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IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE  
DEGREE OF DOCTOR OF PHILOSOPHY

# Organizational practices lean enterprises adopt to focus on value streams

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Universitat Politècnica de Catalunya (UPC)  
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Organizational practices lean enterprises use to focus on value streams  
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*"A ship in port is safe, but that's not what ships are built for"*

Grace Murray Hopper.



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## **ABSTRACT**

The purpose of this thesis is to investigate which practices lean enterprises adopt to focus on value streams. An exploratory case study of four plants is developed. The four plants have successfully performed a lean transformation with significant performance improvements, and belong respectively to Delphi Diesel Systems, Sogefi Filtration, a company within the furniture industry and Renault. The organizational practices associated with value stream focus identified are: (1) the establishment of organizational units based on value streams; (2) the use of a performance measurement system based on value streams, and (3) the adoption of a formal meeting system. These organizational practices were found in all four of the studied companies. The adoption of these practices was standard and consistent across the different organizational units within the studied plants. However, the application of the concepts strongly depended on the specific circumstances of the plants such as size, complexity and lean transformation maturity. This exploratory research provides a contribution in the fields of organizational practices involved in the transition to lean enterprise. Managerial implications consist of the possible application of the described practices to other cases and situations.

**Keywords-** Value stream, lean, performance measurement, meeting system, focus





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I would wish that the readers of this thesis will find their time reading enjoyable and well spent.

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Barcelona, May 2013

## About the author



I would like to give a short background on who I am, which in some ways has probably affected the work presented in this thesis. I am 29 years old. I grew up in Tarragona. I am Industrial Engineer- ETSEIB-UPC, Master in Manufacturing Management obtained at Linköping Institute of Technology (Sweden) and P.hD candidate in Business Administration at UPC. I was employed in Siemens Industrial Turbomachinery AB (Sweden) to complete my Master thesis with a research in the field of Six Sigma in service. The work was first published in an International Conference Proceeding and later in The Total Quality Management Journal. In 2008 I joined Delphi Diesel System, Sant Cugat and currently I am Lean Enterprise Manager, responsible of the lean transformation across all the functions. The topic of the thesis, *“organizational practices lean enterprises adopt to focus on value streams”* is central and has evolved over years within Delphi Diesel Systems S. L., where I have been actively involved in the plant transformation. My main interests are contemporary art, contemporary painting, photography, travelling (over thirty countries in four continents), sportive climbing, windsurfing, kite surfing and scuba diving.

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# 1- INTRODUCTION

This chapter starts with describing the background of the thesis. Afterwards the overall aim of the thesis, objectives and purpose are presented to the reader. The structure of the thesis is given as the last part of this chapter.

## **1.1. Introduction**

Lean management strategy has been widely adopted by manufacturing companies. It is broadly used, in particular, by the automobile industry to achieve high performance standards (Hines et al., 2004). A consequence of the decision to adopt lean management is the use of the tools and the implementation of the practices. A deeper adoption requires organizational changes, based in principles as waste reduction and customer focus (Womack and Jones, 1994). These concepts may surprise somebody who does not know the business world, who might ask himself how it can be possible that organizations do things that are not needed instead of doing things that are of the customers' interest. It is clear that, at least in general terms, this is not done on purpose. A job is done because it is thought to be useful, as we can deduce from the rationality of the persons involved. However, in complex value streams, the perceptions about what is needed and what will generate customer value are in some cases wrong (Zokaei and Hines, 2007). In fact, not needed activities do take place and often the needs of the final clients are not taken enough into account.

To avoid these situations, focusing on value streams has been considered to be a key success factor (e.g. Womack and Jones, 1994; Hines et al., 1998; Liker, 2004). In an outstanding precedent of this idea, Skinner (1974) proposed that manufacturing plants should focus on a limited, concise and manageable set of products, technologies, volumes and markets. More recently, Womack and Jones (1994) stated that different value creating activities can be performed together, but this effort will require a new

organizational model: the lean enterprise. According to Womack and Jones (1994), getting managers to think in terms of the value stream is the critical first step to achieving a lean enterprise. However, no research was found about the organizational practices lean enterprises adopt to obtain the value stream focus. This research addresses this shortcoming.

## **1.2. Research question and objectives**

The purpose of this paper is to perform an exploratory investigation about which practices lean enterprises adopt to focus on value streams with data collected from four plants that successfully performed a lean transformation. The key research question we aim to answer is:

*Which are the practices that lean enterprises adopt to focus on value streams?*

Exploratory research relies on theoretical concepts to guide the design and data collection (Yin, 2003). Based on the literature, three organizational practices associated with value stream focus were identified and adopted as a guide to focus the scope of the research:

- The establishment of organizational units based on the value streams, as mentioned by Womack and Jones (1994), Hines et al. (1998) and Liker (2004); to concentrate the efforts of the teams on

the value stream performance rather than performance of individual people or functions.

- The establishment of a performance measurement system based on value streams, as mentioned by Maskell and Kennedy (2007) and Liker (2004); to measure the most critical value stream factors (such as quality, delivery, flexibility and cost).
- The establishment of a formal meeting system (Maskell and Kennedy, 2007); to coordinate the monitoring of the value stream metrics which measure the performance of the teams at a group level. The objective is to prioritize the corrective actions and the continuous improvement planning with a value stream perspective.

### **1.3. Purpose**

#### **1.3.1. Theoretical contribution**

This research provides an exploratory contribution in the field of organizational practices involved in the transition to lean enterprise. Four case studies illustrate the commonality of the application of general concepts and the particular solutions adopted in each different case.

### 1.3.2. Industrial relevance

For the management community, this paper provides concepts and application examples that can be used in other real practical cases. The cases refer to plants with different sizes, sectors, complexity and lean transformation maturity. It shows that in the studied companies the described principles and practices led to improvements in terms of customer quality, delivery and operational cost.

### 1.3.3. Contributions included in this Thesis

- Article: Olivella, J. and Gregorio, R. (2013) “Organizational practices lean enterprises adopt to focus on value streams”. In second revision in an International Journal.
- Article: Olivella, J. and Gregorio, R. (2013) “A case study of an integrated manufacturing performance measurement- and meeting system” Submitted for publication. Accepted for publication after minor revisions at the Journal of Manufacturing and Technology Management.

### 1.3.4. Additional contributions not included in this Thesis

The following contributions are not included in this thesis but take part of the research work developed by the author during the period of elaboration of the thesis. They include conference contributions in the field of this thesis, as well as the working papers of the specific cases. Previous research

in the field of Six Sigma in Services includes a journal publication and a conference contribution.

- Conference contribution: Gregorio, R., Roquet, J. and Moreno, L. (2012). “From lean production to lean management.”, Barcelona Lean Summit, 2012 (Barcelona, Spain).
- Conference contribution: Gregorio, R., Forton, M. (2011), “IT support for Lean Manufacturing. The Delphi Diesel Systems case” Seminar Series on Innovation and Entrepreneurship. ETSETB-UPC (Barcelona, Spain)
- Article: Gregorio, R. and Cronemyr, P. (2011), “From Expectations and Needs of Service Customers to Control Chart Specification Limits.” The Total Quality Management Journal. 23,2
- Conference contribution: Gregorio, R., Roquet, J. and Voltes. A. (2009) . “Lean in Delphi Diesel Systems, Sant Cugat.”, Barcelona Lean Summit, 2009 (Barcelona, Spain).
- Conference contribution: Gregorio, R. and Cronemyr, P. (2008), ”Breaking the customer code: A new model to transform customer expectations into specification limits.” Proceedings of the 11th

international Quality Management and Organizational  
Development QMOD 2008 (Helsingborg, Sweden).

#### **1.4. Outline of the thesis**

The thesis begins with an introductory chapter, where the overall ideas behind the thesis are presented along with aims and research question. The second chapter describes the research methodology. This is followed by a chapter that presents the literature review that will be used in the case studies and discussion. The case studies are developed in chapter 4. Finally, chapter 5 gives the discussion, conclusions and reflections of the thesis and some views on future research.





## 2- RESEARCH METHODOLOGY

This part of the thesis introduces the approach that was chosen to pursue the research purpose, discussing methodology theory as well as the practical data collection.

As in all research, the results of the research project presented in this thesis rely on the appropriate usage of a research methodology. The method used, case study research approach, is described in detail. According to Yin (1994), three conditions for the selection of the research strategy consists of (a) the type of research question posed, (b) the extent of control over behavioural events, and (c) the degree of focus on contemporary as opposed to historical events. The following table displays these three conditions and shows how each is related to the five major research strategies: experiments, surveys, archival analyses, histories, and case studies (Yin, 1994). Yin states:

*“In general, case studies are the preferred strategy when ‘how’ and ‘why’ questions are being posed, when the investigator has little control over events, and when the focus is on a contemporary phenomenon within some real-life context”.*

(Yin, 1994)

<b><i>Strategy</i></b>	<b><i>Form of Research Question</i></b>	<b><i>Requires Control of Behavioral Events?</i></b>	<b><i>Focuses on Contemporary Events?</i></b>
Experiment	How, why?	Yes	Yes
Survey	Who, what, where, how many, how much?	No	Yes
Archival analysis	Who, what, where, how many, how much?	No	Yes/no
History	How, why?	No	No
Case study	How, why?	No	No

*Table 1. Relevant Situations for Different Research Strategies (Source: Yin, 1994)*

According to Voss *et. al.* (2002) case study research has consistently been one of the most powerful research methods in operations management, particularly in the development of a new theory. There are, however, also some weaknesses linked to case studies. Yin, (1994) identified three traditional prejudices against case studies.

The first one and perhaps the greatest concern have been over the lack of rigour of case study research. Reviewing the use of research methods in operations management, it has been suggested that the relative rarity of case research (when compared to quantitative investigation) is not driven by a methodical bias but by the poor rigour of much of the case research being conducted (Stuart *et al.*, 2002). To avoid these types of biases, the issues regarding validity and reliability become important.

The second common concern about case studies is that they provide little basis for scientific generalization. “How can you generalize from a single case?” is a frequently asked question (Yin, 1994).

The third frequent complaint about case studies is that they are too long and result in massive, unreadable documents (Yin, 1994). This is the same set of arguments used against most methods of qualitative research (Yin, 1994).

## **2.1. Case Study Design**

A research design is the logic that links the data to be collected (and the conclusions to be drawn) to the initial questions of study (Yin, 1994). In this thesis, we use the framework proposed by Yin (1994) with five components of research design that are important for case studies:

- A study's questions
- Its propositions, if any
- Its unit of analysis
- The logic linking the data and the propositions
- The criteria for interpreting the findings

### **2.1.1. Research Question and Propositions**

The first task is to clarify the nature of the study question. The form of the study question results in different types of case study research; these are descriptive, explanatory and exploratory case studies (Yin, 1994).

