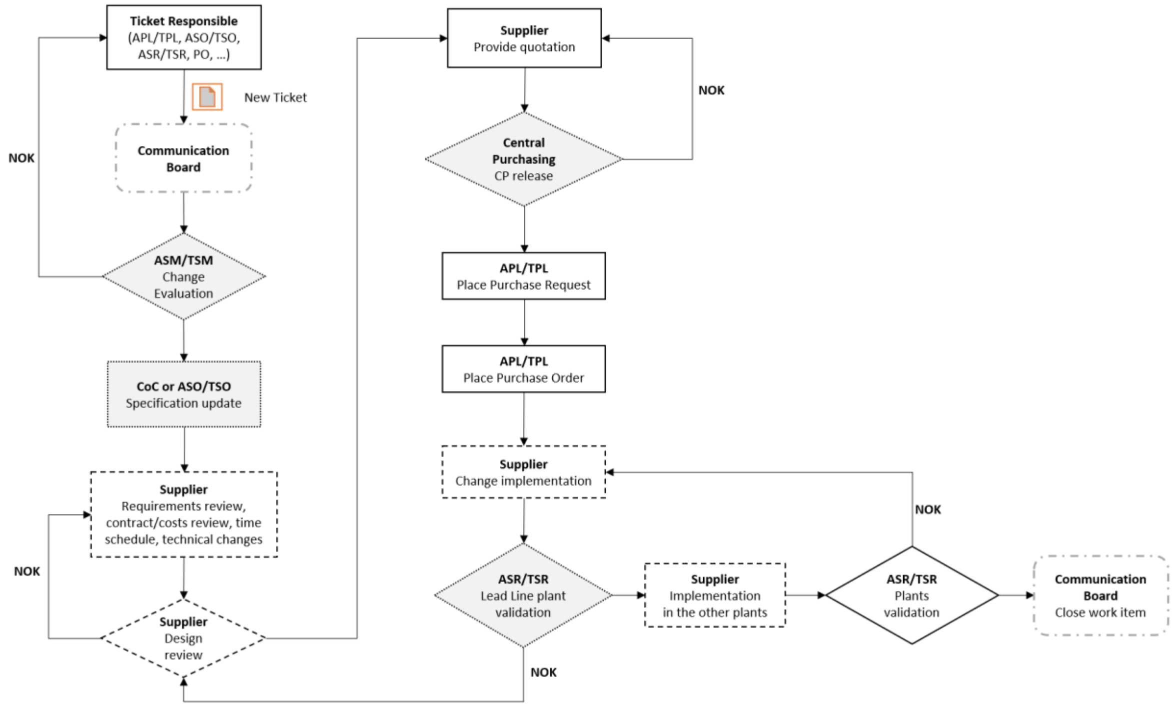

Figure 26 - Workflow regarding global issues (Source: own elaboration)

The process flow B is related to plant issues, which means that they refer to changes that affect only one manufacturing plant and they can be:

- Pre-acceptance - Open points from CM plant during the pre-acceptance process;
- Commissioning - Open points from CM plant during the commissioning process;
- Final acceptance - Open points from CM plant during the final acceptance process;
- Bug - Open points from CM plant regarding functional points, spare parts, line breakdown, and capability issues.

The process flow B refers to lines breakdown, equipment capability (e.g. OEE), functional points, spare parts issues, problems from pre-acceptance, commissioning or final acceptance, and can also be applicable for quotations, purchase orders, and line and station duplications issues. After the Assembly or Testing Station Representative and the Assembly or Testing Project Leader be noticed, the supplier is responsible to solve the detected problem. In the case of the supplier does not solve immediately the raised issue, it is followed on the communication board until it is closed (Figure 27).

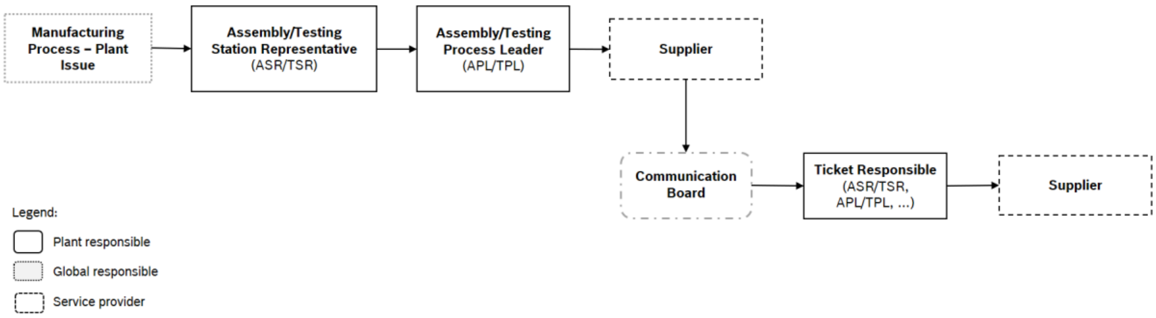

Figure 27 - Communication flow regarding plant issues (Source: own elaboration)

After opening a new ticket on the communication board, the point is discussed with the supplier to implement the corrective actions necessary for its resolution (Figure 28). In the case of yokoten applicable, after the validation on the manufacturing plant that erases the point, the information regarding the modification performed should be transferred to the other manufacturing plants of the project.

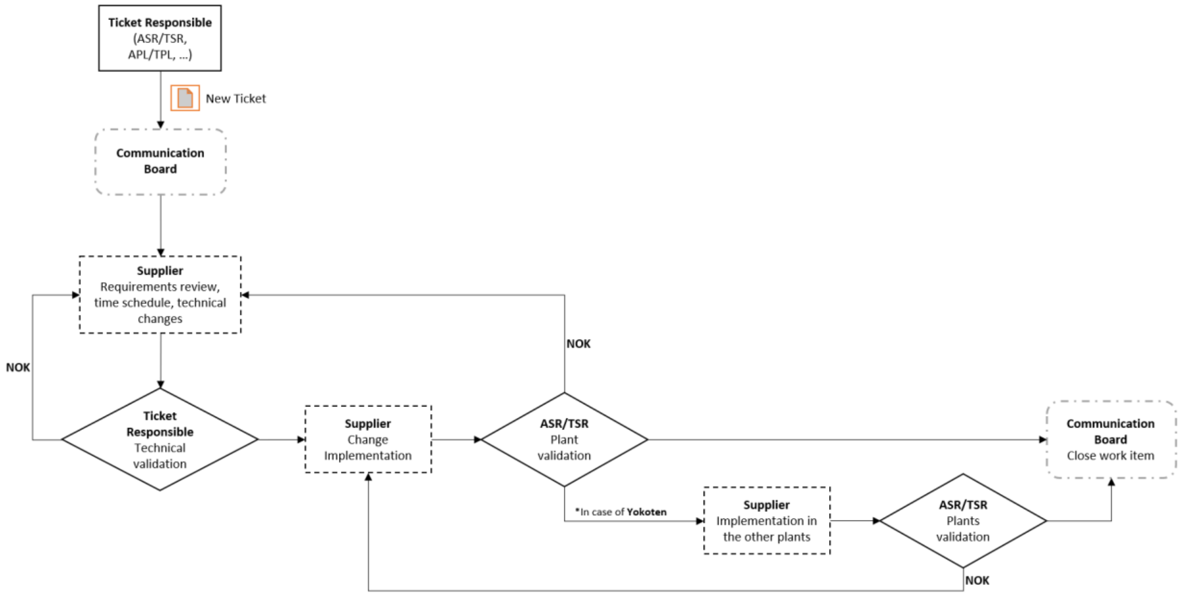

Figure 28 - Workflow regarding plant issues (Source: own elaboration)

On the communication board, either on the global issues or on plant issues, the "Ticket Responsible" is the person who creates the new open point and must track the progress of the point according to the urgency and expected resolution date.

The equipment's maintenance and troubleshooting are responsibility of each manufacturing plant.

In summary, the industrialization process includes several changes to be able to mass-produce, but each change is only allowed after the Lead Line Plant organization approval. The tracking of the changes' progress should go through regular process alignment meetings between the CM team members of every manufacturing process and regular meetings between the CM team and global suppliers. The global synchronization during the Product Engineering Process must be maintained after the Start of Production.

For the management of these changes and improvements in the industrialization process, was defined two indicators to assess global standardization in the "Lead Line Plant Process" Directive, which will be the focus of this case study. Besides these two indicators, to monitor the project is necessary to complete the analysis with other performance measures related with industrialization process and PGL activities of each manufacturing plant, such as the Overall Equipment Effectiveness (OEE) and the First Pass Yield (FPY), among others. Once all of them are relevant to the project's stakeholders must be reviewed in the global and plant management meetings.

After showing how works a global industrialization project at Bosch, it is necessary to explore the topics of the case study and clarify the identified problems. The main goal of this study is to identify evaluation indicators capable of quantifying the industrial maturity level of manufacturing plants and to reflect the global standardization level of equipment, processes, and manufacturing plants.

The two indicators intend to bring transparency for every stakeholder of the project regarding the work done and the work that still needs to be done. As a result, it is possible to have a visual perception of the maturity of the equipment, processes and manufacturing plants involved in the project. Subchapter 4.4 brings forward the approach made to these two global indicators in the Lead Line Project but, first, subchapter 4.3 describes the improvements done in the Lead Line Project regarding information management, which will be useful for the performance analysis of subchapter 4.4.

4.3 Improvements in the Lead Line Project

This subchapter clarifies the measures implemented in the Lead Line Project, which were integrated posteriorly into the Central Directive in order to be carried out from the beginning in future projects.

During the research period in the company, this global industrialization project was in the implementation phase of the manufacturing process of several product variants in multiple manufacturing plants and, due to its large-scale size, the main problem to tackle was the poor organization of the information related to the project. Therefore, several measures have been taken to reduce the irrelevant information and to sum up the relevant one to be easier to understand by anyone involved in the project anywhere in the world. The improvements performed can be summarized to:

1) Identification of the product variants produced per production line, as well as the existing stations and processes of each manufacturing plant in the Lead Line Project;

This first task took place to delete "*the lack of clarification about the stations and processes of each manufacturing plant*". Therefore, were described the product variants and processes of each factory and was shared into the project's folder a document with this information to make it easily accessible to any team member.

The range of mass-produced products of this project has been identified, resulting in the following list:

- Model X: four product variants (variant X_1, variant X_2, variant X_3, variant X_4);
- Model Y: three product variants (variant Y_1, variant Y_2, variant Y_3) and four product variants from an exotic edition (variant Y_4, variant Y_5, variant Y_6, variant Y_7);
- Model Z: one product variant (variant Z_1).

After that, were identified the variants produced in Penang, Braga, and Wuhu. The exotic edition is manufactured exclusively in the factory located in Penang, but all the other variants are produced in both BrgP and PgP1 sites. Meanwhile, the manufacturing plant located in Wuhu produces only the variant X_1.

The Lead Line Project requires seven production lines to produce all these variants. In Annex III, Annex IV and Annex V is possible to observe the industrialization process of each product variant in the factory located in Penang, Braga and Wuhu, respectively.

The Lead Line Design process is constituted by six assembly lines and one testing line, being on this last one that all product variants are tested at the end of all assembly processes to check their compliance with the customer's requirements and product's specifications. These are the production lines required to manufacture all product variants produced in the Lead Line Project. The number of assembly and testing lines in each factory depends on the manufacturing strategy, product variants, and quantities that will be produced. In Annex V, only one variant is manufactured at WhuP so, in this manufacturing plant, only exists the production lines intend to manufacture the variant X_1. On the other hand, in Penang is industrialized all product variants in larger quantities so, this requires several duplications of all assembly and testing lines.

2) Development of the Global Process Owner Matrix;

The Lead Line Project integrates a large CM workforce, so it became important for everyone involved in the project to know what is or not their responsibility in the industrialization process. To mitigate the identified problem of "*the lack of definition of roles and responsibilities*", was integrated in the "Lead Line

Plant Process" Directive the main activities and responsibilities of each function of the global industrialization team (Annex VI) and also, the Global Process Owner Matrix (Annex VII), which includes the names and functions of all elements from the CM industrialization team of the project, providing an easy-to-understand overview for all stakeholders.

3) Standardization of problem-solving process by defining different communication flows for global or plant issues;

In this third step was organized all project information contributing to mitigate the previously identified failure "*the lack of standardization in the problem-solving process*". As a result, to implement changes in equipment and processes every member involved in the project, whether it is a CM member or a supplier, must know their role and responsibilities in the companies' global production footprint.

After aligning global common solutions and transferring relevant know-how to the other manufacturing plants, shown up several changes in the equipment and processes to solve the detected problems and carry out the identified possible improvements.

During the assembly synchronization meetings and line walks to production lines of the Lead Line Project in BrgP, were detected that the main differences between the equipment from the different plants come from defective material and customer claims, which require immediate corrective action by the manufacturing plant where the defective product was manufactured. It was also possible to observe differences in equipment due to replacement costs, where often temporary solution measures become the final solutions adopted by factories as a result of the cost associated with the new equipment or material. Finally, maintenance team interventions on equipment sometimes end in different solutions between the three manufacturing plants of the project.

Therefore, to mitigate the differences between factories and implement changes in equipment and processes as soon as possible, emerged the need to assign responsibilities to the team members and suppliers. In the "Lead Line Plant Process" Directive, described in subchapter 4.2, is presented two possible communication flows according to global or plant issues that were identified during the industrialization process in the different factories of the project. With this, the responsibility of tasks from the open points is easily attributed to the right person, to solve the detected problems and to apply the proposed improvements in equipment and processes.