A *descriptive* case study is one that documents a particular action or series of actions. Thus, what is implied in this type of study is the formation of hypotheses of cause-effect relationships. Hence, the descriptive theory must cover the depth and scope of the case study.

In *exploratory* case studies, fieldwork and data collection may be undertaken prior to definition of the research questions and hypotheses.

However, the framework of the study has been considered as a prelude to some social research.

*Explanatory* case studies are used to pursue an explanatory purpose. The researcher's objective is to pose competing explanations for the same set of events and to indicate how these explanations may apply in other situations. In regard to the other types of case studies, the explanatory case study focuses on generating theories.

Deciding between the different descriptive, exploratory and explanatory designs is closely related to the richness of the related theories to the topic of the study (Yin, 1994). Since there was no previous empirical knowledge addressing the purpose of this thesis, it was considered best to prioritize the search for a deep and qualitative exploratory understanding of the phenomena under study.

The overall key research question we seek to answer is: *Which are the practices that lean enterprises adopt to focus on value streams?* The research propositions can be seen as a further detailed development of the research questions down to an operational level. The main differences between research questions and study propositions are that research questions are formulated according to a gap in theory, whereas the study propositions begin to tell you where to look for relevant evidence. For the exploratory case study, there is a limitation of the possibility to apply the more detailed study propositions mainly due to the lack of existing theory

with which to relate. Therefore, exploratory studies normally lack detailed study propositions (Yin, 1994). Due to the lack of validated knowledge this study lacks of detailed research questions and study propositions.

### 2.1.2. Selecting the Unit of Analysis

The unit of analysis refers to how the case is defined (Yin, 1994). The definition of the unit of analysis is related to the way the initial research question have been defined. The case may represent a single unit of analysis or include multiple or embedded unit of analysis representing subunits within the current case (Yin, 1994). The next figure illustrates the different types of case studies. Type 1 focuses on a single case, and has a single unit of analysis. Type 2 is an embedded single case study, in which the analysis of the case includes the outcome of the subunits. Type 3 involves multiple cases, which are analysed from a holistic viewpoint respectively. Type 4 focuses on the analysis of multiple cases through the outcome of subunits of analysis within each case.

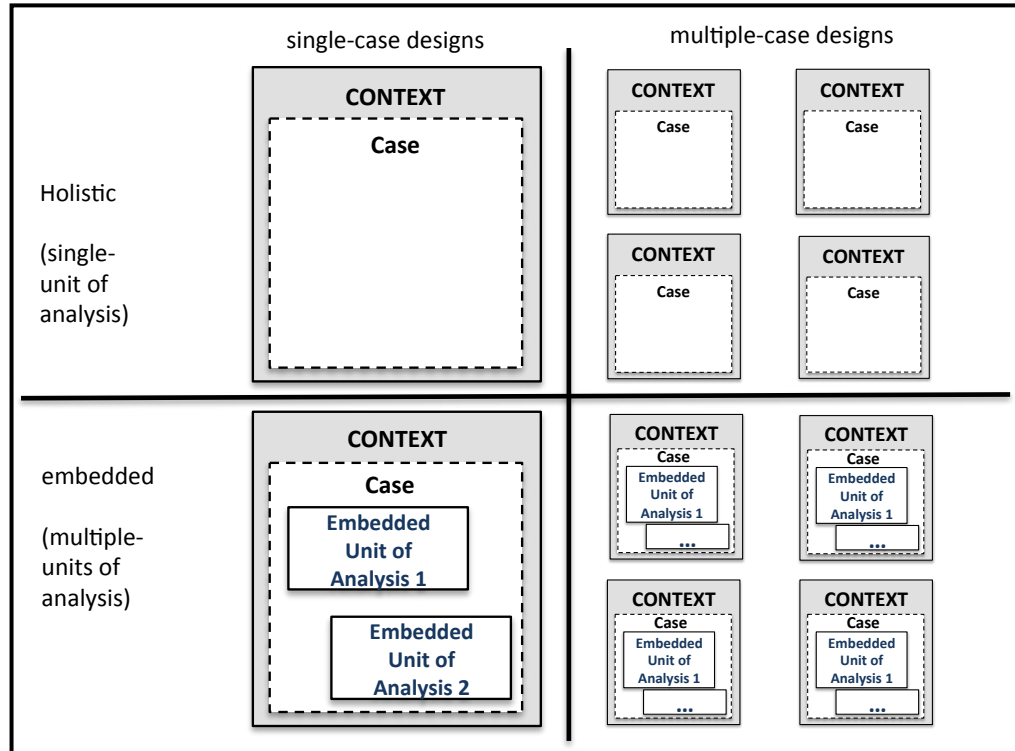


Figure 1- Basic types of designs of case studies (Source: Adapted from Yin, 1994)

According to Stake (1994) a single case provides the researcher with knowledge about that particular case, its complexities, and uniqueness. On the other hand, multiple cases provide the researcher with more compelling evidence, and thus the study is regarded as being more robust (Yin, 1994). A single case study is preferred when it represents a critical case in testing a well-formulated theory and enables the researcher to dig deeper into its complexity and uniqueness. In multiple case studies the underlying logic is based on replication. Each case has to be selected so that it either predicts similar results or produces contrasting results but for predictable reasons. The analysis is primarily concerned with comparisons between the cases.

A multiple exploratory and embedded case study design was selected in this thesis i.e. a Type 4 design. According to Piercy and Rich (2009), the use

of single or small numbers of case studies as knowledge building tools is increasing prevalent in the operations management literature. They mention as an example of that; (Hines *et. al.*, 2002; Strijbosch *et. al.*, 2002; Waring and Wainwright, 2002; Towers and McLoughlin, 2005; Acur and Englyst, 2006; Decoene and Bruggeman, 2006; Krishnamurthy and Yauch, 2007). Other examples quoted in the literature review are: (Choi and Liker, 1995; de Toni and Tonchia, 1996; de Leede and Looise, 1999; de Leede *et. al.*, 2002; Hines *et al.*, 2002; Ward and Graves 2004; McNair *et. al.*, 2006; Zokaei and Hines, 2007; Stenzel, 2007). A specific example of an exploratory case study addressing a limited number of cases can be found in Piercy and Rich (2009), published in the International Journal in Operations Management & Production Management. The authors perform an explanatory case study in three financial service companies in the UK with the purpose of assessing the suitability of lean production methodologies in pure service context.

The criteria for selecting each case company were driven by the research objectives rather than random sampling, as proposed by Yin (1994). To find appropriate companies for this specific case study, a background study was made with experts in the field. In the background study it was concluded that manufacturing plants would be the focus of the study because of their higher maturity levels in terms of lean manufacturing. This study is centred on data collected from Spanish manufacturing plants serving as original and aftermarket suppliers. The four companies selected successfully performed a lean transformation with significant performance improvements. In order to



minimize the cultural aspects, an important selection aspect was that the plants must work in a global or at least European perspective. Other factors also taken into account are, whether these characteristics are present in all the plants of the group and the number of years working with the concept, plant size and process complexity. The companies were selected from a range of different manufacturing sectors, plant sizes and process complexity with the aim to increase the external validity, that is, the possibility that the conclusions also apply in other manufacturing industry settings.

### 2.1.3. Interpreting the Findings

Qualitative research does rely on data collection methods that may be subject to biases such as researcher bias or over-reliance on one source. Utilizing triangulation will help increase research robustness (Patton, 1990). Triangulation is defined as occurring when data from multiple sources from different data collection methods support the same conclusion, or at least, do not contradict it (Huberman and Miles, 2002). Data was gathered from multiple sources, using three different data collection methods (observations, semi-structured interviews and company documentation). Interviews provide depth, subtlety, and personal feeling. Documents provide facts, but are subject to the dangers of selective survival. Direct observation gives access to group processes and can reveal the discrepancies between what is said and what is actually done (Pettigrew, 1990).

One important source of data for the case studies will be semi-structured interviews. The questions formulated for this type of studies are normally

open to give the respondents a chance to go into detail regarding the answers, i.e. the questions were prepared without any specific sequence or answering options (Jacobsen and Nilsson, 1993). The semi-structured interview questions were developed based on the literature reviewed to find answers to these research sub questions.

## **2.2. Research protocol**

To negate the possible effects of some of these biases the researcher must develop a documented, systematic approach to data collection to allow other researchers to assess potential bias. The reliability and validity of case research data is enhanced by a well-designed research protocol (Yin, 1994). The core of the protocol is the set of questions to be used in interviews (Voss *et. al.*, 2002). A well-designed protocol is particularly important to ensure a cross-comparative research study. The following steps are followed in order to pursue the research purpose through the selected methodology.

### 2.2.1. STEP 1- Selection of the cases

The following four companies were selected for this study according to the criteria described in the case study design section.

<i>Plant</i>	<i>Product</i>	<i>Plant size</i>	<i>Process complexity</i>	<i>Years</i>	<i>Main interviewee</i>
Sogefi filtration	Filters	Medium	Medium	From 2 to 5	Plant manager
Delphi Diesel Systems S.L.	Diesel injection pumps	Large	High	More than 10	Operations director
Plant X	Furniture	Medium	Medium	From 5 to 10	Lean manager
Valladolid engines	Engines	Large	High	More than 20	Lean manager

*Table 2. Selected companies for the study. (Source: own elaboration)*

In the preliminary interview with experts in the field it was found that these four case companies could be sufficient for this study, since they provide good in-depth knowledge to fulfil the purpose of the study. According to Voss *et. al.* (2002) the skill of “knowing when to stop” is important in theory building from case studies.

### 2.2.2. STEP 2- Preparation of the visits

Before the data collection began, a common set of semi-structured interview questions was prepared based on the literature review. The

questions were reviewed and given feedback on by experts in the field. Exploratory research relies on theoretical concepts to guide the design and data collection (Yin, 2003). The semi-structured interview questions were separated into six groups. Table 6 shows how the different interview questions are related to theoretical concepts.

The first sets of questions are focused on the description of the characteristics of the case. The second focuses on the description of the production system. The third set of questions addresses which kind of organizational structures that are used in order to adapt the organization to the value streams. The fourth set of questions focuses on the performance measurement system based on value streams. The fifth address the description the kind of measures used to measure value stream performance. The sixth set of questions focus on the description of the formal meeting system. Finally we address the discussion about the importance of the organizational elements to the lean transition.

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**1) Characteristics of the case**

- Company and plant overview
- Which are the different product lines and product groups manufactured in the plant (product structure)?
- Which is the relationship between processes and products (plant process flow diagrams)?

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**2) The production system**

- Lean timeline description (group and plant)
- Which is the lean focus description (tools and organizational)
- Is the lean focus common in the whole group?
- How is the information flow managed through the Value Streams?
- Which is the customer orders and plant process interaction? Which is the plant lead time?
- How is the material flow managed through the Value Streams?
- How is the operation flow managed through the Value Streams?

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*Table 3. First and second set of interview questions. (Source: own elaboration).*

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### **3) Organization units based on value streams**

#### **Description of the organization by Value Stream**

- Which is the plant organizational chart?
- How many layers of management?
- Description and timeline of the autonomous production units.
  - Which is the main criteria to separate the different units (product/customer segment, layout, manufacturing technology)?
  - Is there a VSM manager that is the ultimate responsible in front of the final client?
  - Are the functions totally integrated in the autonomous unit?

#### **Degree of autonomy of the different units**

- Do the units have a high degree of operational decision autonomy?
- Do the units follow plant/ divisional procedures and standards?
- Are the maximum number of resources assigned exclusively to the autonomous units?
- Which is the role of the central functions? Which is their interaction with the units?

#### **Internal interactions between units**

- How is the delimitation of the different units marked?
  - Is there a vendor- client relationship between autonomous production units?

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*Table 4. Third set of interview questions. (Source: own elaboration).*

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#### **4) Performance measurement system based on value streams**

##### **Organization of the indicators**

- Which is the organization of the indicators?

##### **The indicators provide accurate, timely and understandable data for decision making**

- Are the indicators visual for everybody and easy to understand?
- Is the frequency of the information related to the frequency of the process?
- Are the indicators communicated to the employees?

#### **5) Measures for value stream performance**

##### **Result indicators**

- Do the indicators measure mostly financial or non-financial performance?
- Description of the different indicators for the different layers.

##### **Process indicators**

- Which are the process indicators within the autonomous unit which guarantees the quality and stability of the process?
- Is there a vendor- client relationship within the autonomous unit processes?

---

#### **6) Formal meeting system**

- Which is the meetings structure for the different management levels?
- Which is the meetings structure in terms of frequency (daily, weekly, monthly...)?
- Which are the work standards of the teams within the autonomous units?
- How are the indicators used in the meetings?

---

#### **7) The importance of the organizational practices**

- Which are the benefits that you experienced of the lean implementation?
- Which are the benefits that you experienced in the development of the organizational practices within the lean transformation?
- Which are the results in terms of performance of the transformation?

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*Table 5. Fourth, fifth, sixth and seventh set of interview questions. (Source: own elaboration).*

<i>Interview questions</i>	3	4	5	6	7
<i>Main theoretical concept</i>	Plant within a plant The mini-company concept Value stream management	Performance measurement systems VSM costing	Performance measurement systems VSM costing	Value stream management Performance measurement systems	Value stream management

Table 6. Relationship between interview questions and main theoretical concepts. (Source: own elaboration)



### 2.2.3. STEP 3- Field work

Following the formulation of the questions, a pilot study was made to verify the validity and relevance of the questions. The selected pilot study was of SOGEFI filtration SA.

In each case, the interviews were focused on specific areas of the topic, and an individual interview was held on each of these topics. The length of the interviews and site visits varied from 3 to 6 hours, depending on how much information the interviewees were willing to contribute with. All the interviews were recorded to maintain the possibility for the researchers to review details if necessary, or in some cases quote phrases of the interviewee. The interviewees were plant managers, operations directors or lean managers. When developing the research protocol and instruments it is important to address triangulation (McCutcheon and Meredith, 1993). Data was also collected through direct observations made under the study visits to the companies and unstructured interviews with middle managers. We also collected documentation in form of photographs, brochures, company documents and information from the Internet (independent as well as provided from the case companies). All the interviews have been recorded to reduce the observer's biases.

### 2.2.4. STEP 4- Analysis and verification

The four individual case studies were organized with the same structure and were revised, corrected and accepted by the studied organizations. This

was done to reduce errors in the interpretation of the collected data. Single case study approaches cannot offer generalizability in the statistical sense (Yin, 1994). They are however capable of developing and refining generalizable concepts and frames of reference (Pettigrew, 1985). A thorough analysis of a single situation may lead to discovery of non-obvious relationships. An additional level of detail compensates the lack of generality in the single-case studies.

#### 2.2.5. STEP 5- Diffusion

The individual case studies were developed in single descriptive case studies in the form of working papers published as Universitat Politècnica de Catalunya working papers, to provide further knowledge regarding individual companies. One case study was further developed as an exploratory case study for production Journal (see appendix A). Secondly, the conclusions were written in one exploratory multiple case study in form of one article for production journal (see appendix B).

### **2.3. Validity and reliability of the research**

By describing how the research project was conducted, it is our intention that the reader shall be able to form his or her own opinion of the credibility of the study. There are different tactics testing the quality of case study research. Yin (1994) proposes four tests concerning the construct validity, internal validity, external validity, and reliability.

### 2.3.1. Construct validity

Refers to the operational measures that are used, and if they are representative for the concepts that are being studied (Yin, 1994). In the present research we have tried to increase the credibility of the findings by the use of the three techniques suggested by Yin, (1994) (see table 8). The first technique was the use of multiple sources of evidence. Table 9 details the different sources of evidence used together with its strengths and weaknesses. The second technique was to establish a chain of evidence. The research protocol has been thoroughly described and the logic of the link between the interview questions and theoretical concepts has been detailed. The working papers of the specific cases have citations to the different sources, by citing specific documents, interviews and observations. Finally the third technique to increase construct validity is the correction and acceptance of the case study reports by the studied organizations.

<i>Case Study Tactic</i>	<i>Phase of research in which tactic occurs</i>	<i>Use</i>
Use of multiple sources of evidence	Data collection	Used extensively
Establish chain of evidence	Data collection	Used extensively
Have key informants review draft case study report	Composition	Used extensively

*Table 7- Techniques for ensuring construct validity. (Source: Adapted from Yin, 1994).*

<b>Source of evidence</b>	<b>Documentation</b>	<b>Archival records</b>	<b>Interviews</b>	<b>Direct observations</b>	<b>Participant observation</b>	<b>Physical artifacts</b>
<b>Strengths</b>	stable – repeated review unobtrusive - exist prior to case study exact - names etc. broad coverage -extended time span	same as above precise and quantitative	targeted - focuses on case study topic insightful – provides perceived causal inferences	reality - covers events in real time contextual - covers event context	same as above above insightful into interpersonal behaviour	insightful into cultural features insightful into technical operations
<b>Weakness</b>	retrievability – difficult biased selectivity reporting bias - reflects author bias access - may be blocked	same as above privacy might inhibit access	bias due to poor questions response bias incomplete recollection reflexivity – interviewee expresses what interviewer wants to hear	time-consuming selectivity - might miss facts reflexivity - observer's presence might cause change cost - observers need time	same as above above bias due to investigator's actions	selectivity availability
<b>Use</b>	Used extensively	Used extensively	Used extensively	Used extensively	Not used	Not used

Table 8- Sources of evidence used in the research (Source: adapted form Yin, 1994).

### 2.3.2. Internal validity

Refers to establishing a causal relationship, whereby certain conditions are shown to lead to other conditions (for explanatory or causal studies only, and not for descriptive or exploratory studies) (Yin, 1994). Due to the exploratory nature of the study, techniques for increasing internal validity were not used.

<i>Case Study Tactic</i>	<i>Phase of research in which tactic occurs</i>	<i>Use</i>
Do pattern-matching	Data analysis	Not used
Do explanation building	Data analysis	Not used
Address rival explanations	Data analysis	Not used
Use logic models	Data analysis	Not used

*Table 9- Techniques for ensuring internal validity (Source: adapted from Yin, 1994)*

### 2.3.3. External validity

Relates to if a result of a study can be applied to circumstances outside the specific setting in which the research was carried out (Yin, 1994). Yin (1994) argues that case study research does not aim to contribute to a statistical generalisation (generalising from a sample to a universe), but to make analytical generalisation by generalising a particular set of results to some broader theory. Based on this statement, the analytical generalisation on case study findings may be enhanced by thoroughly describing how cases were selected with respect to a rich, theoretical framework and specify how typical this case is compared to prior studies (Yin, 1994). Yin (1994) proposes that each case have been selected so that it either a) predicts

similar results (a literal replication) or b) predicts contrasting results but for predictable reasons (a theoretical replication). The logic behind the selection of the different cases was done to increase external validity. The cases were selected on the basis to predict similar results (a literal replication in Yin's (1994) terms). The analytical generalisation of the results is supported by placing the results from the case studies into the context of other theories and research. This provides the basis for theory development.

<i>Case Study Tactic</i>	<i>Phase of research in which tactic occurs</i>	<i>Use</i>
Use theory in single-case studies	Research design	Not used
Use replication logic in multiple-case studies	Research design	Used extensively

*Table 10- Techniques for ensuring external validity (Source: adapted form Yin, 1994)*

#### 2.3.4. Reliability

Reliability relates to if a study can be repeated with the same results. The goal of reliability is to minimize the errors and biases in a study (Yin, 1994). We aim to increase reliability i.e. the ability for other researchers to repeat the study in the future, by thoughtfully describing the specific steps of the research protocol, the methods used and the presentation of the semi-structured interview questions. The critical pieces of evidence have been presented in the working papers. Other sources of information have been referenced. The sources of information such as interview transcripts have been organized in a database.

<i>Case Study Tactic</i>	<i>Phase of research in which tactic occurs</i>	<i>Use</i>
Use case study protocol	Data collection	Used extensively
Develop case study database	Data collection	Used extensively

*Table 11- Techniques for ensuring reliability (Adapted from Yin, 1994)*





### 3- LITERATURE REVIEW

A literature review was made in order to study the state of the art of the topic under study. A search of research papers and conceptual papers was done. Research was also made in books, journals and conference proceedings.

*“There is nothing so practical as a good theory”*

Kurt Lewin (1890-1947)

### **3.1. Lean manufacturing**

John Krafcik, first employed the word “Lean” to describe the production techniques introduced by Taiichi Ohno at Toyota after World War II. He was studying developments in the automobile industry as part of the MIT International Motor Vehicle Programme. The work was published in the book *The Machine that Changed the World* (Womack *et. al.*, 1990). Womack and Jones (1996) identified five lean principles to guide organisations in all sectors of the economy, including service, in lean transformation (Womack and Jones, 1996):

- (1) Value. Determine what it is customers value (specifically, what they are prepared to pay for) in the product or service.
- (2) The value stream. Map out (with a process or value stream map), how value is delivered. Use this as a basis for eliminating any area that does not add value.
- (3) Flow. Ensure products and information seamlessly flow from start to finish of the value stream. Remove inventory or buffer zone with the use of structural enablers such as modular designs, cellular working, general purpose machines, multi-skilled workers.
- (4) Pull. Only deliver what is actually demanded (pulled) by the customer rather than serving from stocks or buffers.