4) Customization of an enterprise project management tool to store all the tasks of the Open Point List of the project;

As mentioned earlier, pending tasks of the project joined the Open Point List. It is necessary to close these open points to achieve the desired robustness in the production lines of the Lead Line Project.

Therefore, in the Lead Line Project all manufacturing plants have a common list where is stored all open tasks regarding the necessary changes in equipment and processes from the different factories. The several modifications and improvements on the MAE and the EWAK can be divided into pre-acceptance, commissioning, final acceptance, OPL (bug), process change request, new requirement, new kick-off.

The fourth action made was the customization of a tool that aims to reduce "*the difficulty in sharing information and know-how*" and "*the difficulty in planning and tracking activities*". This tool is used in the project team's CM biweekly meetings, as well as in the biweekly meetings between the manufacturing plants and the global suppliers, reducing "*the insufficient collaboration and communication between the team members and suppliers*".

This tool provides an overview of all pending actions of the project, simplifying the activities delegation to team members and the due dates control of each open point. As a result, this supervision avoids delays in the execution of project activities and fights "*the poor transparency of the work done and the pending activities of each manufacturing plant*".

At the beginning of the project, the Lead Line Project OPL was in an excel file but working on such a file has proved to be an obstacle for project management. The main difficulty in the global standardization measures application came from extracting data from the excel file, once the information was extensive and not organized. To overcome this difficulty, the Open Point List of the project was transferred to a more suitable tool considering the project needs, named Rational Team Concert.

The RTC is the support software tool chosen to manage all the relevant information for Lead Line Synchronization of the global industrialization project in the study. This tool powered by International Business Machines Corporation is an issue tracking platform that allows the systematic and effective management of the Open Points List of the project, managing the tasks regarding the equipment improvements in the three manufacturing plants.

Additionally, the RTC tool allows the supplier's integration into the tool, boosting, as already mentioned, the collaboration and communication between team members and suppliers, and the regular update of information from both parts.

For the Lead Line Project, was customized a project area on RTC exclusively dedicated to managing all the information coming from the Lead Line Synchronization of the three manufacturing plants of this global project. Therefore, the RTC tool is used in project synchronization meetings to follow-up the open points status of each team member and each factory.

To cover all project needs was shaped an open point template for Lead Line Project (Annex VIII). In the customized new open point, the main fields for the study are:

- Created By – The person that opened the new open point, being also considered the "Ticket Responsible";
- Category - The category of the new open point, which can be pre-acceptance, commissioning, final acceptance, OPL (bug), process change request, new requirement, and new kick- off;
- Relevance - The product variant(s) of the project affected by the new open point;
- Production line – The production line(s) of the project affected by the new open point;
- Action Required On – The equipment affected by the new open point, that can be the MAE and/or the EWAK;
- Process station - The workstation(s) affected by the new open point;
- Plant Status – The status of the new open point in each manufacturing plant, which may vary from open, to be checked, ongoing, closed until not applicable, in case of the factory does not need the change.

After clarifying the product variants manufactured, the equipment and the production lines of each manufacturing plant, and knowing the responsibilities and procedures to follow for each task, it has become easier and visible for all project stakeholders, the existing open points, and its tracking in the RTC tool. This fourth step became essential for filtering the data needed to perform the global standardization measures proposed in the next step.

5) Development of performance measurement indicators to evaluate the status of all manufacturing plants and to obtain relevant results regarding the pending work.

From the RTC project area of the Lead Line Project was extracted the necessary information and data to fill the degree of industrialization and the degree of standardization of the project proposed by the researcher.

A case study was conducted to demonstrate the practical implementation and validation of two proposed indicators that appear to clarify the current situation of the project, responding to "*the poor transparency of the work done and the pending tasks of each manufacturing plant*" and to "*the difficulty in having a visual overview of the status of each manufacturing plant in global terms*".

As a result, it is possible to have a visual perception of the industrialization maturity level of the equipment, processes and manufacturing plants involved in the project.

The two proposed evaluation indicators are presented in subchapter 4.4, starting with the degree of standardization and, after, the degree of implementation.

4.4 Global Standardization Indicators

In this subchapter is presented the approach proposed by the researcher in practical terms to mitigate the last two raised problems in the Lead Line Project, "*the poor transparency of the work done and the pending tasks of each manufacturing plant*" and "*the difficulty in having a visual overview of the status of each manufacturing plant in global terms*".

In this way, this subchapter summarizes all the information regarding the situation of the different manufacturing plants of the Lead Line Project, according to the standard profile and each other, through the application of two standardization indicators for global industrialization projects: the degree of standardization and the degree of implementation.

4.4.1 Degree of Standardization

The first proposed evaluation indicator is the Degree of Standardization, which is a Key Performance Indicator that intends to obtain a longitudinal analysis of the equipment's maturity level in the manufacturing plants according to the project phase and, at the same time, compare the similarity of equipment and processes between factories. To do that, different equipment evaluation criteria were created, depending on the quality gate in which is the analyzed variant.

The selected criteria are based on the literature review and the acquired experience from the project development.

The evaluation of the MAE, the workbench, and EWAK, the support equipment of the product, of each workstation follow the same criteria and can be assigned a rating of 0%, 25%, 50%, 75%, and 100%. The criteria for evaluating these percentages are quality-gates-oriented, and the assigned percentage of each equipment is the one that meets all the required criteria according to the current project phase, as is shown in Table 2.

Table 2 - Assessment criteria for MAE and EWAK in each phase of the project (Source: own elaboration)

Level		QGC0 & QGC1	QGC2	QGC3	QG4 & QG5
0%	Global PGL not planned or manufacturing concept not agreed and/or not approved by management	x	-	-	-
	Manufacturing concept not aligned with Lead Line plant coordination	-	x	x	x
25%	Pending manufacturing concept approval by management	-	x	x	x
50%	Manufacturing concept aligned with Lead Line plant coordination	-	x	x	x
	Similar manufacturing concept with different automation level approved by management	-	x	x	x
	Equipment's reuse approved by management	-	x	x	x
	Open points	-	>30	>20	>10
75%	Manufacturing concept aligned with Lead Line plant coordination	-	x	x	x
	Similar manufacturing concept with different automation level approved by management	-	x	x	x
	Equipment's reuse approved by management	-	x	x	X
	Open points	-	>15 & ≤30	>10 & ≤20	>3 & ≤10
100%	Global PGL roll-out ongoing	x	-	-	-
	Manufacturing concept aligned with Lead Line plant coordination	-	x	x	X
	Similar manufacturing concept with different automation level approved by management	-	x	x	X
	Equipment's reuse approved by management	-	x	x	X
	Open points	-	≤15	≤10	≤3
	In case of the variant is produced only in one manufacturing plant	-	x	x	X

If the equipment or process have not been approved by management, it is assigned a rating of 0%, being necessary to understand the reasons that led to its implementation rejection. From the QG2, it is considered a rating of 0% when the concept is not globally aligned.

The 25% rating is assigned to the process whenever in QG2, QG3, QG4 or QG5, the manufacturing concept is pending by the management approval.

Considering now that the manufacturing concept is already approved and under the coordination of Lead Line Plant and only has a different degree of automation level than the other factories or it is used existent equipment, a rating of 50%, 75% or 100% may be given. The differentiating factor is the number of open points of this process in the respective factory, because, as already mentioned, the OPL of the project includes all points regarding pre-acceptance, commissioning, final acceptance, OPL (bug), process change request, new requirement, and new variant kick-off issues.

At the operating level, after detecting the problem or improvement of the equipment or process, the point is considered as open when a ticket is created in the project's Open Point List. Once the team aligned the required tasks to close the point, it is considered closed when the changes are implemented and validated by factories.

Once the project open points translate the pending tasks related to changes in equipment and processes, the lower the number of open points, the closer it is from the maturity state needed for mass production.

In the Lead Line Project, the different factories are in different environmental contexts, in countries such as Malaysia and China considered low-cost countries, the wages tend to be lower than in Portugal. In profitable terms, a highly automated process is more profitable for the Portuguese plant so, after management approval, different automation levels may be possible for similar equipment, depending on the most profitable situation for the project.

Equipment reuse is also a measure of cost savings, where similar factory equipment can and should be used if management considers it appropriate. Any differences that may exist due to the reuse of equipment should be improved until it becomes as similar as possible to the overall aligned solution.

Additionally, it is necessary to mention that the 100% rating can also be assigned during QG0 or QG1, when the manufacturing concept is approved, driving to the PGL activities realization associated with the process.

If the product variant is produced only in one factory, the equipment is always rated at 100%, once the process does not require a global alignment.

Given the evaluation criteria, it is important to understand how is calculated the degree of standardization which can be achieved by the overall average of the project, through the average classification of all processes in every manufacturing plants, under the total number of processes.

The Degree of standardization is defined as follows:

$$\text{Degree of Standardization } (\%) = \frac{\text{Processes assessment (average of all plants)}}{\text{Total processes}}$$

To simplify the research analysis will be conducted a separate study for MAE and EWAK. To study the level of maturity of the MAE and EWAK from all manufacturing plants was defined as a random categorical variable - X - which will be ranked from 0%, 25%, 50%, 75% to 100%.

In the Excel tool, were made two templates for the degree of standardization application, for both MAE (Table 3) and EWAK (Table 4). These templates were integrated into the "Lead Line Plant Process" Directive to be used in every global industrialization project from Bosch Car Multimedia in the future.

In the case of MAE, the variants under analysis to study the level of maturity of the MAE in all manufacturing plants, it was defined as:

X $_{i,j}$ **=** *"MAE from workstation i on the plant j"*

i ϵ {process 1, process 2, process 3, ...}

j ϵ {plant A, plant B, plant C, ...}

Table 3 - Template degree of standardization of MAE (Source: own elaboration)

		Assembly MAE			
		Plant A	Plant B	Plant C	Degree of Standardization
Assembly A	Process 1				
	Process 2				
	Process 3				
	Process 4				
Assembly B	Process 5				
	Process 6				
	Process 7				
	Process 8				
Final Assembly	Process 9				
	Process 10				
	Process 11				
	Process 12				
MAE average Assembly					

		Testing MAE			
		Plant A	Plant B	Plant C	Degree of Standardization
Testing	Process 13				
	Process 14				
	Process 15				
	Process 16				
MAE average Testing					

	Plant A	Plant B	Plant C	Degree of Standardization
Total MAE average				

Meanwhile, for EWAK the degree of standardization analyses the following variants:

X $_{i,j,w}$ **=** *"EWAK from workstation I for variant j on the plant w"*

i ϵ {process 1, process 2, process 3, …}

j ϵ {variant A, variant B, variant C, …}

w ϵ {plant A, plant B, plant C, …}

Table 4 - Template degree of standardization EWAK (Source: own elaboration)

		Assembly EWAK											
		Plant A			Plant B			Plant C			Degree of Standardization		
		Variant x	Variant y	Variant z	Variant x	Variant y	Variant z	Variant x	Variant y	Variant z	Variant x	Variant y	Variant z
Assembly A	Process 1												
	Process 2												
	Process 3												
	Process 4												
Assembly B	Process 5												
	Process 6												
	Process 7												
	Process 8												
Final Assembly	Process 9												
	Process 10												
	Process 11												
	Process 12												
EWAK average Assembly													

		Testing EWAK											
		Plant A			Plant B			Plant C			Degree of Standardization		
		Variant x	Variant y	Variant z	Variant x	Variant y	Variant z	Variant x	Variant y	Variant z	Variant x	Variant y	Variant z
Testing	Process 13												
	Process 14												
	Process 15												
	Process 16												
EWAK average Testing													

	Plant A			Plant B			Plant C			Degree of Standardization		
	Variant x	Variant y	Variant z	Variant x	Variant y	Variant z	Variant x	Variant y	Variant z	Variant x	Variant y	Variant z
Total EWAK average												

This part of the study combines the data of Lead Line Project of Bosch company with the previously described framework. Although this indicator is intended for longitudinal analysis of the project due to the limited time of the researcher in the company, this indicator only was applied once.

Through the RTC tool, it was possible to extract the data of the number of open points concerning the pre-acceptance, commissioning, final acceptance, OPL (bug) , process change request, new requirement, and new variant kick-off, for each MAE process and for each factory of the Lead Line Project. The terminology not applicable (n.a.) is used when the factory does not have the respective process. In Annex IX is counted the total open points from the MAE of each process at the manufacturing plants located in Malaysia, Portugal, and China.

The same process was done for the EWAK, extracting the open points of several product variants from the RTC tool, and can be seen in Annex X, Annex XI and Annex XII, for PgP1, BrgP and WhuP, respectively.

To simplify the analysis of the exposed data, it is assumed that all product variants are in the same phase of the life cycle, which is in QGC4. It is only considered one of the existing production lines in each factory since the duplication of lines or equipment is from the responsibility of each factory. The same happens with equipment changes, which, once validated, must be duplicated in the similar equipment of the factory and must be ensured by the plant team.

Applying the degree of standardization on the Lead Line project resulted in the Annex XIII for MAE and Annex XIV, Annex XV, Annex XVI and Annex XVII for EWAK.

Thus, depending on the number of open points of each equipment, MAE or EWAK, a percentage was allocated according to the criteria of Table 2 during QGC4.