(5) Perfection. Continually seek to improve the processes and systems with the above principles, striving for perfection.

Lean management strategy has been widely adopted by manufacturing companies. It is broadly used, in particular, by the automobile industry to achieve high performance standards (Hines *et. al.*, 2004). Yet despite its pre-eminence, the lean production model and the research that informed it, raise a number of theoretical and methodological concerns (Williams and Haslam, 1992). Pettersen (2009) conducted a literature review in search of the definition of lean production based on 12 articles and 13 books and concluded that lean production is not clearly defined in the reviewed literature: (Krafcik, 1988; Oliver *et. al.*, 1996; Sánchez and Pérez, 2001 ; Lewis, 2000 ; Mumford, 1994; James-Moore and Gibbons, 1997 ; MacDuffie *et. al.*, 1996 ; Dankbaar, 1997; Chong *et al.*, 2001; Hayes and Pisano, 1994; Jagdev and Browne, 1998; Cusumano, 1994). Books: (Womack *et. al.*, 1990; Womack and Jones, 2005; Bicheno, 2004; Ōno, 1988; Monden, 1998; Liker, 2004; Feld, 2000; Dennis, 2002; Schonberger, 1982; Shingo *et. al.*, 1989; Rother and Shook, 2003; Jones and Womack, 2002; Smalley, 2004).

According to Hines *et. al.* (2004) lean is constantly evolving, implying that any “definition” of the concept will only be a “still image” of a moving target, only being valid in a certain point in time. The authors summarize the Lean evolution as a focus on quality (during the literature of early 1990s), through quality, cost and delivery (late 1990s), to customer value from 2000

onwards (Hines *et. al.* 2004). Hines *et. al.* (2004) concludes that Lean had moved away from a merely “shop-floor-focus” on waste and cost reduction, to an approach that contingently sought to enhance value (or perceived value) to customers by adding product or service features and/or removing wasteful activities.

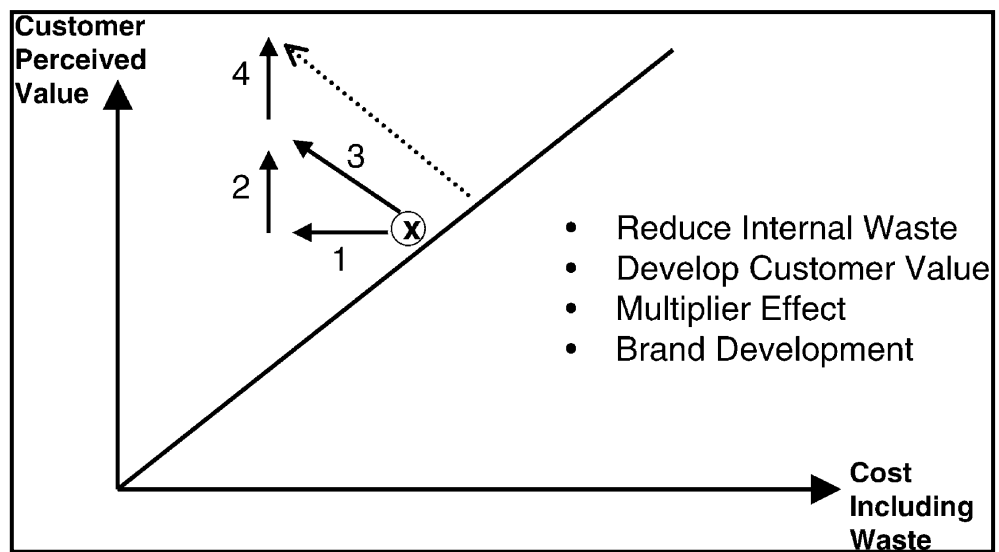


Figure 2. Relation of value, cost and waste. (Source: Hines, 2004)

Hines *et. al.*, (2004) found that the distinction of lean thinking at the strategic level, and lean production at the operational level is crucial to understanding lean as a whole in order to apply the right tools and strategies to provide customer value.

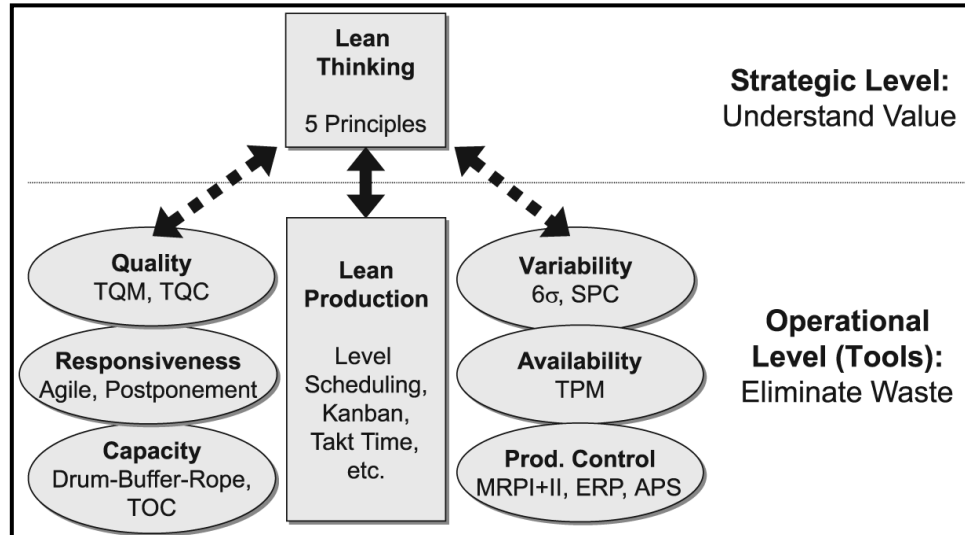


Figure 3 Lean- A framework. (Source: Hines et. al, 2004)

Pettersen (2009) state that through adapting and combining the two approaches to lean suggested by Hines *et al.* (2004) (strategic and operational) and the two suggested by Shah and Ward (2007) (philosophical and practical) respectively, lean can be characterized in four different definable approaches.

“The term ostensive signifies a shift of focus from general philosophy towards issues that can only be defined by examples, whereas performative and practical focus on the things that are done. The term discrete signifies a focus on isolated events, such as individual improvement projects using the “lean toolbox” (see Bicheno, 2004; Nicholas and Soni, 2006), or the final state of “leanness” (see Krafcik, 1988). As a contrast, the term continuous signifies a process oriented perspective, focusing on the continuous efforts; the philosophy of “lean thinking” or “the Toyota way” (see Womack and Jones, 2003; Liker, 2004) or the process of “becoming lean” (see Liker, 1998; Karlsson and Ahlström, 1996)” Pettersen 2009.

	<i>Discrete (Operational)</i>	<i>Continuous (Strategic)</i>
Ostensive (Philosophical)	Leanness	Lean thinking
Performative (Practical)	Toolbox lean	Becoming lean

*Table 12- An illustration of the four definable approaches to lean production (Source: Pettersen, 2009)*

Following the framework suggested by Pettersen (2009) (see table above) this thesis investigates the definable approach to lean production of the “Process of becoming lean” (Practical and Strategic). As stated in the introduction, the purpose of this thesis is to investigate, with data collected from four plants that successfully performed a transformation, which practices lean enterprises adopt to focus on value streams. The organizational practices under analysis are: (1) the establishment of organizational units based on value streams; (2) the use of a performance measurement system based on value streams, and (3) the adoption of a formal meeting system. In overall, we aim to gain insights about the significance of these practices for the transition to lean enterprise.

In the next sections the literature review is centered on the topics of organizational focus, value stream management, performance measurement and meeting systems.

## **3.2. Organizational focus**

### 3.2.1. The focused factory

In a seminal article, Skinner (1974) suggested that factories can be more focused by grouping various products and resources into several manufacturing units with each unit focusing on a limited, concise, and manageable set of products, technologies, volume and markets. According to Skinner (1974), "... let each manufacturing unit work on a limited task instead of the usual complex mix of conflicting objectives, products, and technologies ...". This should lead to the "focused factory". However, Skinner states that if it is not possible to focus the whole factory, one should adopt the 'plant within a plant' (PWP) notion. PWP is achieved by dividing the existing facility into organizationally and physically separated sections. He states that each PWP should have its own facilities within which it can concentrate on its particular manufacturing task, using its own work force management approaches, production control and organization structure. Wheelwright (1984) found that companies with fewer product lines were found to be more profitable than companies with more product lines. Bozarth and Edwards (1997) found that PWPs might not be entirely successful at buffering plants from the negative impact of diverse market requirements. Bozarth and Edwards (1997) did an exploratory case study with a sample of 24 plants serving as original equipment and aftermarket suppliers to the automotive industry. They founded that market focus and manufacturing focus are increased through focused work cells or Plant Within a Plant and have an impact in performance. Impact in effectiveness

was not measured. However the results suggest that PWPs might not be entirely successful at buffering plants from the negative impact of diverse market requirements. Bozarth (1993) presents a conceptual model of focus and discusses how focus may be related to manufacturing performance. Bozarth (1992) studied the effect of market /manufacturing congruence on plant performance at a make-to-stock chair manufacturer. The result of this exploratory study shows a strong relationship between perceived manufacturing effectiveness (measured as ability to meet customer requirements) and marketing/manufacturing congruence.

### 3.2.2. Autonomous production units

A similar concept of the PWP is the concept of autonomous production units. According to Labit (1994) the term was first used by some automobile manufacturers, particularly by Volkswagen, as early as the 1970s. For this manufacturer, the greatest characteristic of this concept of working groups is that even as early as the 1970s, they were ‘developed and promoted by the IG Metall trade union and not by company management’ in order to humanise work (Labit, 1994). The objective was to reorganise the workers’ responsibilities by integrating different tasks at different levels of responsibility in order to offer the workers the means of acquiring new skills and reinforcing their autonomy (Labit, 1994). However, from the mid-1980s, management realised that using this concepts could be a way of increasing productivity, and IG Metall was forced to stand up for its own conception of teamwork (Gorgeu and Matieu, 2005). Since the beginning of the 1990s, the automobile industry has been undergoing a dual process:



companies have been bought out by powerful groups; plants turned into subsidiary companies; and factories split up into several distinct production units (Gorgeu and Matieu, 2005). According to Gorgeu and Matieu (2005) in France, autonomous production units were established in 1990s first at Renault and after at Peugeot. Following their example, the suppliers introduced the units very gradually as an experiment in a workshop or a new factory before generalising the concept (Gorgeu and Matieu, 2005).

Camuffo and Miccelli (1997) investigate the impact of elemental organizational units in Italian, Spanish and French plants. The research is based on empirical evidence accumulated in FIAT, Renault and Seat. According to the authors the first line supervisors play a crucial hierarchical role, especially in automated contexts and their function strongly affects the plant global performance. They coined the term Mediterranean Lean Production referring to that original and idiosyncratic evolutionary pattern.

### 3.2.3. The mini-company process

Other similar concept of the PWP and APUs is the mini-company process. It was Suzaki (1993) who coined the term “mini-company” for work groups who are responsible for their supplier-client relationships. Each work group within the company has its own process. The next process is viewed as the customer and the previous process is viewed as the supplier of every unit. The mini-company process (Suzaki, 1993) is the dynamic side of the mini-company concept. It represents a cycle in which in every period the name and mission are under discussion, and in which in every period the relevant

clients and suppliers are identified and visited. These visits are oriented at overall assessments of the mini-company. In realising the cycle of the mini-company process every time the requirements of (internal or external) customers and suppliers are made visible for the mini-company by itself. These requirements are the inputs for the improvement programme. At the end of each cycle, the results are reported to management. Since every cycle in the end is restarted this is in fact a regular evaluation of the functioning of the mini-company on the basis of market requirements (de Leede and Looise, 1999). Later works by de Leede and Looise (1999) and de Leede *et al.* (2002) performed descriptive case study at Philips CMA electronic industry in the Netherlands concluding that the mini-company organizational design for Continuous Improvement has a self-propelling capacity for Continuous improvement involving everyone in the shop floor and a constant and market-oriented source for improvement.

### 3.2.3. Cellular manufacturing

In order to divide a facility into physically separated sections cellular manufacturing propose to divide physically a large job shop into numerous small production cells (Greene and Sadowski, 1984). Each cell is designed to efficiently produce common types or shapes of parts having similar machine, operation, and fixture requirements. Griffiths *et al.* (2000) claims that customer-focused manufacturing is achieved through manufacturing cells where all the resources are focused on one customer, instead of a product or product family. However the objective of cellular manufacturing is not to organize the shop floor from a customer perspective but to

eliminate or minimize complexity and to improve productivity. Carrie and Mannion (1975) reported a cell design procedure, which each cell is initially created as a flow shop and iteratively reduced in size, forfeiting simple unidirectional material flow for higher machine utilization. Pattanaik and Sharma (2009) state that as some of the lean manufacturing concepts are different from that of cellular manufacturing, some new cell design methodology is required. In order to synchronize all the cells in a value stream they propose as central concept the rate at which work progresses through the factory is called flow rate or Takt. Griffiths et al. (2000) presents an explanatory case study based on 35 OEMs and SMEs in the auto industry in the UK and claims that customer-focused manufacturing is achieved through manufacturing cells where all the resources are focused on one customer, instead of a product or product family. Molleman and Broekhuis (2001) performed a descriptive case study at Holec Algemene TOelevering in the Netherlands. The study concludes that cellular manufacturing is an attempt “to bring the customers closer to the shop floor”. Cellular manufacturing enables a flat organizational structure, the decentralization of many support functions to the clusters or to the cells, the feedback of performance and the positive attitude towards continuous improvement among workers. Bullinger *et. al.* (1995) present a conceptual paper where they conclude that manageable, decentralized and independently responsible segments form the basis of the customer-oriented enterprise. Decentralized structures, zero default quality or Project management are characteristics of a customer-orientated enterprise. The way towards this starts in management.

Plant within a plant (Skinner, 1974), autonomous production units (Labit, 1994), the mini company (Suzaki, 1993) and cellular manufacturing (Greene and Sadowski, 1984) are outstanding precedents that aim to minimize complexity and to enhance the focus of the organization to a common objective. These concepts point out the convenience of focusing the organization in a set of activities, but not necessarily to the value stream.

### **3.3. Value stream management**

Value stream concept was introduced by Hines and Rich (1997) and further developed as a tool by Rother and Shook (2003). Value stream is defined as the sequence of activities that are made from the reception of the customer order to the delivery of the product or service (Womack and Jones, 1994). The value stream encompasses the production flow from raw material into the arms of the customer, and the design flow from concept to launch (Rother and Shook, 2003). In this thesis refers as value stream as the “door-to-door” production flow inside the plant.

Later work further explores the tool of value stream mapping. Lasa *et. al.* (2008) performed an exploratory case study of a company that manufacture plastic casings for mobile phones in Spain in which the process of application of the Value Stream Mapping is described. The aim was to explore the level in which the theory of VSM is able to adapt to real practical circumstances. The research shows that the VSM is a valuable tool for redesigning the productive systems according to the lean system.

Nevertheless, there are some key points that the implementation teams have to take into account: the time and training resources spent, the use of suitable information systems and a suitable management of the application phases. Emiliani and Stec (2004) present an exploratory case study based on one manufacturing and one Service Company of the USA. The authors present for the first time how value-stream maps can be used to determine leadership beliefs, behaviours, and competencies. The beliefs, behaviours, and competencies of leaders skilled in Value Stream Mapping management thinking and practice are shown to be remarkably different, and constitute an alternative and simpler route for identifying leadership problems and improving leadership effectiveness. Diaz *et. al.* (2007) performed an in-depth analysis of the operations of an Indian non-for-profit organisation. Based on process and value stream map analysis, the authors identify the key lean practices and propose a conceptual model for the improvement of healthcare operations. Other examples of applications of the Value Stream Mapping tool in various sectors in manufacturing and services are largely reported in the literature (Arbulu and Tommelein, 2002; Alves *et. al.*, 2005; Seth and Gupta, 2005; Lummus *et. al.*, 2006; Abdulmalek and Rajgopal, 2007; Seth *et. al.*, 2008; Singh and Sharma, 2009)

Some authors propose methods to improve the value stream mapping tool by helping to focus on the final customer. Hines *et. al.* (1998) proposed a methodology for helping to create “effective value streams” labelled as the “value stream analysis tool” or VALSAT. VALSAT is essentially the refinement and re application of the quality function deployment (QFD)

(Akao, 2004) method to the supply chain. Despite efforts to verify the technique through application to one company, the VALSAT method remains largely theoretical. Zokaei and Hines (2007) performed an exploratory case study focused on the UK dairy industry. The authors present the “Supply Chain Kano-QFD”, an integrative method which helps drive effectiveness by focusing on how the various supply chain members might jointly develop innovative solutions to create unique, individualized sources of consumer value.

However, some authors view the value stream as a central and more strategic concept for the lean transformation. Hines *et. al.* (1998) developed the value stream mapping approach into a more strategic and holistic method called Value Stream Management with more focus on human resources. Value stream management was defined as a strategic and operational approach designed to help a company or a complete supply chain to achieve a lean status (Hines *et. al.*, 1998). According to Womack and Jones (1994) the lean enterprise is a new organizational model. The value stream is which defines the lean enterprise. The lean enterprise is then a group of individuals, functions, and legally separate but operationally synchronized companies. Getting managers to think in terms of the value stream is the critical first step to achieving a lean enterprise. According to Liker (2003) someone with a real leadership skills and a deep understanding of the product and process must be responsible for the process of creating value for customers and must be accountable to the customers. Lean enterprise transformations are reported in the literature. For example, Ianni

(2011) describes the lean transformation at PSA; Dani (2010) explores the leadership aspects of a lean transformation and present lean transformations at Deere & Company, Rockwell International, Jake Brake (Danaher) and HON Company. Other authors present techniques to assist lean transformations (Comm and Mathaisel, 2008; Nightingale and Mize, 2002). Roth (2011) presents a change model to sustain lean transformations.

Pettersen (2009) found out that human relations management issues for lean manufacturing were discussed by 78% of the authors (team organization, cross training and employee involvement. None of the characteristics were discussed by authors Bicheno (2004) and Shingo *et al.* (1989). Pettersen (2009) states that one thing that lean and TQM have in common is seeing the organization as a system (Womack and Jones 1996; Bicheno 2004). But there is a slight difference in perspective between the two concepts. Whereas TQM has a strong focus on the internal structure and integration of departments within the organization, lean stresses a supply chain perspective, seeing the internal production operations as a part of a value stream from the sub-suppliers to the end customer (e.g. Jones and Womack, 2002; Rother and Shook, 2003). Hines *et al.* (2002) explores an integration of approaches developed within the 'lean thinking, strategic cost management, marketing and policy deployment areas' in a explanatory case study based on a automotive retailer in the UK. Hines *et al.* (2002) state that lean management addresses processes not functions, and it is a practical and analytical fact-based approach.

### **3.4. Performance measurement systems**

As value streams became the primary organizational requirement for a lean enterprise, it only follows that the performance measurement is organized in the same manner. The performance measurement revolution started in the late 1970s and early 1980s with the dissatisfaction of traditional backward-looking accounting systems (Nudurupati and Bititci, 2005). Since then, there has been a constant development in designing performance measurement (Nudurupati and Bititci, 2005). Neely et al. (2005) described performance measurement as a set of metrics used for quantifying both the efficiency and effectiveness of an action. Within the lean manufacturing context a manufacturing measure is a standard that defines performance criteria for manufacturing processes so that everyone in the organization are working towards the same goal (Khadem *et. al.*, 2008). Lewis and Slack (2003) mentioned five types of performance objectives based on cost, flexibility, speed, dependability and quality. According to Keegan *et. al.* (1989), most performance measurement systems used in firms include too many different measures which makes it difficult to understand the “big picture”. Schmenner and Vollmann (1994) argued that most organizations were using wrong measures and failing to use the correct measurements in correct ways. According to Neely *et. al.* (1997) if performance indicators are not well designed, it can result in dysfunctional behaviours, encouraging individuals to make the wrong decisions. According to Liker (2003) metrics are used very differently by Toyota compared to most companies. They are an overall tool for tracking progress



of the company and they are a key tool for continuous improvement. Liker (2003) suggest to eliminate the old metrics and to measure a variety of value stream metrics from lead time to inventory levels to first-pass quality and treat these metrics as seriously as labor productivity and other short-term cost metrics. According to Koenigsaecker and Dani (2010) Toyota measure its business through a few measures, and if you improve each of them every year, “good things happen.” The performance metrics are: Quality improvement (Q), Delivery/lead time/flow improvement (D), Cost/productivity improvement (C) and Human development (HD).