After assigning the percentages, the average of MAE from each process was calculated, as we can see in the example of process 1 for the MAE equipment, and from each factory.

$$\text{Degree of Standardization Process 1}$$
$$= \frac{\text{Process 1 (PgP1)} + \text{Process 1 (BrgP)} + \text{Process 1 (WhuP)}}{\text{Total processes (PgP1 + BrgP + WhuP)}}$$
$$= \frac{100\% + 75\% + \text{n.a.}}{2} = 87{,}5\%$$

Subsequently, the average of EWAK from each process of the multiple variants of the different factories was calculated, as in the example of process 17 for variant X1, and it was also determined the average of each variant per factory.

$$\text{Degree of Standardization Process 17 variant X1}$$
$$= \frac{\text{Process 17 variant X1 (PgP1)} + \text{Process 17 variant X1 (BrgP)} + \text{Process 17 Variant X1 (WhuP)}}{\text{Total processes (PgP1 + BrgP + WhuP)}}$$
$$= \frac{75\% + 100\% + 100\%}{3} = 91{,}67\%$$

The Degree of Standardization to MAE equipment (Annex XIII) provided a clear overview of the status of each process globally. The main critical processes in production line D are processes 31, 34, 35, and 37, which affect the manufacturing plants located in Penang and Braga. As it is possible to observe in Figure 29, process 35 is the one that requires the highest attention as it is rated at 50% for both PgP1 and BrgP, meaning that the MAE of process 35 at the time of the evaluation has more than 10 open points in each factory. This process has a value of 50% in the degree of standardization of the project signed with a red circle in Figure 29.

Assembly D	Process 30	100%	100%	n.a.	100%
	Process 31	50%	75%	n.a.	63%
	Process 32	75%	75%	n.a.	75%
	Process 33	100%	100%	n.a.	100%
	Process 34	50%	75%	n.a.	63%
	Process 35	50%	50%	n.a.	50%
	Process 36	100%	100%	n.a.	100%
	Process 37	50%	75%	n.a.	63%
	Process 38	100%	100%	n.a.	100%
	Process 39	100%	100%	n.a.	100%
	Process 40	75%	75%	n.a.	75%

Figure 29 - Critical Processes from Assembly Line D (Source: own elaboration)

In addition to production line D, the production line F is the only one that also has processes with a global classification of 50%, namely process 53 and process 59 (Figure 30). Concerning process 57, although in PgP1 and WhuP has a rating of 50%, in Braga factory has more than 3 but less than 10 open points regarding the MAE, which results in a rating of 75%.

Assembly F	Process 51	75%	100%	100%	92%
	Process 52	100%	100%	100%	100%
	Process 53	50%	50%	50%	50%
	Process 54	n.a.	100%	n.a.	100%
	Process 55	100%	100%	100%	100%
	Process 56	100%	100%	100%	100%
	Process 57	50%	75%	50%	58%
	Process 58	n.a.	75%	n.a.	75%
	Process 59	50%	50%	50%	50%

Figure 30 - Critical Processes from Assembly Line F (Source: own elaboration)

These results show that in the case of MAE, these critical processes should be the focus of project team. Once the critical processes in terms of global standardization are identified, the project manager should verify the category of the open points from the critical processes to check if any alignment or information sharing between the team members of the different factories are required or to outline the necessary activities as soon as possible.

Usually, open points related to process change requests and new requirements to the previous specification of the equipment tend to be longer points to close due to the implementation and validation time in production. Therefore, the project manager should consider these points as a priority during team meetings or even as a priority in meetings with suppliers after the overall internal CM solution is aligned.

From the MAE analysis, it was possible to conclude that PgP1 is the factory more uniform regarding the intended requirements for each process. On the other hand, WhuP is the factory less standard compared to the rest of the project's factories, this means that the plant located in Wuhu, the several MAE have more changes and corrections to be made.

In the analysis of the EWAK equipment (Annex XIV, Annex XV, Annex XVI and Annex XVII), only process 53 for variant X_1 was identified as critical. In other words, the EWAK from process 53 of variant X_1 is the one that needs the most attention from the project team as it is farther from being able to support serial production.

4.4.2 Degree of Implementation

The Degree of Implementation is a Key Performance Indicator based on the closed points of each manufacturing plant, aiming to understand the current situation of each factory and, simultaneously, compare with the situation of the other manufacturing plants.

This indicator quantifies the percentage of closed points of each manufacturing plant by the total points of that same factory.

Basically, the Degree of Implementation can simply be defined as:

$$\text{Degree of Implementation (\%)} = \frac{\text{Closed points}}{\text{Total points}} \times 100$$

As a result, the higher number of closed points, the greater will be the degree of implementation of the manufacturing plant.

Applying now this KPI into the Lead Line Project, all points of the project since the beginning of the industrialization process until the evaluation date were counted. Thus, Table 5 includes the total points of each manufacturing plant, the number of closed points, and also, the number of open points that were already extracted to fulfill the degree of standardization.

Table 5 - Open points, closed points and total points of each manufacturing plant (Source: own elaboration)

	Open Points	Closed Points	Total Points
PgP1	719	2276	2995
BrgP	552	1983	2535
WhuP	151	456	607

For each plant, the data necessary to complete the degree of implementation was collected, obtaining a graph of the current situation and the percentage of industrial maturity of the equipment, including MAE and EWAK represented in Figure 31 (PgP1), Figure 32 (BrgP) and Figure 33 (WhuP).

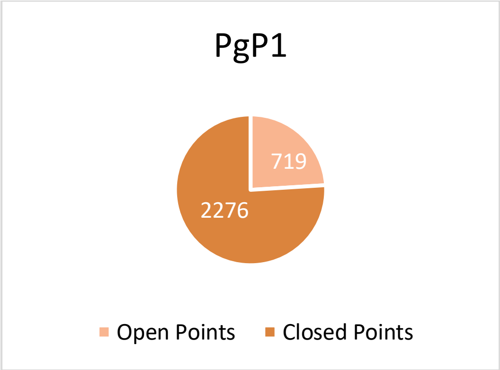

Figure 31 - Points status for PgP1 (Source: own elaboration)

$$\text{Degree of Implementation PgP1 (\%)} = \frac{2276}{2995} \times 100 = 75{,}99\%$$

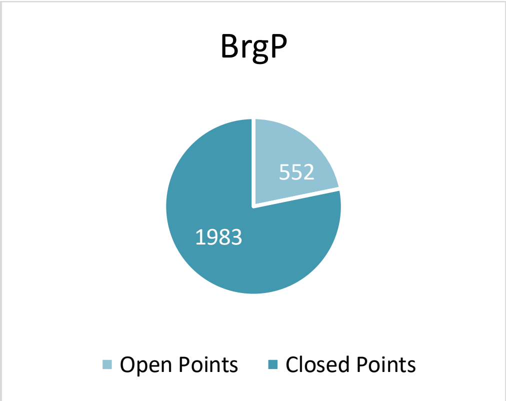

Figure 32 - Points status for BrgP (Source: own elaboration)

$$\text{Degree of Implementation BrgP (\%)} = \frac{1983}{2535} \times 100 = 78{,}22\%$$

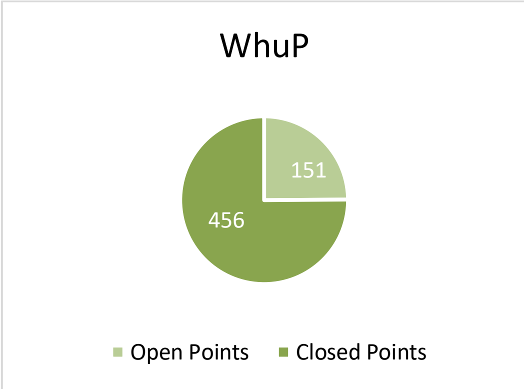

Figure 33 - Points status for WhuP (Source: own elaboration)

$$\text{Degree of Implementation WhuP (\%)} = \frac{456}{607} \times 100 = 75{,}12\%$$

Crossing the degree of implementation obtained in each factory is possible to realize that in terms of overall industrial maturity of equipment, the factory located in Wuhu has the lowest value being the factory considered the latest factory in the process of implementing changes in equipment and processes.

By transferring the project points to the RTC management support tool, this indicator has been simplified by filtering the relevant fields to the analysis. In this way, the RTC allows the collection of the total points, open points and even closed points of each factory.

Currently, the Degree of implementation incorporates the monthly project status report for the entire team and the management, providing an easy-to-understand view of the current state of each manufacturing plant.

Such as the Degree of Standardization, this indicator also provides transparency regarding the work done and project's pending tasks. However, both indicators have some limitations that will be exposed in the next chapter and followed by improvement proposals for future research.

5. Conclusions and Future Research

This dissertation project had a focus on the development of indicators to assess the standardization of equipment and processes in global industrialization projects. To this end, the research work followed a case study strategy conducted at Bosch Car Multimedia, where the researcher was able to comprehensively understand the complexity of a global project in the automotive industry.

From the literature review, it was possible to conclude that the competitiveness of markets led companies to expand their barriers beyond national boundaries and to adopt global production networks to compete and cooperate for a greater share of value. The automotive industry has also evolved into mass customization production with a user-focused approach, producing in different locations around the world with new flexible production lines that incorporate product differentiation in a controlled and optimized way.

During the development of this study, the researcher accomplished the five goals proposed, starting with the analysis of a global industrialization project at Bosch, the Lead Line Project. This allowed the collection of data through qualitative techniques, being the participant observation on the meetings between all CM team members from Penang, Braga, and Wuhu, and also between CM team and global suppliers, the most relevant source of data gathering used during this study. However, the direct observation of production lines during line walks in Braga plant, and the analysis of documents, also contributed to study the Lead Line Project that began by identifying the equipment and processes of the different manufacturing plants dispersed worldwide, which meets the first objective proposed, *"study the equipment and processes that compose the industrialization process of a global project in the automotive industry"*.

The second goal proposed was to *"identify the factors that cause equipment differentiation between manufacturing plants in a global industrialization project"* that the researcher, through the contact with the industrial reality, concluded that the main differences in equipment come from defective materials, customer claims, costs replacement of materials and equipment, as well as interventions by the maintenance team.

As a result of the study done to the Lead Line Project, it was possible to identify the main weaknesses of the project and understand the main difficulties in managing all information related to it. In this way, emerged the need to *"define an approach to address the difficulties of managing an industrialization project in several countries"* which refers us to the Lead Line Approach described in the "Lead Line Plant Process" Directive. The Central Directive was developed to guide the global team, since the development of the product until its industrialization in manufacturing plants dispersed around the world.

Additionally, the researcher made some improvements to the Lead Line Project to have a better organization of the information and to analyze the standardization of the industrialization process into the different manufacturing plants of the project. This brings up the last two objectives proposed for this study: *"develop an analysis tool to measure the degree of standardization of equipment and processes among the manufacturing plants in a global project"* and *"develop an analysis tool to measure the degree of industrial implementation of each manufacturing plant in a global project"*.

Therefore, in this study two indicators were developed based on the open points of each manufacturing plant and were then applied to the Lead Line Project.

As it was expected, the indicators implemented as an attempt to achieve the last two proposed objectives had a good impact on the project. Nevertheless, the two measures were applied for the first time in a global industrialization project at Bosch, being recognized some difficulties and limitations during the implementation of the degree of standardization and the degree of implementation.

One of the difficulties identified was the manual data insertion into the excel file in both indicators, this requires time from the project synchronization manager, taking at least one hour to update the project status table, and calculating the KPIs. As an improvement proposal, this data could be directly updated into the excel tool. As a result, the excel file would automatically generate the project status table from the RTC data extraction of the useful information from the industrialization process of each manufacturing plant, as well as, would automatically create the KPI. Additionally, graphics can be created with the progress of the project over time or by comparing project planned vs reality.

These indicators have a longitudinal character, but the limited time that the researcher was cooperating with the company, the time spent following up the pending tasks of the three factories and the time dispended in improving the information organization of the Lead Line Project, restricted their long-term application. Thus, both indicators were applied once for this study but will continue to be analyzed in the future of the project.

Also, another limitation found was the attribution of equal importance to the several types of open points that exist in the Lead Line Project (pre-acceptance, commissioning, final acceptance, bug, process change request, new requirement, and new kick-off). Therefore, in the future, it could be studied the possibility of assigning different percentages according to the level of effort required to close the point (e.g., PCRs are points that tend to take longer to implement in all factories, given the number of associated processes that it has).

Regarding the degree of standardization, it could also be made an “Automation level sheet” which would be a support document for recording deviations requests in equipment's automation level among the several manufacturing plants of the project during the PGL phase.

Finally, the work performed will be an asset for the management of global industrialization projects where the two proposed indicators can be used to monitor and control the industrialization process globally.