According to Tangen (2004), the most well known performance measurement system is probably the balanced scorecard system, developed and promoted by Kaplan and Norton (1992). The balanced scorecard proposes that a company should use a balanced set of measures that allows top managers to take a quick but comprehensive view of the business. However, according to Ghalayini *et. al.* (1997), the main weakness of this approach is that it is primarily designed to provide senior managers with an overall overview of the performance. Thus, it is not intended for (nor is it applicable to) the factory operations level. Further, they also argue that the balanced scorecard is constructed as a monitoring and controlling tool rather than an improvement tool. In order to align senior managers’ strategic objectives with the organization, Ishikawa (1985) diffused the strategic planning/strategic management methodology of Hoshin Kanri. It assumes daily controls and performance measures are in place: According to Akao (1988), with Hoshin Kanri, the daily crush of events and quarterly bottom-

line pressures do not take precedence over strategic plans; rather, these short-term activities are determined and managed by the plans themselves (Akao, 1988).

"Each person is the expert in his or her own job, and Japanese TQC (Total Quality Control) is designed to use the collective thinking power of all employees to make their organization the best in its field [...] Top managers and middle managers must be bold enough to delegate as much authority as possible. That is the way to establish respect for humanity as your management philosophy. It is a management system in which all employees participate, from the top down and from the bottom up, and humanity is fully respected. Ishikawa, (1985)"

#### 3.4.1 Process measurement

The literature stresses the importance of measuring not only the result but also the process. Process measures determine result measures (such as the financial indicators) and "are spoken in the language of the land that is being measured" (while financial indicators are the same everywhere) (Meyer, 1994). Deming (1986) made the first distinction between process-oriented manufacturing and goal-oriented manufacturing. Users of the former focus on process and view product quality as a consequence of a quality process, but users of the latter focus on the result and view product quality as a strategic goal. Deming differentiated, for example "zero defects" as a process versus a company goal. He explained that both approaches can lead to its achievement at the price of inspection and dismal productivity. Improvements in the process can lead to zero defects as a natural consequence. According to De Haas *et. al.* (2000) the "what to achieve?"

question has to be answered in terms of result indicators, while the “how to achieve?” question needs to be tackled in terms of process indicators. Ishikawa (1985) argued that one commonly thinks of quality as a trait found in the final product, but it is crucial to think of quality in the process “en route” to the creation of that quality product. Imai (1995) contrasted the varying implications of process-oriented thinking and results-oriented thinking in management. Imai (1995) attributed the success of Japanese manufacturing to process-oriented thinking. He pointed out that results-oriented management is probably a remnant of the mass-production legacy and that process-oriented management is more suited for the post-industrial, high-tech, high touch society. Choi and Liker (1995) presented an exploratory case study based on seven automotive suppliers located in the Detroit area. The paper studies the implementation of continuous improvement. Using both qualitative and quantitative data, they observed empirically a relationship between process-oriented values and continuous improvement effectiveness. They propose to combine result oriented measures with process oriented measures. They conclude that what a process orientation of continuous improvement brings to the research is customer orientation and logical reduction of the work process with the notion of the “mini company” (Suzaki, 1993).

The Overall Equipment Effectiveness (OEE) is an important process oriented metric. The OEE measure is accepted by management consultants as a primary performance metric (Hansen, 2001). The OEE measure, applied by autonomous small groups on the shop-floor together with quality control

tools, is an important complement to the traditional top-down oriented performance measurement systems (Jonsson and Lesshammar, 1999). OEE is defined as a measure of total equipment performance, that is, the degree to which the equipment is doing what it is supposed to do (Williamson, 2006). Many companies routinely hit capacity constraints and immediately consider adding overtime for existing workers, hiring workers for new shifts, or buying new production lines to boost their production capacity (Muchiri and Pintelon, 2008). For such companies, the OEE tool can help them to optimize the performance of the existing capacity (Muchiri and Pintelon, 2008). The OEE measure is a bottom-up approach where an integrated workforce strives to achieve overall equipment effectiveness by eliminating the six big losses (Nakajima, 1988): (1) Breakdown losses (2) Set-up and adjustment losses (3) Idling and minor stoppage losses (4) Reduced speed losses (5) Quality defects and rework losses (6) Start-up losses. According to Jonsson and Lesshammar (1999) the data collection of the OEE should be at such detailed level that it fulfils its objectives without being unnecessarily demanding of resources. Sometimes the process itself is so complex that it is impossible to avoid a detailed data collection (Jonsson and Lesshammar, 1999). The data collection can then be facilitated by measuring the actual time after each downtime and speed loss, instead of measuring the frequency of these losses (Jonsson and Lesshammar, 1999). The most important objective of OEE is not to get an optimum measure, but to get a simple measure that tells the production personnel where to spend their improvement resources (Jonsson and Lesshammar, 1999). However, Scott and Pisa (1998) pointed out that the gains made in OEE, while

important and ongoing, are insufficient. It is necessary to focus one's attention beyond the performance of individual tools towards the performance of the whole factory. The ultimate objective is a highly efficient integrated system, not brilliant individual tools. Scott and Pisa (1998) coined the term "overall factory effectiveness" (OFE), which is about combining activities and relationships between different machines and processes, and integrating information, decisions and actions across many independent systems and subsystems. Jonsson and Lesshammar (1999) agree with that idea and agree that OEE is a measure of internal efficiency. OEE does not measure the strategy, flow orientation and external effectiveness dimensions to any great extent.

#### 3.4.2. Value stream costing

Different authors highlight the importance of the value stream based operational performance measurement system. In this section it is explained the concept of value stream costing which allows to organize the accountancy systems with a value stream perspective. Value stream costing has its precedents in the work performed by Cooper and Kaplan (1988). The authors gave voice to a feeling of dissatisfaction with management accounting held by many managers. Johnson and Kaplan said that management accounting practice had stagnated since the 1920s. Management accounting was irrelevant, even a detriment to managers facing increased competition and rapid change in the global economy of the late 20th century.

Stenzel (2007) define value stream costing as the process of assigning the actual expenses of an enterprise to value streams, rather than to products, services, or departments. According to Maskell and Kennedy (2007) companies using lean accounting have better information for decision making; have simple and timely reports that are clearly understood by everyone in the company; understand the true financial impact of lean changes; and focus the business around the value created for the customers.

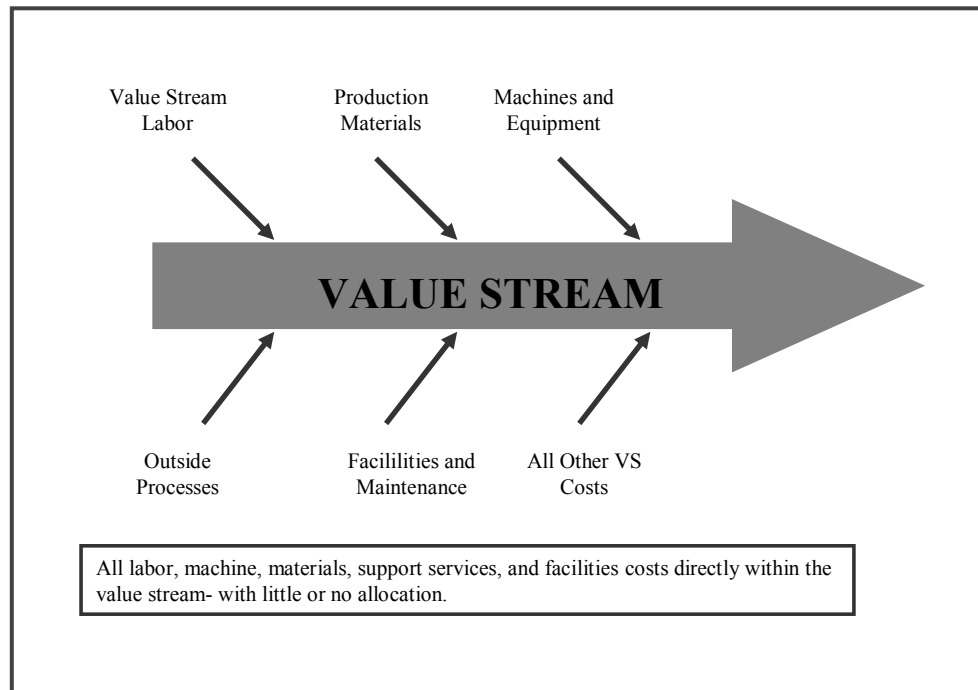


Figure 4- Value Stream Costing. (Source: Stenzel, 2007)

Ward and Graves (2004) performed an explanatory case study in the aerospace sector in the UK as part of the lean Aerospace initiative (UK LAI). The authors discuss the shortfalls of the traditional accountancy systems and describe an accounting system for the aerospace industry. The paper recommends the adoption of Value Stream costing as the ideal. However points the difficulties of adopting Value Stream costing in VSM

with high variety of different components. They also recommend the use of financial and non-financial measures for operational performance. Maskell and Kennedy (2007) describes several primary lean accounting methods and tools that support three key aspects of a lean organization- visual management, value stream management, and continuous improvement. They state that Lean companies are less concerned about the cost of the individual products within the value streams and are more concerned about the costs of the value stream as a whole.

#### 3.4.3. Visualization and information gathering of performance measures

Sánchez and Pérez (2001) state that lean production implies decentralization of responsibilities to production line workers and a decrease of hierarchic levels within the company. According to the authors, the efficient operation of a lean organization requires the diffusion of information to all levels. This is also highlighted by Womack *et. al.* (1990) and Womack and Jones (1996). The aim is to deliver timely and useful information down to the production line. However, it is not obvious how firms should measure their manufacturing performances (Jonsson and Lesshammar, 1999). This section explores literature in the topic of visualization and information gathering of performance measures.

Cecelja (2002), states that there are a number of different methods by which shop-floor data collection can be performed. The simplest, and cheapest, is paper recording and manual storage. This method makes it fairly difficult to use and analyse the data; hence there is a greater probability that

the data will not be used to improve the process, making the exercise pointless. The second method is paper recording and input into an MRP system. Finally, dedicated shop-floor data collection systems can be implemented.

Lean advocates have the idea of putting in place a simplified information management system (Houy, 2005). They consider that organizations based on continuous flow should limit information needs to local communication between upstream and downstream production units. In their view, it is preferable for employees to search for the information they need and when they need it, rather than configuring software to provide information that is repeated at predetermined times (Cottyn *et. al.*, 2011). According to Maskell and Baggaley (2006) continuous improvement (CI) is motivated and tracked using value stream performance boards. Typically these visual boards are updated weekly and used by the value stream CI team to identify improvement areas, initiate PDCA projects, and monitor their progress. Maskell and Kennedy (2007) highlight that performance should be displayed visually to everybody. They propose the box score to present a three-dimensional view of the value stream's performance, operational performance, capacity information and financial performance and proposes to do it weekly. Eriksen (2007) states that with the use of performance management boards it becomes easier to keep the team focused. Richey (1996) observed that winners of the 1996 Shingo prize for manufacturing excellence primary used a visual performance management system on the shop floor.



<b>Operational</b>	<b>3-Feb</b>	<b>12-Feb</b>	<b>19-Feb</b>	<b>26-Feb</b>	<b>5-Mar</b>	<b>12-Mar</b>	<b>19-Mar</b>	<b>26-Mar</b>	<b>GOAL 31-Mar</b>
Units per person	31,77	30,46	32,5	32,2	33,7				35,3
On-time shipment	96,2%	98,2%	98,5%	97,6%	97,2%				98%
First time thru	42%	44%	43	47	54				62%
Dock-to-dock days	12,5	11,9	10,9	9,3	8,9				8
Average cost	\$115	\$115	\$117	\$112	\$111				\$ 107
AP days-AR days	8	8	8	8	8				8
<b>Capacity</b>									
Productive	22%	23%	21%	22%	22%				22%
Non productive	58%	60%	55%	57%	58%				37%
Available capacity	20%	22%	21%	20%	20%				41%
<b>Financial</b>									
Revenue	\$325	\$325	\$325	\$325	\$325				\$325
Material costs	\$109	\$107	\$111	\$119	\$111				\$111
Conversion costs	\$92	\$96	\$97	\$94	\$94				\$94
Inventory	\$192	\$191	\$194	\$195	\$198				\$198
Value stream profit	\$112	\$117	\$116	\$119	\$119				\$119
Value stream ROS	36,9%	35,9%	34,7%	35,2%	36,9%				36,9%

Figure 5- Example of value stream box score. (Source: Stenzel 2007).

The application of information technology and lean principles have for a long time been seen as mutually exclusive, but both approaches are more and more claimed to be interdependent and complementary (Cottyn *et. al.* 2011). In complex manufacturing processes the support of IT in the MPMS can trigger, feed or validate the Lean decision-making and continuous improvement process by always basing the decisions on the production flow. According to Cooper and Kaplan (1988) the frequency of reported information should follow the cycle of the production process being measured. In departments producing hundreds of parts per hour, the per-unit materials, labour, machine time, and utility consumptions should be reported daily or even hourly. They state that is not much help to get monthly cost reports for an operation that turns out many parts per second. A company maintains control best at the shop-floor level by frequent reports of measures like yield, defects, output, setup and throughput times and physical inventory levels. The authors recommend the use of IT for operational performance measurement.

### **3.5. Formal meeting system**

The establishment of a formal meeting system complements the setting up of the performance measurement system. Meetings can only be effective with the appropriate information. Gathering information would make no sense if it is not clearly established what will be done with it. According to Dani (2010) there is a belief at Toyota that reports and meetings that occur away from the actual site of the work being discussed will lead to incorrect assumptions and conclusions. According to Maskell and Kennedy (2007) all

routine meetings are held and decision making is discussed around the visual performance that measure the value stream performance boards in the shop floor.

According to Fletcher and Taplin (1997), with the emphasis on cross functional teams, natural work groups and continuous improvement task forces, companies must learn how to formally plan and review the activities of these emerging horizontal organizations. Operating review meetings emphasize planning, performance review and continuous improvement (Fletcher and Taplin, 1997). The philosophical core of the operating review meetings is an emphasis on the future, not the past. During these meetings, the focus is kept solely on interdepartmental key performance indicators (KPI)s. They suggest as main point of the meetings procedures to (1) Hold regular meetings, (2) Set an established agenda (3) Review exceptions and commitments, (4) Make performance improvement plans (5) Document meeting action items.

Another meeting system reported in the literature is the continuous improvement meetings. These meetings are not studied in this thesis because they are performed outside the formal meeting context. According to Lillrank (2001) continuous improvement teams are organized as a parallel system outside the formal line organization. In the Japanese organizational context it would be unacceptable to allow “the voluntary spirit” to spread into the formal work organization.

### **3.6. Conclusions of the literature review**

Leading authors highlight the importance of value stream focus from a conceptual point of view (e.g. Womack and Jones, 1994; Hines *et. al.*, 1998; Liker, 2004). Works dealing with the topics of organizational focus, value stream management, performance measurement or meeting systems are present in the literature. However no research was found in the literature about the organizational practices lean enterprises adopt to obtain the value stream focus. This research addresses this shortcoming.

## 4- CASE STUDIES

This part of the Thesis develops the case study of four plants. The four plants have successfully performed a lean transformation with significant performance improvements, and belong respectively to Delphi Diesel Systems, Sogefi Filtration, a company within the furniture industry and Renault.



## **4.1- CASE STUDY A: SOGEFI Filtration plant of Cerdanyola del Vallès, Spain**

### **4.1.1. Characteristics of the case**

#### **4.1.1.1. The company**

SOGEFI Filter Division is one of the leading European developers and manufacturers of filters for automotive and heavy-duty applications. 3,500 employees create in 2010 an annual output of 180 million filters. The filter division owns 18 sites worldwide with local presence in Europe, South America, USA, China and Egypt.

SOGEFI Filter Division, is part of SOGEFI, an Italian Group, specialized on the worldwide markets in two product lines: systems of engine and cabin filtration and suspensions components. The company has a global presence: 5 continents and 16 countries, with 46 plants. In its two divisions, filters (52 % of turnover) and suspension parts (48 % of turnover), the group employs 6,200 people worldwide in 2010. Leader in its core business in Europe and South America, SOGEFI is active on the markets of the first equipment and the original and independent aftermarket. SOGEFI stock is traded on the Milan Stock Exchange.

#### 4.1.1.2. Products and process

The describe case corresponds to the lean transformation of the filter manufacturing plant of Sogefi Filtration S.A. at Cerdanyola del Vallès, Barcelona. Data was collected through an interview of the plant manager and a visit to the plant in December 2010.



*Figure 6- Sogefi Filtration Plant at Cerdanyola del Vallès. (Source: Mundorecambioy taller, 2012)*

The Plant's product range comprises oil, petrol, diesel, air motor and cabin air filter elements and complete modules for two product lines; first equipment and the original and independent aftermarket of filters for automotive and heavy duty applications.



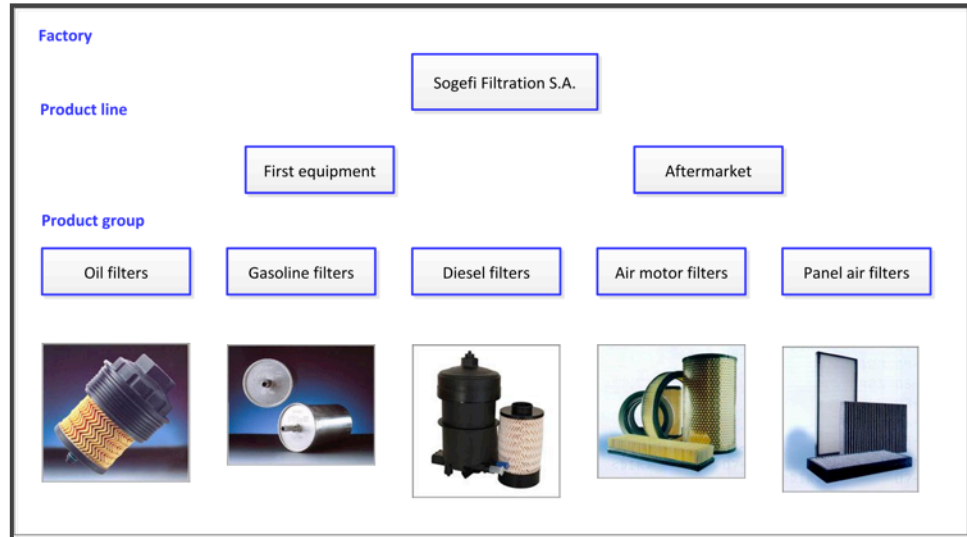


Figure 7. Products at SOGEFI filtration. (Source: own elaboration)

The production process is composed by an injection process, a media pleating process and an assembly process as can be seen in the process flow diagram.

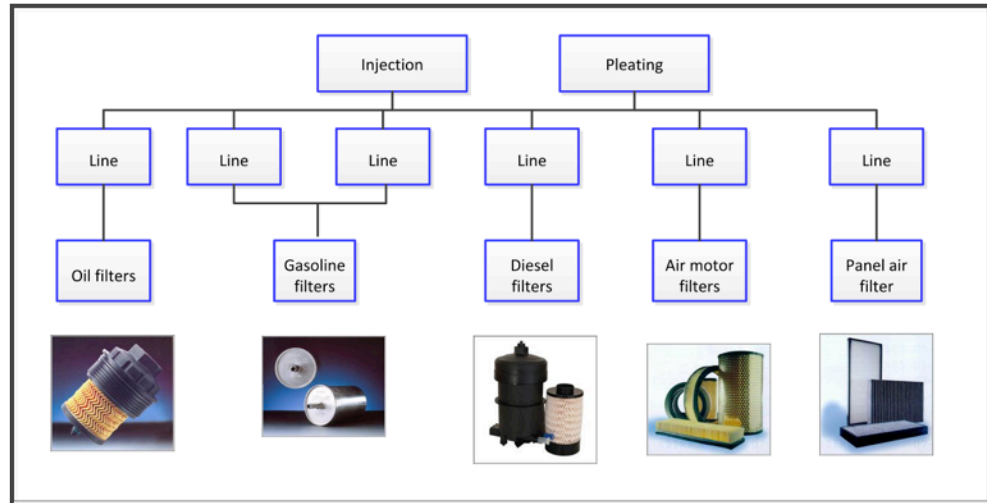


Figure 8. Process at SOGEFI filtration. (Source: own elaboration).

In the process flow diagram it can be observed that all the products converge from injection and pleating process. After the injection and pleating process, the products go to different product lines for assembly i.e. the assembly process is a product/cell oriented meaning that there is one line

per manufactured product. The two product markets: first equipment and aftermarket are manufactured through the same line product line.

#### **4.1.2. The production system**

In 2005, the interviewee, a former Valeo Autonomous Production Unit Manager joined SOGEFI filtration as plant Operations Director. The Sogefi Kaizen Way of Lean implementation was introduced in 2009 in a global level. In fact it was no more than an intensive continuation and formalisation of former lean management policies. The SOGEFI Kaizen Way focuses on six axis comprising cleanliness and safety, Total Preventive Management, zero waste, quality, employee involvement and visual management. All the plants in the group are measured by an annual audit made by the global Kaizen director. The group places a budget to improve these axes to a minimum level to the entire group.