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ANNEXES

ANNEX I – CHARACTERISTICS OF SAMPLES DEVELOPED IN PEP PHASES

A sample (or Prototype Sample Production - PSP):

- Functional prototype with a low level of maturity and only partially final materials and semi-finished parts
- Suitable for function tests but not for endurance tests
- Restrictions in function, regarding customer and Bosch specifications (for instance, operating voltage, operating temperature, appearance and dimensions)

B sample (or Development Sample Production):

- Prototype with a high level of maturity, largely made from final (i.e. defined for series production) materials and semi-finished parts
- Connecting and mounting dimensions correspond to the series production
- Suitable for endurance tests and preliminary tests of customer for testing the overall functional scope and the technical requirements

C sample (or Tools Sample Production - TSP):

- Prototype that confirms internal product release and finalization of the development phase
- Design is verified and then validated by the customer
- Processes and tools are finished, as far as they affect product properties, and series functionality is available
- Software specification is possibly not yet completely fulfilled

D sample (or Pilot):

- Sample that completely fulfills specification and that is produced on pilot series
- All parts are produced with series production tools and processes
- Mounted and tested under series production conditions
- Software has the format for the series production

Annex II – Deviation List

Deviation List

Number	Requester	Request date	Process category	Process step	Deviation description	Deviation reason	Risk analysis	Cost benefit analysis	Involved plants	Links	Status	Date	Synchronization Manager
1		<Date>											
2													
3													
4													
5													
6													
7													
8													

Annex III – Processes per Product Variant in PgP1

		PgP1											
		X_1	X_2	X_3	X_4	Y_1	Y_2	Y_3	Y_4	Y_5	Y_6	Y_7	Z_1
Assembly A	Process 1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Process 2	✓	-	✓	✓	✓	✓	✓	-	✓	✓	✓	✓
	Process 3	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Process 4	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Process 5	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Process 6	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Process 7	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Assembly B	Process 8	-	-	✓	-	✓	-	✓	-	-	✓	✓	-
	Process 9	-	-	✓	-	✓	-	✓	-	-	✓	✓	-
	Process 10	-	-	✓	-	✓	-	✓	-	-	✓	✓	-
	Process 11	-	-	✓	-	✓	-	✓	-	-	✓	✓	-
Assembly C	Process 12	-	-	-	-	-	-	-	-	-	-	-	-
	Process 13	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Process 14	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Process 15	✓	-	-	✓	✓	✓	-	-	✓	✓	✓	✓
	Process 16	✓	-	-	✓	✓	✓	-	-	✓	✓	✓	✓
	Process 17	✓	-	-	✓	✓	✓	✓	-	✓	✓	✓	✓
	Process 18	✓	-	✓	✓	✓	✓	✓	-	✓	✓	✓	✓
	Process 19	-	-	-	✓	✓	✓	-	-	✓	✓	✓	-
	Process 20	-	-	-	✓	✓	-	-	-	✓	✓	✓	-
	Process 21	-	-	-	✓	✓	✓	-	-	-	-	-	-
	Process 22	-	-	-	✓	✓	-	-	-	✓	✓	✓	-
	Process 23	-	-	✓	-	-	-	-	-	-	-	-	✓
	Process 24	-	-	-	-	-	-	✓	-	-	-	-	-
	Process 25	✓	-	✓	-	-	-	✓	-	-	-	-	✓
	Process 26	-	✓	-	✓	✓	✓	-	✓	✓	✓	✓	-
	Process 27	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Process 28	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Process 29	-	✓	-	-	-	-	-	✓	-	-	-	-
Assembly D	Process 30	-	✓	✓	✓	-	-	-	-	-	-	-	-
	Process 31	-	✓	✓	✓	✓	✓	✓	-	-	-	-	-
	Process 32	-	✓	✓	✓	-	✓	✓	-	-	-	-	-
	Process 33	-	-	-	-	✓	-	✓	-	-	-	-	-
	Process 34	-	✓	✓	✓	✓	✓	✓	-	-	-	-	-
	Process 35	-	✓	✓	✓	✓	✓	✓	-	-	-	-	-
	Process 36	-	✓	✓	✓	✓	✓	✓	-	-	-	-	-
	Process 37	-	✓	✓	✓	✓	✓	✓	-	-	-	-	-
	Process 38	-	✓	-	✓	✓	✓	-	-	-	-	-	-
	Process 39	-	✓	✓	✓	-	✓	✓	-	-	-	-	-
	Process 40	-	✓	✓	✓	✓	✓	✓	-	-	-	-	-

		PgP1											
		X_1	X_2	X_3	X_4	Y_1	Y_2	Y_3	Y_4	Y_5	Y_6	Y_7	Z_1
Assembly E	Process 41	-	-	-	-	-	-	-	✓	✓	✓	✓	-
	Process 42	-	-	-	-	-	-	-	✓	✓	✓	✓	-
	Process 43	-	-	-	-	-	-	-	-	-	✓	✓	-
	Process 44	-	-	-	-	-	-	-	✓	✓	✓	✓	-
	Process 45	-	-	-	-	-	-	-	✓	✓	✓	✓	-
	Process 46	-	-	-	-	-	-	-	✓	✓	✓	✓	-
	Process 47	-	-	-	-	-	-	-	✓	✓	✓	✓	-
	Process 48	-	-	-	-	-	-	-	✓	✓	✓	✓	-
	Process 49	-	-	-	-	-	-	-	✓	✓	-	-	-
	Process 50	-	-	-	-	-	-	-	✓	✓	✓	✓	-
Assembly F	Process 51	✓	-	-	-	-	-	-	-	-	-	-	-
	Process 52	✓	-	-	-	-	-	-	-	-	-	-	-
	Process 53	✓	-	-	-	-	-	-	-	-	-	-	-
	Process 54	-	-	-	-	-	-	-	-	-	-	-	-
	Process 55	✓	-	-	-	-	-	-	-	-	-	-	-
	Process 56	✓	-	-	-	-	-	-	-	-	-	-	-
	Process 57	✓	-	-	-	-	-	-	-	-	-	-	-
	Process 58	-	-	-	-	-	-	-	-	-	-	-	-
	Process 59	✓	-	-	-	-	-	-	-	-	-	-	-
Testing	Process 60	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Process 61	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Process 62	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Process 63	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Process 64	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Process 65	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Process 66	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Process 67	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Process 68	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Process 69	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Process 70	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Process 71	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Annex IV – Processes per Product Variant in BrgP

		BrgP											
		X_1	X_2	X_3	X_4	Y_1	Y_2	Y_3	Y_4	Y_5	Y_6	Y_7	Z_1
Assembly A	Process 1	✓	✓	✓	✓	✓	✓	✓	-	-	-	-	✓
	Process 2	✓	-	✓	✓	✓	✓	✓	-	-	-	-	✓
	Process 3	✓	✓	✓	✓	✓	✓	✓	-	-	-	-	✓
	Process 4	✓	✓	✓	✓	✓	✓	✓	-	-	-	-	✓
	Process 5	✓	✓	✓	✓	✓	✓	✓	-	-	-	-	✓
	Process 6	✓	✓	✓	✓	✓	✓	✓	-	-	-	-	✓
	Process 7	✓	✓	✓	✓	✓	✓	✓	-	-	-	-	✓
Assembly B	Process 8	-	-	✓	-	✓	-	✓	-	-	-	-	-
	Process 9	-	-	✓	-	✓	-	✓	-	-	-	-	-
	Process 10	-	-	✓	-	✓	-	✓	-	-	-	-	-
	Process 11	-	-	✓	-	✓	-	✓	-	-	-	-	-
Assembly C	Process 12	-	-	✓	✓	-	-	-	-	-	-	-	-
	Process 13	✓	✓	✓	✓	✓	✓	✓	-	-	-	-	✓
	Process 14	✓	✓	✓	✓	✓	✓	✓	-	-	-	-	✓
	Process 15	✓	-	-	✓	✓	✓	-	-	-	-	-	✓
	Process 16	✓	-	-	✓	✓	✓	-	-	-	-	-	✓
	Process 17	✓	-	-	✓	✓	✓	✓	-	-	-	-	✓
	Process 18	✓	-	✓	✓	✓	✓	✓	-	-	-	-	✓
	Process 19	-	-	-	✓	✓	✓	-	-	-	-	-	-
	Process 20	-	-	-	✓	✓	-	-	-	-	-	-	-
	Process 21	-	-	-	-	-	-	-	-	-	-	-	-
	Process 22	-	-	-	✓	✓	-	-	-	-	-	-	-
	Process 23	-	-	✓	-	-	-	-	-	-	-	-	✓
	Process 24	-	-	-	-	-	-	✓	-	-	-	-	-
	Process 25	✓	-	✓	-	-	-	✓	-	-	-	-	✓
	Process 26	-	✓	-	✓	✓	✓	-	-	-	-	-	-
	Process 27	✓	✓	✓	✓	✓	✓	✓	-	-	-	-	✓
	Process 28	✓	✓	✓	✓	✓	✓	✓	-	-	-	-	✓
	Process 29	-	✓	-	-	-	-	-	-	-	-	-	-
Assembly D	Process 30	-	✓	-	✓	-	-	-	-	-	-	-	-
	Process 31	-	✓	-	✓	✓	✓	✓	-	-	-	-	-
	Process 32	-	✓	-	✓	-	✓	✓	-	-	-	-	-
	Process 33	-	-	-	-	✓	-	✓	-	-	-	-	-
	Process 34	-	✓	-	✓	✓	✓	✓	-	-	-	-	-
	Process 35	-	✓	-	✓	✓	✓	✓	-	-	-	-	-
	Process 36	-	✓	-	✓	✓	✓	✓	-	-	-	-	-
	Process 37	-	✓	-	✓	✓	✓	✓	-	-	-	-	-
	Process 38	-	✓	-	✓	✓	✓	-	-	-	-	-	-
	Process 39	-	✓	-	✓	-	✓	-	-	-	-	-	-
	Process 40	-	✓	-	✓	✓	✓	✓	-	-	-	-	-

		BrgP											
		X_1	X_2	X_3	X_4	Y_1	Y_2	Y_3	Y_4	Y_5	Y_6	Y_7	Z_1
Assembly E	Process 41	-	-	-	-	-	-	-	-	-	-	-	-
	Process 42	-	-	-	-	-	-	-	-	-	-	-	-
	Process 43	-	-	-	-	-	-	-	-	-	-	-	-
	Process 44	-	-	-	-	-	-	-	-	-	-	-	-
	Process 45	-	-	-	-	-	-	-	-	-	-	-	-
	Process 46	-	-	-	-	-	-	-	-	-	-	-	-
	Process 47	-	-	-	-	-	-	-	-	-	-	-	-
	Process 48	-	-	-	-	-	-	-	-	-	-	-	-
	Process 49	-	-	-	-	-	-	-	-	-	-	-	-
	Process 50	-	-	-	-	-	-	-	-	-	-	-	-
Assembly F	Process 51	✓	-	-	-	-	-	-	-	-	-	-	-
	Process 52	✓	-	✓	-	-	-	-	-	-	-	-	-
	Process 53	✓	-	✓	-	-	-	-	-	-	-	-	-
	Process 54	-	-	✓	-	-	-	-	-	-	-	-	-
	Process 55	✓	-	✓	-	-	-	-	-	-	-	-	-
	Process 56	✓	-	✓	-	-	-	-	-	-	-	-	-
	Process 57	✓	-	✓	-	-	-	-	-	-	-	-	-
	Process 58	-	-	✓	-	-	-	-	-	-	-	-	-
	Process 59	✓	-	✓	-	-	-	-	-	-	-	-	-
Testing	Process 60	✓	✓	✓	✓	✓	✓	✓	-	-	-	-	✓
	Process 61	✓	✓	✓	✓	✓	✓	✓	-	-	-	-	✓
	Process 62	✓	✓	✓	✓	✓	✓	✓	-	-	-	-	✓
	Process 63	✓	✓	✓	✓	✓	✓	✓	-	-	-	-	✓
	Process 64	✓	✓	✓	✓	✓	✓	✓	-	-	-	-	✓
	Process 65	✓	✓	✓	✓	✓	✓	✓	-	-	-	-	✓
	Process 66	✓	✓	✓	✓	✓	✓	✓	-	-	-	-	✓
	Process 67	✓	✓	✓	✓	✓	✓	✓	-	-	-	-	✓
	Process 68	✓	✓	✓	✓	✓	✓	✓	-	-	-	-	✓
	Process 69	✓	✓	✓	✓	✓	✓	✓	-	-	-	-	✓
	Process 70	✓	✓	✓	✓	✓	✓	✓	-	-	-	-	✓
	Process 71	✓	✓	✓	✓	✓	✓	✓	-	-	-	-	✓

ANNEX V – PROCESSES PER PRODUCT VARIANT IN WHUP

		WhuP											
		X_1	X_2	X_3	X_4	Y_1	Y_2	Y_3	Y_4	Y_5	Y_6	Y_7	Z_1
Assembly A	Process 1	-	-	-	-	-	-	-	-	-	-	-	-
	Process 2	-	-	-	-	-	-	-	-	-	-	-	-
	Process 3	-	-	-	-	-	-	-	-	-	-	-	-
	Process 4	-	-	-	-	-	-	-	-	-	-	-	-
	Process 5	-	-	-	-	-	-	-	-	-	-	-	-
	Process 6	-	-	-	-	-	-	-	-	-	-	-	-
	Process 7	-	-	-	-	-	-	-	-	-	-	-	-
Assembly B	Process 8	-	-	-	-	-	-	-	-	-	-	-	-
	Process 9	-	-	-	-	-	-	-	-	-	-	-	-
	Process 10	-	-	-	-	-	-	-	-	-	-	-	-
	Process 11	-	-	-	-	-	-	-	-	-	-	-	-
Assembly C	Process 12	-	-	-	-	-	-	-	-	-	-	-	-
	Process 13	✓	-	-	-	-	-	-	-	-	-	-	-
	Process 14	✓	-	-	-	-	-	-	-	-	-	-	-
	Process 15	✓	-	-	-	-	-	-	-	-	-	-	-
	Process 16	✓	-	-	-	-	-	-	-	-	-	-	-
	Process 17	✓	-	-	-	-	-	-	-	-	-	-	-
	Process 18	✓	-	-	-	-	-	-	-	-	-	-	-
	Process 19	-	-	-	-	-	-	-	-	-	-	-	-
	Process 20	-	-	-	-	-	-	-	-	-	-	-	-
	Process 21	-	-	-	-	-	-	-	-	-	-	-	-
	Process 22	-	-	-	-	-	-	-	-	-	-	-	-
	Process 23	-	-	-	-	-	-	-	-	-	-	-	-
	Process 24	-	-	-	-	-	-	-	-	-	-	-	-
	Process 25	✓	-	-	-	-	-	-	-	-	-	-	-
	Process 26	-	-	-	-	-	-	-	-	-	-	-	-
	Process 27	✓	-	-	-	-	-	-	-	-	-	-	-
	Process 28	✓	-	-	-	-	-	-	-	-	-	-	-
	Process 29	-	-	-	-	-	-	-	-	-	-	-	-
Assembly D	Process 30	-	-	-	-	-	-	-	-	-	-	-	-
	Process 31	-	-	-	-	-	-	-	-	-	-	-	-
	Process 32	-	-	-	-	-	-	-	-	-	-	-	-
	Process 33	-	-	-	-	-	-	-	-	-	-	-	-
	Process 34	-	-	-	-	-	-	-	-	-	-	-	-
	Process 35	-	-	-	-	-	-	-	-	-	-	-	-
	Process 36	-	-	-	-	-	-	-	-	-	-	-	-
	Process 37	-	-	-	-	-	-	-	-	-	-	-	-
	Process 38	-	-	-	-	-	-	-	-	-	-	-	-
	Process 39	-	-	-	-	-	-	-	-	-	-	-	-
	Process 40	-	-	-	-	-	-	-	-	-	-	-	-

		WhuP											
		X_1	X_2	X_3	X_4	Y_1	Y_2	Y_3	Y_4	Y_5	Y_6	Y_7	Z_1
Assembly E	Process 41	-	-	-	-	-	-	-	-	-	-	-	-
	Process 42	-	-	-	-	-	-	-	-	-	-	-	-
	Process 43	-	-	-	-	-	-	-	-	-	-	-	-
	Process 44	-	-	-	-	-	-	-	-	-	-	-	-
	Process 45	-	-	-	-	-	-	-	-	-	-	-	-
	Process 46	-	-	-	-	-	-	-	-	-	-	-	-
	Process 47	-	-	-	-	-	-	-	-	-	-	-	-
	Process 48	-	-	-	-	-	-	-	-	-	-	-	-
	Process 49	-	-	-	-	-	-	-	-	-	-	-	-
	Process 50	-	-	-	-	-	-	-	-	-	-	-	-
Assembly F	Process 51	✓	-	-	-	-	-	-	-	-	-	-	-
	Process 52	✓	-	-	-	-	-	-	-	-	-	-	-
	Process 53	✓	-	-	-	-	-	-	-	-	-	-	-
	Process 54	-	-	-	-	-	-	-	-	-	-	-	-
	Process 55	✓	-	-	-	-	-	-	-	-	-	-	-
	Process 56	✓	-	-	-	-	-	-	-	-	-	-	-
	Process 57	✓	-	-	-	-	-	-	-	-	-	-	-
	Process 58	-	-	-	-	-	-	-	-	-	-	-	-
	Process 59	✓	-	-	-	-	-	-	-	-	-	-	-
Testing	Process 60	✓	-	-	-	-	-	-	-	-	-	-	-
	Process 61	✓	-	-	-	-	-	-	-	-	-	-	-
	Process 62	✓	-	-	-	-	-	-	-	-	-	-	-
	Process 63	✓	-	-	-	-	-	-	-	-	-	-	-
	Process 64	✓	-	-	-	-	-	-	-	-	-	-	-
	Process 65	✓	-	-	-	-	-	-	-	-	-	-	-
	Process 66	✓	-	-	-	-	-	-	-	-	-	-	-
	Process 67	✓	-	-	-	-	-	-	-	-	-	-	-
	Process 68	✓	-	-	-	-	-	-	-	-	-	-	-
	Process 69	✓	-	-	-	-	-	-	-	-	-	-	-
	Process 70	✓	-	-	-	-	-	-	-	-	-	-	-
	Process 71	✓	-	-	-	-	-	-	-	-	-	-	-

ANNEX VI – RESPONSIBILITIES PER PROJECT FUNCTION

Project Function	Description
Global Industrialization Project Manager (Global Ind. PjM)	a) Manage and report Global Project Management Plan (schedule, risk, scope, communication, scope) b) Coordinate A and B samples build and ensure the handover to the plants c) Main interface between development team and plants d) Support PPC calculation e) Consolidate and track global investment budget - Prepare and start MAE Approval Process and remote operations, e.g. re-flashing - Track global budget, including potential re-flashing locations and update MAE Approval Request f) Apply TcPCM calculation and support Make and/or Buy Process g) Optimize manufacturing process, focusing on cost reduction h) Lead global manufacturing SE and PGL activities i) Coordinate project risk management and define countermeasures j) Promote the easy transfer of the project between locations k) Ensure "Lead Line Plant Process" Directive fulfillment l) Ensure plants readiness for QGC m) Organize regular alignments and follow-up of the performance indicators between plants, e.g. FPY and OEE n) Follow and implement customer requirements for manufacturing o) Conduct manufacturing risk analysis for MAE equipment's reuse p) Coordinate plants PM's common activities
Assembly/Testing Synchronization Manager (ASM/TSM)	a) Active participation in Global Project Team activities and meetings b) Ensure same level of production line equipment's implementation in all locations based on global specification c) Lead the alignment meetings with Plant Process Engineers from the different locations* d) Track sample build line problems due to process, testers and jigs/fixtures and ensure the lessons learned are transfer to other CM plants e) Coordinate process change requests and improvements between plants f) Support the discussions with global suppliers for changes introduction in the plants* g) Ensure technical support to purchase and service contract requirements h) Monitor and report project synchronization status (KPR/KPI) i) Support on project goals achievement and schedules (schedule, risk, scope, communication, milestones, SDL) j) Active participation on global investment budget consolidation/tracking *Task to be aligned with the Station Owner
Assembly/Testing Station Owner (ASO/TSO)	a) Perform workstation specification requirements b) Support Synchronization Manager on OPL's, new requirement's and PCR'S control in all CM plants, including with external suppliers c) Control and update workstation specification index d) Responsible for technical discussion with suppliers and purchasing
Assembly/Testing Process Leader (APL/TPL)	According plant documentation (Team contracting, Service Level Agreement, Plant Project Team)
Assembly/Testing Station Representative (ASR/TSR)	According plant documentation (Team contracting, Service Level Agreement, Plant Project Team)
Plant team	According plant documentation (Team contracting, Service Level Agreement, Plant Project Team)
Centers of Competence (MFT-CoC)	Refer to organization of the "Center of Competence"

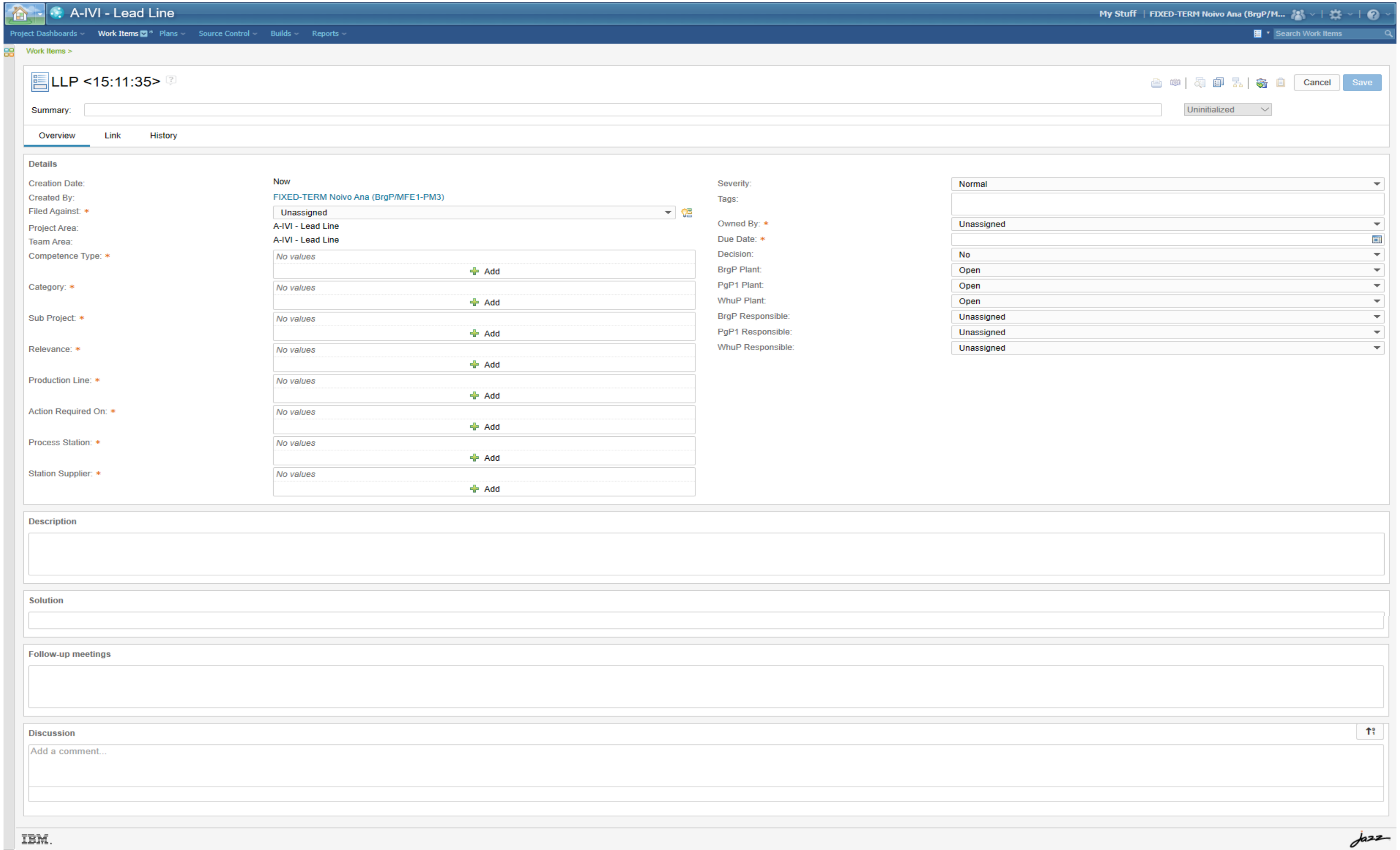
Annex VII – Global Process Owner Matrix

BOSCH — Global Process Owner Matrix

Manufacturing Processes	Process Engineering	Center of Competence	Assembly/Testing Station Owner (ASO/TSO)	Plant A Station Representative (ASO/TSO)	Plant B Station Representative (ASO/TSO)	Plant C Station Representative (ASO/TSO)	Supplier
Process 1							
Process 2							
Process 3							

		Escalation Path Level 1		Escalation Path Level 2		Escalation Path Level 3	
	Global Coordination	Assembly Synchronization Manager (ASM)		Global Ind. PjM		Management	
		Testing Synchronization Manager (TSM)				Management	
Assembly	Plant A	Project Leader (APL)		Plant Engineering Process		Management	
	Plant B	Project Leader (APL)		Plant Engineering Process		Management	
	Plant C	Project Leader (APL)		Plant Engineering Process		Management	
Testing	Plant A	Project Leader (TPL)		Plant Engineering Process		Management	
	Plant B	Project Leader (TPL)		Plant Engineering Process		Management	
	Plant C	Project Leader (TPL)		Plant Engineering Process		Management	

ANNEX VIII – NEW OPEN POINT TEMPLATE RTC FOR LEAD LINE PROJECT



ANNEX IX – TOTAL OPEN POINTS OF MAE FROM ALL MANUFACTURING PLANTS

		PgP1	BrgP	WhuP	Total Open Points MAE per Process
Assembly A	Process 1	2	4	n.a.	6
	Process 2	1	1	n.a.	2
	Process 3	3	5	n.a.	8
	Process 4	0	0	n.a.	0
	Process 5	1	1	n.a.	2
	Process 6	2	1	n.a.	3
	Process 7	1	1	n.a.	2
Assembly B	Process 8	2	2	n.a.	4
	Process 9	1	1	n.a.	2
	Process 10	0	0	n.a.	0
	Process 11	2	1	n.a.	3
Assembly C	Process 12	n.a.	1	n.a.	1
	Process 13	2	2	2	6
	Process 14	6	4	5	15
	Process 15	5	5	5	15
	Process 16	6	7	6	19
	Process 17	4	3	3	10
	Process 18	5	4	4	13
	Process 19	1	1	n.a.	2
	Process 20	3	1	n.a.	4
	Process 21	0	1	n.a.	1
	Process 22	1	n.a.	n.a.	1
	Process 23	0	1	n.a.	1
	Process 24	1	1	n.a.	2
	Process 25	0	0	1	1
	Process 26	1	0	n.a.	1
	Process 27	4	3	2	9
	Process 28	5	2	3	10
	Process 29	5	2	n.a.	7
Assembly D	Process 30	2	2	n.a.	4
	Process 31	11	10	n.a.	21
	Process 32	7	9	n.a.	16
	Process 33	3	3	n.a.	6
	Process 34	11	9	n.a.	20
	Process 35	12	12	n.a.	24
	Process 36	2	1	n.a.	3
	Process 37	11	10	n.a.	21
	Process 38	0	0	n.a.	0
	Process 39	0	1	n.a.	1
	Process 40	6	8	n.a.	14

Assembly E	Process 41	1	n.a.	n.a.	1
	Process 42	0	n.a.	n.a.	0
	Process 43	0	n.a.	n.a.	0
	Process 44	0	n.a.	n.a.	0
	Process 45	1	n.a.	n.a.	1
	Process 46	2	n.a.	n.a.	2
	Process 47	1	n.a.	n.a.	1
	Process 48	1	n.a.	n.a.	1
	Process 49	0	n.a.	n.a.	0
	Process 50	0	n.a.	n.a.	0
Assembly F	Process 51	5	3	3	11
	Process 52	1	2	1	4
	Process 53	13	12	12	37
	Process 54	n.a.	1	n.a.	1
	Process 55	1	1	1	3
	Process 56	0	0	1	1
	Process 57	11	8	11	30
	Process 58	n.a.	6	n.a.	6
	Process 59	11	12	12	35
Total Open Points MAE Assembly per Plant		177	165	72	414
Testing	Process 60	2	1	2	5
	Process 61	3	3	2	8
	Process 62	1	5	2	8
	Process 63	1	1	0	2
	Process 64	7	8	8	23
	Process 65	0	2	0	2
	Process 66	2	0	1	3
	Process 67	3	4	3	10
	Process 68	2	2	4	8
	Process 69	1	1	1	3
	Process 70	0	0	0	0
	Process 71	0	1	0	1
Total Open Points MAE Testing per Plant		22	28	23	73
Total Open Points MAE Assembly + Testing		199	193	95	487

Annex X – Total Open Points of EWAK from PgP1

		PgP1												Total Open Points EWAK per Process
		X_1	X_2	X_3	X_4	Y_1	Y_2	Y_3	Y_4	Y_5	Y_6	Y_7	Z_1	
Assembly E	Process 41	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	0	0	0	0	n.a.	0
	Process 42	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	1	1	0	1	n.a.	3
	Process 43	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	1	0	n.a.	1
	Process 44	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	1	1	0	0	n.a.	2
	Process 45	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	2	0	2	1	n.a.	5
	Process 46	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	1	1	1	2	n.a.	5
	Process 47	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	1	1	0	0	n.a.	2
	Process 48	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	0	0	0	1	n.a.	1
	Process 49	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	0	0	n.a.	n.a.	n.a.	0
	Process 50	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	1	0	1	1	n.a.	3
Assembly F	Process 51	4	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	4
	Process 52	2	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	2
	Process 53	11	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	11
	Process 54	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	0
	Process 55	2	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	2
	Process 56	2	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	2
	Process 57	3	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	3
	Process 58	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	0
	Process 59	1	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	1
Total Open Points EWAK Assembly per Plant		48	39	30	43	38	37	30	20	26	29	33	22	395
Testing	Process 60	2	1	2	0	1	0	1	1	0	1	0	1	10
	Process 61	1	1	1	0	1	1	1	1	0	0	1	2	10
	Process 62	0	0	0	0	1	0	0	0	1	0	1	1	4
	Process 63	0	0	1	1	0	0	0	1	0	0	1	1	5
	Process 64	4	4	3	4	4	3	4	2	3	2	3	3	39
	Process 65	1	0	1	1	1	0	0	1	0	0	2	0	7
	Process 66	2	1	0	0	0	1	1	0	0	1	1	1	8
	Process 67	1	1	0	1	1	1	1	0	1	0	1	1	9
	Process 68	0	1	0	0	0	0	0	1	0	1	0	1	4
	Process 69	1	2	1	0	1	1	1	2	4	1	4	0	18
	Process 70	0	1	0	0	1	0	0	1	0	0	0	0	3
	Process 71	0	1	0	2	1	1	1	0	0	0	1	1	8
Total Open Points EWAK Testing per Plant		12	13	9	9	12	8	10	10	9	6	15	12	125
Total Open Points EWAK Assembly + Testing		60	52	39	52	50	45	40	30	35	35	48	34	520

		PgP1												Total Open Points EWAK per Process
		X_1	X_2	X_3	X_4	Y_1	Y_2	Y_3	Y_4	Y_5	Y_6	Y_7	Z_1	
Assembly A	Process 1	1	0	0	1	0	2	0	1	0	1	2	1	9
	Process 2	0	n.a.	0	1	1	2	0	n.a.	0	1	2	1	8
	Process 3	0	3	0	0	0	0	1	1	3	0	1	2	11
	Process 4	2	1	1	2	1	1	1	1	2	0	0	1	13
	Process 5	1	1	0	0	1	2	1	0	1	1	2	1	11
	Process 6	1	0	1	0	0	1	1	1	0	1	0	1	7
	Process 7	0	0	0	1	1	1	0	1	1	1	0	1	7
Assembly B	Process 8	n.a.	n.a.	0	n.a.	1	n.a.	1	n.a.	n.a.	1	0	n.a.	3
	Process 9	n.a.	n.a.	1	n.a.	1	n.a.	2	n.a.	n.a.	0	0	n.a.	4
	Process 10	n.a.	n.a.	0	n.a.	0	n.a.	0	n.a.	n.a.	0	0	n.a.	0
	Process 11	n.a.	n.a.	0	n.a.	0	n.a.	0	n.a.	n.a.	1	1	n.a.	2
Assembly C	Process 12	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	0
	Process 13	1	2	0	1	1	2	0	2	1	0	2	1	13
	Process 14	2	1	4	2	4	5	1	3	3	3	3	2	33
	Process 15	1	n.a.	n.a.	3	4	4	n.a.	n.a.	2	1	1	1	17
	Process 16	4	n.a.	n.a.	2	2	1	n.a.	n.a.	1	0	1	5	16
	Process 17	4	n.a.	n.a.	0	1	1	3	n.a.	1	2	2	3	17
	Process 18	1	n.a.	0	1	3	1	2	n.a.	1	3	2	1	15
	Process 19	n.a.	n.a.	n.a.	1	2	2	n.a.	n.a.	0	1	1	n.a.	7
	Process 20	n.a.	n.a.	n.a.	4	1	n.a.	n.a.	n.a.	2	1	1	n.a.	9
	Process 21	n.a.	n.a.	n.a.	1	0	0	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	1
	Process 22	n.a.	n.a.	n.a.	1	1	n.a.	n.a.	n.a.	1	2	1	n.a.	6
	Process 23	n.a.	n.a.	2	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	1	3
	Process 24	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	2	n.a.	n.a.	n.a.	n.a.	n.a.	2
	Process 25	0	n.a.	2	n.a.	n.a.	n.a.	0	n.a.	n.a.	n.a.	n.a.	0	2
	Process 26	n.a.	1	n.a.	0	0	0	n.a.	1	0	0	0	n.a.	2
	Process 27	2	1	1	4	0	0	3	1	2	1	2	0	17
	Process 28	3	2	1	1	1	0	1	1	1	3	3	0	17
	Process 29	n.a.	1	n.a.	n.a.	n.a.	n.a.	n.a.	0	n.a.	n.a.	n.a.	n.a.	1
Assembly D	Process 30	n.a.	1	2	1	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	4
	Process 31	n.a.	7	3	4	3	2	2	n.a.	n.a.	n.a.	n.a.	n.a.	21
	Process 32	n.a.	3	2	2	n.a.	2	2	n.a.	n.a.	n.a.	n.a.	n.a.	11
	Process 33	n.a.	n.a.	n.a.	n.a.	0	n.a.	0	n.a.	n.a.	n.a.	n.a.	n.a.	0
	Process 34	n.a.	3	1	2	2	2	1	n.a.	n.a.	n.a.	n.a.	n.a.	11
	Process 35	n.a.	4	3	3	4	1	1	n.a.	n.a.	n.a.	n.a.	n.a.	16
	Process 36	n.a.	3	2	2	1	1	2	n.a.	n.a.	n.a.	n.a.	n.a.	11
	Process 37	n.a.	3	2	1	0	2	2	n.a.	n.a.	n.a.	n.a.	n.a.	10
	Process 38	n.a.	1	n.a.	0	0	1	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	2
	Process 39	n.a.	0	0	1	n.a.	0	0	n.a.	n.a.	n.a.	n.a.	n.a.	1
	Process 40	n.a.	1	2	1	2	1	1	n.a.	n.a.	n.a.	n.a.	n.a.	8

ANNEX XI – TOTAL OPEN POINTS OF EWAK FROM BRGP

		BrgP												Total Open Points EWAK per Process
		X_1	X_2	X_3	X_4	Y_1	Y_2	Y_3	Y_4	Y_5	Y_6	Y_7	Z_1	
Assembly A	Process 1	1	1	0	1	0	3	0	n.a.	n.a.	n.a.	n.a.	1	7
	Process 2	1	n.a.	0	1	2	2	0	n.a.	n.a.	n.a.	n.a.	1	7
	Process 3	0	2	0	0	0	0	1	n.a.	n.a.	n.a.	n.a.	1	4
	Process 4	2	1	1	2	1	1	1	n.a.	n.a.	n.a.	n.a.	1	10
	Process 5	1	1	0	0	1	1	1	n.a.	n.a.	n.a.	n.a.	0	5
	Process 6	0	0	1	0	0	1	1	n.a.	n.a.	n.a.	n.a.	1	4
	Process 7	0	0	0	1	1	1	0	n.a.	n.a.	n.a.	n.a.	1	4
Assembly B	Process 8	n.a.	n.a.	0	n.a.	1	n.a.	1	n.a.	n.a.	n.a.	n.a.	n.a.	2
	Process 9	n.a.	n.a.	1	n.a.	0	n.a.	2	n.a.	n.a.	n.a.	n.a.	n.a.	3
	Process 10	n.a.	n.a.	0	n.a.	0	n.a.	0	n.a.	n.a.	n.a.	n.a.	n.a.	0
	Process 11	n.a.	n.a.	0	n.a.	0	n.a.	0	n.a.	n.a.	n.a.	n.a.	n.a.	0
Assembly C	Process 12	n.a.	n.a.	1	1	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	2
	Process 13	1	1	1	1	0	1	0	n.a.	n.a.	n.a.	n.a.	1	6
	Process 14	2	1	5	3	5	1	1	n.a.	n.a.	n.a.	n.a.	1	19
	Process 15	1	n.a.	n.a.	3	4	4	n.a.	n.a.	n.a.	n.a.	n.a.	1	13
	Process 16	5	n.a.	n.a.	2	2	1	n.a.	n.a.	n.a.	n.a.	n.a.	5	15
	Process 17	3	n.a.	n.a.	0	1	2	3	n.a.	n.a.	n.a.	n.a.	3	12
	Process 18	1	n.a.	0	1	3	1	1	n.a.	n.a.	n.a.	n.a.	1	8
	Process 19	n.a.	n.a.	n.a.	1	3	1	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	5
	Process 20	n.a.	n.a.	n.a.	3	1	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	4
	Process 21	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	0
	Process 22	n.a.	n.a.	n.a.	1	1	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	2
	Process 23	n.a.	n.a.	1	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	1	2
	Process 24	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	1	n.a.	n.a.	n.a.	n.a.	n.a.	1
	Process 25	0	n.a.	2	n.a.	n.a.	n.a.	1	n.a.	n.a.	n.a.	n.a.	1	4
	Process 26	n.a.	1	n.a.	0	0	0	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	1
	Process 27	2	1	3	5	0	0	4	n.a.	n.a.	n.a.	n.a.	0	15
	Process 28	3	2	1	0	1	0	1	n.a.	n.a.	n.a.	n.a.	0	8
	Process 29	n.a.	0	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	0
Assembly D	Process 30	n.a.	1	n.a.	1	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	2
	Process 31	n.a.	5	n.a.	4	2	2	2	n.a.	n.a.	n.a.	n.a.	n.a.	15
	Process 32	n.a.	3	n.a.	2	n.a.	2	2	n.a.	n.a.	n.a.	n.a.	n.a.	9
	Process 33	n.a.	n.a.	n.a.	n.a.	0	n.a.	0	n.a.	n.a.	n.a.	n.a.	n.a.	0
	Process 34	n.a.	2	n.a.	2	2	2	1	n.a.	n.a.	n.a.	n.a.	n.a.	9
	Process 35	n.a.	4	n.a.	3	3	1	1	n.a.	n.a.	n.a.	n.a.	n.a.	12
	Process 36	n.a.	2	n.a.	2	1	1	1	n.a.	n.a.	n.a.	n.a.	n.a.	7
	Process 37	n.a.	2	n.a.	2	1	2	3	n.a.	n.a.	n.a.	n.a.	n.a.	10
	Process 38	n.a.	0	n.a.	0	0	1	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	1
	Process 39	n.a.	0	n.a.	1	n.a.	0	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	1
	Process 40	n.a.	1	n.a.	1	1	1	0	n.a.	n.a.	n.a.	n.a.	n.a.	4

		BrgP												Total Open Points EWAK per Process
		X_1	X_2	X_3	X_4	Y_1	Y_2	Y_3	Y_4	Y_5	Y_6	Y_7	Z_1	
Assembly E	Process 41	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	0
	Process 42	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	0
	Process 43	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	0
	Process 44	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	0
	Process 45	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	0
	Process 46	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	0
	Process 47	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	0
	Process 48	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	0
	Process 49	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	0
	Process 50	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	0
Assembly F	Process 51	3	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	3
	Process 52	1	n.a.	0	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	1
	Process 53	11	n.a.	6	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	17
	Process 54	n.a.	n.a.	1	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	1
	Process 55	1	n.a.	1	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	2
	Process 56	3	n.a.	1	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	4
	Process 57	3	n.a.	2	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	5
	Process 58	n.a.	n.a.	1	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	1
	Process 59	1	n.a.	0	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	1
Total Open Points EWAK Assembly per Plant		46	31	29	44	37	32	29	0	0	0	0	20	268
Testing	Process 60	1	1	2	0	1	0	1	n.a.	n.a.	n.a.	n.a.	0	6
	Process 61	1	1	2	0	2	0	1	n.a.	n.a.	n.a.	n.a.	1	8
	Process 62	0	0	0	0	1	1	0	n.a.	n.a.	n.a.	n.a.	0	2
	Process 63	0	0	1	1	0	0	0	n.a.	n.a.	n.a.	n.a.	1	3
	Process 64	5	5	3	4	4	3	5	n.a.	n.a.	n.a.	n.a.	3	32
	Process 65	1	0	1	1	1	0	0	n.a.	n.a.	n.a.	n.a.	0	4
	Process 66	2	1	1	0	0	1	1	n.a.	n.a.	n.a.	n.a.	1	7
	Process 67	1	1	0	1	1	1	1	n.a.	n.a.	n.a.	n.a.	1	7
	Process 68	0	1	2	0	0	0	0	n.a.	n.a.	n.a.	n.a.	1	4
	Process 69	0	2	1	2	2	1	0	n.a.	n.a.	n.a.	n.a.	0	8
	Process 70	0	1	0	0	1	0	0	n.a.	n.a.	n.a.	n.a.	0	2
	Process 71	1	1	1	1	1	1	1	n.a.	n.a.	n.a.	n.a.	1	8
Total Open Points EWAK Testing per Plant		12	14	14	10	14	8	10	0	0	0	0	9	91
Total Open Points EWAK Assembly + Testing		58	45	43	54	51	40	39	0	0	0	0	29	359

Annex XII – Total Open Points of EWAK from WhuP

		WhuP												Total Open Points EWAK per Process
		X_1	X_2	X_3	X_4	Y_1	Y_2	Y_3	Y_4	Y_5	Y_6	Y_7	Z_1	
Assembly A	Process 1	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	0
	Process 2	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	0
	Process 3	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	0
	Process 4	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	0
	Process 5	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	0
	Process 6	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	0
	Process 7	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	0
Assembly B	Process 8	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	0
	Process 9	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	0
	Process 10	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	0
	Process 11	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	0
Assembly C	Process 12	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	0
	Process 13	1	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	1
	Process 14	2	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	2
	Process 15	1	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	1
	Process 16	5	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	5
	Process 17	3	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	3
	Process 18	2	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	2
	Process 19	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	0
	Process 20	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	0
	Process 21	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	0
	Process 22	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	0
	Process 23	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	0
	Process 24	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	0
	Process 25	0	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	0
	Process 26	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	0
	Process 27	2	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	2
	Process 28	3	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	3
	Process 29	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	0
Assembly D	Process 30	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	0
	Process 31	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	0
	Process 32	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	0
	Process 33	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	0
	Process 34	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	0
	Process 35	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	0
	Process 36	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	0
	Process 37	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	0
	Process 38	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	0
	Process 39	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	0
	Process 40	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	0

		WhuP												Total Open Points EWAK per Process
		X_1	X_2	X_3	X_4	Y_1	Y_2	Y_3	Y_4	Y_5	Y_6	Y_7	Z_1	
Assembly E	Process 41	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	0
	Process 42	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	0
	Process 43	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	0
	Process 44	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	0
	Process 45	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	0
	Process 46	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	0
	Process 47	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	0
	Process 48	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	0
	Process 49	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	0
	Process 50	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	0
Assembly F	Process 51	4	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	4
	Process 52	2	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	2
	Process 53	11	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	11
	Process 54	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	0
	Process 55	2	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	2
	Process 56	2	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	2
	Process 57	2	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	2
	Process 58	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	0
	Process 59	1	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	1
Total Open Points EWAK Assembly per Plant		43	0	0	0	0	0	0	0	0	0	0	0	43
Testing	Process 60	2	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	2
	Process 61	1	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	1
	Process 62	0	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	0
	Process 63	0	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	0
	Process 64	5	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	5
	Process 65	1	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	1
	Process 66	1	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	1
	Process 67	1	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	1
	Process 68	0	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	0
	Process 69	1	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	1
	Process 70	0	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	0
	Process 71	1	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	1
Total Open Points EWAK Testing per Plant		13	0	0	0	0	0	0	0	0	0	0	0	13
Total Open Points EWAK Assembly + Testing		56	0	0	0	0	0	0	0	0	0	0	0	56

ANNEX XIII – DEGREE OF STANDARDIZATION OF MAE

		Assembly MAE			
		PgP1	BrgP	WhuP	Degree of Standardization
Assembly A	Process 1	100%	75%	n.a.	88%
	Process 2	100%	100%	n.a.	100%
	Process 3	100%	75%	n.a.	88%
	Process 4	100%	100%	n.a.	100%
	Process 5	100%	100%	n.a.	100%
	Process 6	100%	100%	n.a.	100%
	Process 7	100%	100%	n.a.	100%
Assembly B	Process 8	100%	100%	n.a.	100%
	Process 9	100%	100%	n.a.	100%
	Process 10	100%	100%	n.a.	100%
	Process 11	100%	100%	n.a.	100%
Assembly C	Process 12	n.a.	100%	n.a.	100%
	Process 13	100%	100%	100%	100%
	Process 14	75%	75%	75%	75%
	Process 15	75%	75%	75%	75%
	Process 16	75%	75%	75%	75%
	Process 17	75%	100%	100%	92%
	Process 18	75%	75%	75%	75%
	Process 19	100%	100%	n.a.	100%
	Process 20	100%	100%	n.a.	100%
	Process 21	100%	100%	n.a.	100%
	Process 22	100%	n.a.	n.a.	100%
	Process 23	100%	100%	n.a.	100%
	Process 24	100%	100%	n.a.	100%
	Process 25	100%	100%	100%	100%
	Process 26	100%	100%	n.a.	100%
	Process 27	75%	100%	100%	92%
	Process 28	75%	100%	100%	92%
	Process 29	75%	100%	n.a.	88%
Assembly D	Process 30	100%	100%	n.a.	100%
	Process 31	50%	75%	n.a.	63%
	Process 32	75%	75%	n.a.	75%
	Process 33	100%	100%	n.a.	100%
	Process 34	50%	75%	n.a.	63%
	Process 35	50%	50%	n.a.	50%
	Process 36	100%	100%	n.a.	100%
	Process 37	50%	75%	n.a.	63%
	Process 38	100%	100%	n.a.	100%
	Process 39	100%	100%	n.a.	100%
	Process 40	75%	75%	n.a.	75%

		Assembly MAE			
		PgP1	BrgP	WhuP	Degree of Standardization
Assembly E	Process 41	100%	n.a.	n.a.	100%
	Process 42	100%	n.a.	n.a.	100%
	Process 43	100%	n.a.	n.a.	100%
	Process 44	100%	n.a.	n.a.	100%
	Process 45	100%	n.a.	n.a.	100%
	Process 46	100%	n.a.	n.a.	100%
	Process 47	100%	n.a.	n.a.	100%
	Process 48	100%	n.a.	n.a.	100%
	Process 49	100%	n.a.	n.a.	100%
	Process 50	100%	n.a.	n.a.	100%
Assembly F	Process 51	75%	100%	100%	92%
	Process 52	100%	100%	100%	100%
	Process 53	50%	50%	50%	50%
	Process 54	n.a.	100%	n.a.	100%
	Process 55	100%	100%	100%	100%
	Process 56	100%	100%	100%	100%
	Process 57	50%	75%	50%	58%
	Process 58	n.a.	75%	n.a.	75%
	Process 59	50%	50%	50%	50%
MAE average Assembly		89%	90%	84%	88%

		Testing MAE			
		Plant A	Plant B	Plant C	Degree of Standardization
Testing	Process 60	100%	100%	100%	100%
	Process 61	100%	100%	100%	100%
	Process 62	100%	75%	100%	92%
	Process 63	100%	100%	100%	100%
	Process 64	75%	75%	75%	75%
	Process 65	100%	100%	100%	100%
	Process 66	100%	100%	100%	100%
	Process 67	100%	75%	100%	92%
	Process 68	100%	100%	75%	92%
	Process 69	100%	100%	100%	100%
	Process 70	100%	100%	100%	100%
	Process 71	100%	100%	100%	100%
MAE average Testing		98%	94%	96%	96%

	Plant A	Plant B	Plant C	Degree of Standardization
Total MAE average	93%	92%	90%	92%

Annex XIV – Degree of Standardization of EWAK from PgP1

		PgP1											
		X_1	X_2	X_3	X_4	Y_1	Y_2	Y_3	Y_4	Y_5	Y_6	Y_7	Z_1
Assembly A	Process 1	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
	Process 2	100%	n.a.	100%	100%	100%	100%	100%	n.a.	100%	100%	100%	100%
	Process 3	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
	Process 4	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
	Process 5	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
	Process 6	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
	Process 7	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Assembly B	Process 8	n.a.	n.a.	100%	n.a.	100%	n.a.	100%	n.a.	n.a.	100%	100%	n.a.
	Process 9	n.a.	n.a.	100%	n.a.	100%	n.a.	100%	n.a.	n.a.	100%	100%	n.a.
	Process 10	n.a.	n.a.	100%	n.a.	100%	n.a.	100%	n.a.	n.a.	100%	100%	n.a.
	Process 11	n.a.	n.a.	100%	n.a.	100%	n.a.	100%	n.a.	n.a.	100%	100%	n.a.
Assembly C	Process 12	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 13	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
	Process 14	100%	100%	75%	100%	75%	75%	100%	100%	100%	100%	100%	100%
	Process 15	100%	n.a.	n.a.	100%	75%	75%	n.a.	n.a.	100%	100%	100%	100%
	Process 16	75%	n.a.	n.a.	100%	100%	100%	n.a.	n.a.	100%	100%	100%	75%
	Process 17	75%	n.a.	n.a.	100%	100%	100%	100%	n.a.	100%	100%	100%	100%
	Process 18	100%	n.a.	100%	100%	100%	100%	100%	n.a.	100%	100%	100%	100%
	Process 19	n.a.	n.a.	n.a.	100%	100%	100%	n.a.	n.a.	100%	100%	100%	n.a.
	Process 20	n.a.	n.a.	n.a.	75%	100%	n.a.	n.a.	n.a.	100%	100%	100%	n.a.
	Process 21	n.a.	n.a.	n.a.	100%	100%	100%	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 22	n.a.	n.a.	n.a.	100%	100%	n.a.	n.a.	n.a.	100%	100%	100%	n.a.
	Process 23	n.a.	n.a.	100%	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	100%
	Process 24	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	100%	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 25	100%	n.a.	100%	n.a.	n.a.	n.a.	100%	n.a.	n.a.	n.a.	n.a.	100%
	Process 26	n.a.	100%	n.a.	100%	100%	100%	n.a.	100%	100%	100%	100%	n.a.
	Process 27	100%	100%	100%	75%	100%	100%	100%	100%	100%	100%	100%	100%
	Process 28	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
	Process 29	n.a.	100%	n.a.	n.a.	n.a.	n.a.	n.a.	100%	n.a.	n.a.	n.a.	n.a.
Assembly D	Process 30	n.a.	100%	100%	100%	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 31	n.a.	75%	100%	75%	100%	100%	100%	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 32	n.a.	100%	100%	100%	n.a.	100%	100%	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 33	n.a.	n.a.	n.a.	n.a.	100%	n.a.	100%	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 34	n.a.	100%	100%	100%	100%	100%	100%	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 35	n.a.	75%	100%	100%	75%	100%	100%	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 36	n.a.	100%	100%	100%	100%	100%	100%	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 37	n.a.	100%	100%	100%	100%	100%	100%	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 38	n.a.	100%	n.a.	100%	100%	100%	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 39	n.a.	100%	100%	100%	n.a.	100%	100%	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 40	n.a.	100%	100%	100%	100%	100%	100%	n.a.	n.a.	n.a.	n.a.	n.a.

		PgP1											
		X_1	X_2	X_3	X_4	Y_1	Y_2	Y_3	Y_4	Y_5	Y_6	Y_7	Z_1
Assembly E	Process 41	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	100%	100%	100%	100%	n.a.
	Process 42	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	100%	100%	100%	100%	n.a.
	Process 43	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	100%	100%	n.a.
	Process 44	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	100%	100%	100%	100%	n.a.
	Process 45	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	100%	100%	100%	100%	n.a.
	Process 46	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	100%	100%	100%	100%	n.a.
	Process 47	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	100%	100%	100%	100%	n.a.
	Process 48	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	100%	100%	100%	100%	n.a.
	Process 49	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	100%	100%	n.a.	n.a.	n.a.
	Process 50	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	100%	100%	100%	100%	n.a.
Assembly F	Process 51	75%	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 52	100%	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 53	50%	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 54	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 55	100%	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 56	100%	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 57	100%	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 58	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 59	100%	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
EWAK average Assembly		95%	98%	99%	98%	98%	98%	100%	100%	100%	100%	100%	99%

		PgP1											
		X_1	X_2	X_3	X_4	Y_1	Y_2	Y_3	Y_4	Y_5	Y_6	Y_7	Z_1
Testing	Process 60	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
	Process 61	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
	Process 62	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
	Process 63	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
	Process 64	75%	75%	100%	75%	75%	100%	75%	100%	100%	100%	100%	100%
	Process 65	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
	Process 66	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
	Process 67	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
	Process 68	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
	Process 69	100%	100%	100%	100%	100%	100%	100%	100%	75%	100%	75%	100%
	Process 70	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
	Process 71	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
EWAK average Testing		98%	98%	100%	98%	98%	100%	98%	100%	98%	100%	98%	100%

	PgP1											
	X_1	X_2	X_3	X_4	Y_1	Y_2	Y_3	Y_4	Y_5	Y_6	Y_7	Z_1
Total EWAK average	96%	98%	100%	98%	98%	99%	99%	100%	99%	100%	99%	99%

ANNEX XV – DEGREE OF STANDARDIZATION OF EWAK FROM BRGP

		BrgP											
		X_1	X_2	X_3	X_4	Y_1	Y_2	Y_3	Y_4	Y_5	Y_6	Y_7	Z_1
Assembly A	Process 1	100%	100%	100%	100%	100%	100%	100%	n.a.	n.a.	n.a.	n.a.	100%
	Process 2	100%	n.a.	100%	100%	100%	100%	100%	n.a.	n.a.	n.a.	n.a.	100%
	Process 3	100%	100%	100%	100%	100%	100%	100%	n.a.	n.a.	n.a.	n.a.	100%
	Process 4	100%	100%	100%	100%	100%	100%	100%	n.a.	n.a.	n.a.	n.a.	100%
	Process 5	100%	100%	100%	100%	100%	100%	100%	n.a.	n.a.	n.a.	n.a.	100%
	Process 6	100%	100%	100%	100%	100%	100%	100%	n.a.	n.a.	n.a.	n.a.	100%
	Process 7	100%	100%	100%	100%	100%	100%	100%	n.a.	n.a.	n.a.	n.a.	100%
Assembly B	Process 8	n.a.	n.a.	100%	n.a.	100%	n.a.	100%	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 9	n.a.	n.a.	100%	n.a.	100%	n.a.	100%	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 10	n.a.	n.a.	100%	n.a.	100%	n.a.	100%	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 11	n.a.	n.a.	100%	n.a.	100%	n.a.	100%	n.a.	n.a.	n.a.	n.a.	n.a.
Assembly C	Process 12	n.a.	n.a.	100%	100%	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 13	100%	100%	100%	100%	100%	100%	100%	n.a.	n.a.	n.a.	n.a.	100%
	Process 14	100%	100%	75%	100%	75%	100%	100%	n.a.	n.a.	n.a.	n.a.	100%
	Process 15	100%	n.a.	n.a.	100%	75%	75%	n.a.	n.a.	n.a.	n.a.	n.a.	100%
	Process 16	75%	n.a.	n.a.	100%	100%	100%	n.a.	n.a.	n.a.	n.a.	n.a.	75%
	Process 17	100%	n.a.	n.a.	100%	100%	100%	100%	n.a.	n.a.	n.a.	n.a.	100%
	Process 18	100%	n.a.	100%	100%	100%	100%	100%	n.a.	n.a.	n.a.	n.a.	100%
	Process 19	n.a.	n.a.	n.a.	100%	100%	100%	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 20	n.a.	n.a.	n.a.	100%	100%	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 21	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 22	n.a.	n.a.	n.a.	100%	100%	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 23	n.a.	n.a.	100%	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	100%
	Process 24	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	100%	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 25	100%	n.a.	100%	n.a.	n.a.	n.a.	100%	n.a.	n.a.	n.a.	n.a.	100%
	Process 26	n.a.	100%	n.a.	100%	100%	100%	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 27	100%	100%	100%	75%	100%	100%	75%	n.a.	n.a.	n.a.	n.a.	100%
	Process 28	100%	100%	100%	100%	100%	100%	100%	n.a.	n.a.	n.a.	n.a.	100%
	Process 29	n.a.	100%	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Assembly D	Process 30	n.a.	100%	n.a.	100%	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 31	n.a.	75%	n.a.	75%	100%	100%	100%	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 32	n.a.	100%	n.a.	100%	n.a.	100%	100%	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 33	n.a.	n.a.	n.a.	n.a.	100%	n.a.	100%	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 34	n.a.	100%	n.a.	100%	100%	100%	100%	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 35	n.a.	75%	n.a.	100%	100%	100%	100%	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 36	n.a.	100%	n.a.	100%	100%	100%	100%	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 37	n.a.	100%	n.a.	100%	100%	100%	100%	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 38	n.a.	100%	n.a.	100%	100%	100%	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 39	n.a.	100%	n.a.	100%	n.a.	100%	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 40	n.a.	100%	n.a.	100%	100%	100%	100%	n.a.	n.a.	n.a.	n.a.	n.a.

		BrgP											
		X_1	X_2	X_3	X_4	Y_1	Y_2	Y_3	Y_4	Y_5	Y_6	Y_7	Z_1
Assembly E	Process 41	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 42	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 43	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 44	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 45	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 46	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 47	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 48	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 49	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 50	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Assembly F	Process 51	100%	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 52	100%	n.a.	100%	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 53	50%	n.a.	75%	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 54	n.a.	n.a.	100%	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 55	100%	n.a.	100%	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 56	100%	n.a.	100%	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 57	100%	n.a.	100%	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 58	n.a.	n.a.	100%	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 59	100%	n.a.	100%	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
EWAK average Assembly		97%	98%	98%	98%	98%	99%	99%					99%

		BrgP											
		X_1	X_2	X_3	X_4	Y_1	Y_2	Y_3	Y_4	Y_5	Y_6	Y_7	Z_1
Testing	Process 60	100%	100%	100%	100%	100%	100%	100%	n.a.	n.a.	n.a.	n.a.	100%
	Process 61	100%	100%	100%	100%	100%	100%	100%	n.a.	n.a.	n.a.	n.a.	100%
	Process 62	100%	100%	100%	100%	100%	100%	100%	n.a.	n.a.	n.a.	n.a.	100%
	Process 63	100%	100%	100%	100%	100%	100%	100%	n.a.	n.a.	n.a.	n.a.	100%
	Process 64	75%	75%	100%	75%	75%	100%	100%	n.a.	n.a.	n.a.	n.a.	100%
	Process 65	100%	100%	100%	100%	100%	100%	100%	n.a.	n.a.	n.a.	n.a.	100%
	Process 66	100%	100%	100%	100%	100%	100%	100%	n.a.	n.a.	n.a.	n.a.	100%
	Process 67	100%	100%	100%	100%	100%	100%	100%	n.a.	n.a.	n.a.	n.a.	100%
	Process 68	100%	100%	100%	100%	100%	100%	100%	n.a.	n.a.	n.a.	n.a.	100%
	Process 69	100%	100%	100%	100%	100%	100%	100%	n.a.	n.a.	n.a.	n.a.	100%
	Process 70	100%	100%	100%	100%	100%	100%	100%	n.a.	n.a.	n.a.	n.a.	100%
	Process 71	100%	100%	100%	100%	100%	100%	100%	n.a.	n.a.	n.a.	n.a.	100%
EWAK average Testing		98%	98%	100%	98%	98%	100%	100%					100%

	BrgP											
	X_1	X_2	X_3	X_4	Y_1	Y_2	Y_3	Y_4	Y_5	Y_6	Y_7	Z_1
Total EWAK average	97%	98%	99%	98%	98%	100%	100%					99%

Annex XVI – Degree of Standardization of EWAK from WhuP

		WhuP											
		X_1	X_2	X_3	X_4	Y_1	Y_2	Y_3	Y_4	Y_5	Y_6	Y_7	Z_1
Assembly A	Process 1	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 2	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 3	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 4	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 5	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 6	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 7	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Assembly B	Process 8	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 9	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 10	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 11	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Assembly C	Process 12	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 13	100%	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 14	100%	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 15	100%	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 16	75%	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 17	100%	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 18	100%	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 19	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 20	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 21	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 22	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 23	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 24	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 25	100%	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 26	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 27	100%	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 28	100%	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 29	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Assembly D	Process 30	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 31	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 32	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 33	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 34	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 35	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 36	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 37	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 38	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 39	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 40	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.

		WhuP											
		X_1	X_2	X_3	X_4	Y_1	Y_2	Y_3	Y_4	Y_5	Y_6	Y_7	Z_1
Assembly E	Process 41	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 42	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 43	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 44	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 45	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 46	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 47	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 48	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 49	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 50	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Assembly F	Process 51	75%	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 52	100%	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 53	50%	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 54	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 55	100%	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 56	100%	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 57	100%	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 58	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 59	100%	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
EWAK average Assembly		94%											

		WhuP											
		X_1	X_2	X_3	X_4	Y_1	Y_2	Y_3	Y_4	Y_5	Y_6	Y_7	Z_1
Testing	Process 60	100%	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 61	100%	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 62	100%	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 63	100%	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 64	75%	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 65	100%	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 66	100%	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 67	100%	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 68	100%	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 69	100%	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 70	100%	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Process 71	100%	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
EWAK average Testing		98%											

	WhuP											
	X_1	X_2	X_3	X_4	Y_1	Y_2	Y_3	Y_4	Y_5	Y_6	Y_7	Z_1
Total EWAK average	96%											

ANNEX XVII – DEGREE OF STANDARDIZATION FROM ALL MANUFACTURING PLANTS

		Degree of Standardization											
		X_1	X_2	X_3	X_4	Y_1	Y_2	Y_3	Y_4	Y_5	Y_6	Y_7	Z_1
Assembly A	Process 1	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
	Process 2	100%		100%	100%	100%	100%	100%		100%	100%	100%	100%
	Process 3	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
	Process 4	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
	Process 5	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
	Process 6	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
	Process 7	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Assembly B	Process 8			100%		100%		100%			100%	100%	
	Process 9			100%		100%		100%			100%	100%	
	Process 10			100%		100%		100%			100%	100%	
	Process 11			100%		100%		100%			100%	100%	
Assembly C	Process 12			100%	100%								
	Process 13	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
	Process 14	100%	100%	75%	100%	75%	88%	100%	100%	100%	100%	100%	100%
	Process 15	100%			100%	75%	75%			100%	100%	100%	100%
	Process 16	75%			100%	100%	100%			100%	100%	100%	75%
	Process 17	92%			100%	100%	100%	100%		100%	100%	100%	100%
	Process 18	100%		100%	100%	100%	100%	100%		100%	100%	100%	100%
	Process 19				100%	100%	100%			100%	100%	100%	
	Process 20				88%	100%				100%	100%	100%	
	Process 21				100%	100%	100%						
	Process 22				100%	100%				100%	100%	100%	
	Process 23			100%									100%
	Process 24							100%					
	Process 25	100%		100%				100%					100%
	Process 26		100%		100%	100%	100%		100%	100%	100%	100%	
	Process 27	100%	100%	100%	75%	100%	100%	88%	100%	100%	100%	100%	100%
	Process 28	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
	Process 29		100%						100%				
Assembly D	Process 30		100%	100%	100%								
	Process 31		75%	100%	75%	100%	100%	100%					
	Process 32		100%	100%	100%		100%	100%					
	Process 33					100%		100%					
	Process 34		100%	100%	100%	100%	100%	100%					
	Process 35		75%	100%	100%	88%	100%	100%					
	Process 36		100%	100%	100%	100%	100%	100%					
	Process 37		100%	100%	100%	100%	100%	100%					
	Process 38		100%		100%	100%	100%						
	Process 39		100%	100%	100%		100%	100%					
	Process 40		100%	100%	100%	100%	100%	100%					

		Degree of Standardization											
		X_1	X_2	X_3	X_4	Y_1	Y_2	Y_3	Y_4	Y_5	Y_6	Y_7	Z_1
Assembly E	Process 41								100%	100%	100%	100%	
	Process 42								100%	100%	100%	100%	
	Process 43										100%	100%	
	Process 44								100%	100%	100%	100%	
	Process 45								100%	100%	100%	100%	
	Process 46								100%	100%	100%	100%	
	Process 47								100%	100%	100%	100%	
	Process 48								100%	100%	100%	100%	
	Process 49								100%	100%			
	Process 50								100%	100%	100%	100%	
Assembly F	Process 51	83%											
	Process 52	100%		100%									
	Process 53	50%		75%									
	Process 54			100%									
	Process 55	100%		100%									
	Process 56	100%		100%									
	Process 57	100%		100%									
	Process 58			100%									
	Process 59	100%		100%									
EWAK average Assembly		96%	98%	99%	98%	98%	99%	100%	100%	100%	100%	100%	99%

		Degree of Standardization											
		X_1	X_2	X_3	X_4	Y_1	Y_2	Y_3	Y_4	Y_5	Y_6	Y_7	Z_1
Testing	Process 60	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
	Process 61	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
	Process 62	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
	Process 63	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
	Process 64	75%	75%	100%	75%	75%	100%	88%	100%	100%	100%	100%	100%
	Process 65	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
	Process 66	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
	Process 67	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
	Process 68	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
	Process 69	100%	100%	100%	100%	100%	100%	100%	100%	75%	100%	75%	100%
	Process 70	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
	Process 71	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
EWAK average Testing		98%	98%	100%	98%	98%	100%	99%	100%	98%	100%	98%	100%

	Degree of Standardization											
	X_1	X_2	X_3	X_4	Y_1	Y_2	Y_3	Y_4	Y_5	Y_6	Y_7	Z_1
Total EWAK average	97%	98%	99%	98%	98%	99%	99%	100%	99%	100%	99%	99%