The production system drives the information and material flow through the operations as follows. The customers perform monthly orders that are pacified and scheduled in the assembly lines and injection and pleating process with a weekly schedule. The door to door lead time is 20 days whereas the process value added time is 1 minute. The main flow interruption, by process configuration, is the injection/pleating process and the assembly lines process and it is managed by a supermarket of maximum 15 days of material per product accounting for 75% of the process lead time.

### **4.1.3. Organizational practices**

As pointed out in the introduction, this case study focuses on organizational aspects in terms of organization and management indicators. The manager in charge of the lean implementation believes in the organization based in value stream. Effectively, he said that:

*“I was professionally developed at Valeo, I have developed organizations in Autonomous Production Units. When I arrived I tried to do exactly the same here but it did not work, so I had to rethink about how to organize the teams following the principles of team work, policompetence and use of lean tools [...] We did not reach to create totally autonomous units with all the functions integrated [...] However the focus of the teams is the production line, not the Unit or the Group, in a completely transversal way, this is the main success factor”*

Ghislain Audion, SOGEFI Plant Manager

In spite of this, an in depth reorganization of the plant was not considered possible when the process of implementation of lean management begins. The adopted solution consists in maintaining a pure functional hierarchical organization, while the function of integrating the activity to the value streams was assigned to other organizational elements. These elements are continuous improvement groups and management indicators, which were appropriately designed to fulfil such a mission, as showed next.

#### 4.1.3.1. Organizational units based on value streams

The hierarchy within SOGEFI consisted of four layers: general manager, plant manager, supervisors and operators. The production is organised in four units.

- (1) Line 1, line 6
- (2) Line 2, line 3, line 4, line 5
- (3) Injection
- (4) Pleating

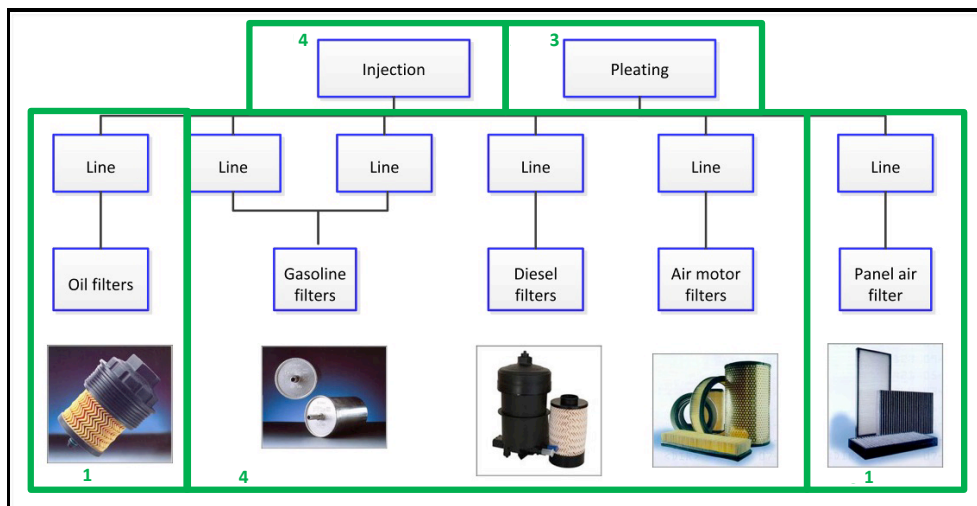


Figure 9- Differentiation among units at SOGEFI filtration. (Source: Own elaboration)

SOGEFI is organized functionally. The resources of each function report to the function director and are placed in one or various units depending on the workload or assigned projects.

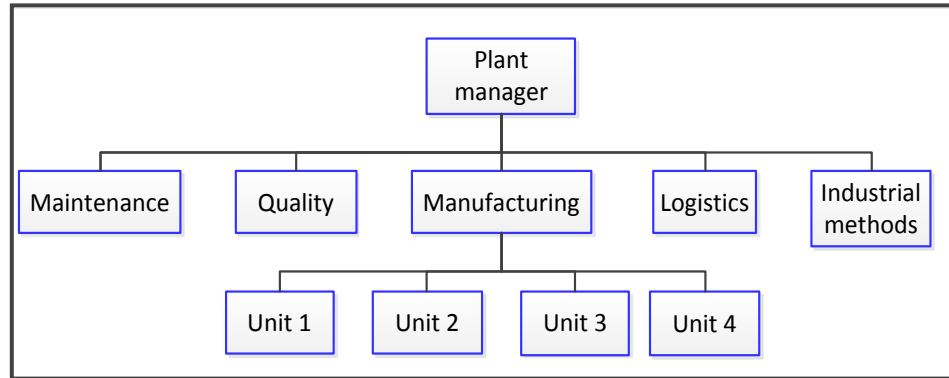


Figure 10. Plant organization at SOGEFI filtration. (Source: own elaboration).

However, for continuous improvement, SOGEFI Filtration SA organizes the teams by value stream segments. These teams are called the “Continuous Improvement Teams” and were established in 2007. The general approach is characterized by a focus on step-by-step improvements and daily problem-solving. The organization focuses on many small improvements which were achieved by an interdisciplinary approach lead by Kaizen engineers with full time dedication to one unit with the joint efforts of part- time resources for continuous improvement of quality engineers, method/Indus, maintenance and manufacturing. Line operators or other support functions are integrated in the teams when needed. The plant is organised in 8 manufacturing “Continuous Improvement Teams”. Logistics and maintenance are also organized as Continuous Improvement Teams.

The manager of the plant explained that:

*“The continuous improvement of the different lines is leaded by the kaizen engineers. We have three kaizen engineers that are from industrialization/method department that are in charge of a certain number of lines, they are the leaders of the continuous improvement of those lines. They lead teams composed by quality,*

*maintenance, production and other functions when needed [...]. Every group of lines has its own Continuous Improvement Group (GMC). The GMC acts in an autonomous manner, not just in the kaizen-continuous improvement but also in general problem-solving activities in terms of quality, efficiency, line stoppages and scrap. Here we do not have completely developed a structure in Autonomous Production Units, we have shared resources between different GMC, and however the teams work directly in the line in a very transversal way.”*

Ghislain Audion, SOGEFI Plant Manager

At senior management level, the kaizen committee, led by the Plant Manager and formed by managers of the company, report to the Divisional Operations Director and the Group Kaizen Director. In order to extend the main concept of the “Continuous Improvement Teams”, functional departments such as Finance or Human Resources are enrolled in one continuous improvement project per year.

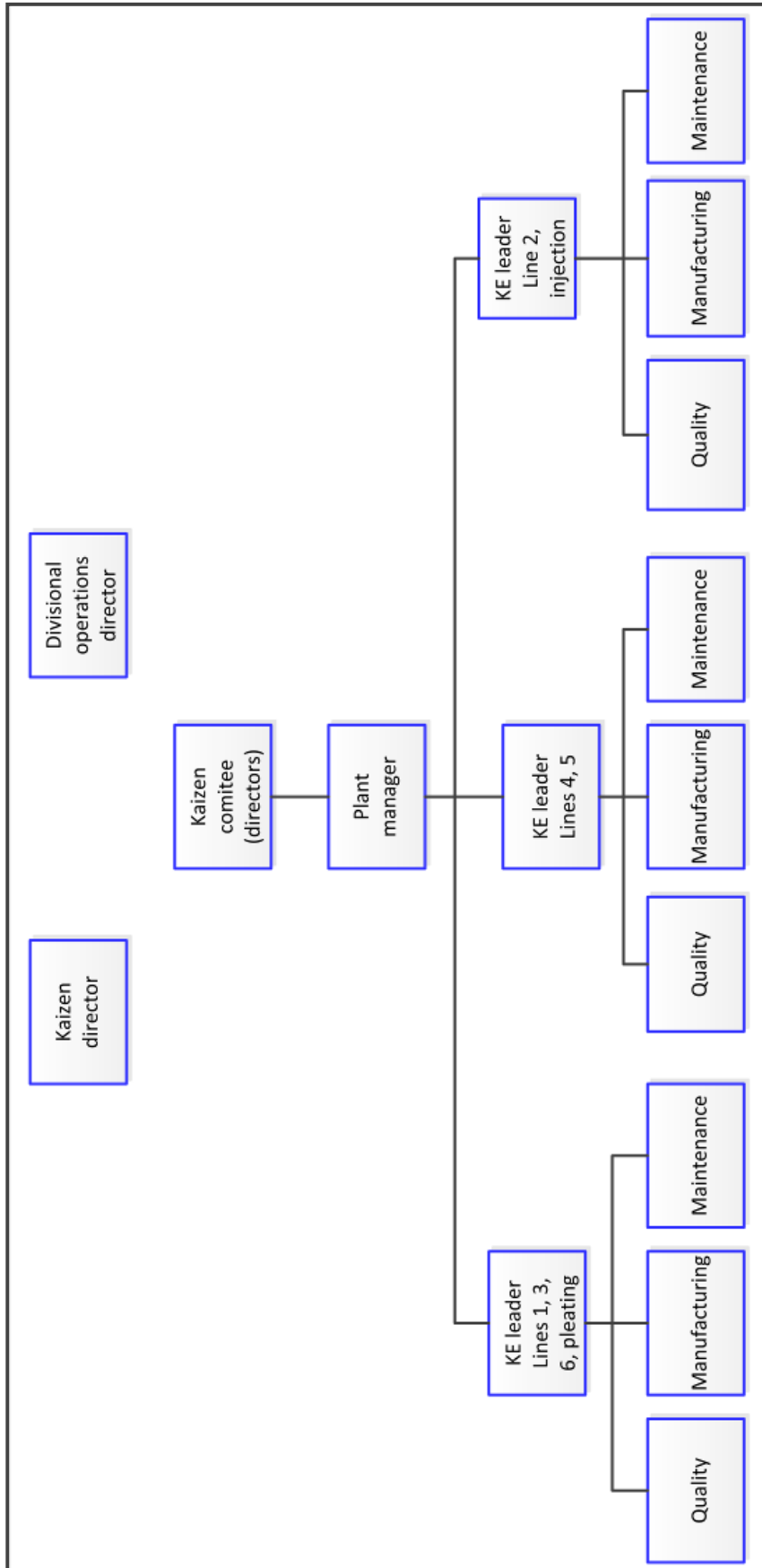


Figure 11. Organization of the Continuous improvement teams at SOGEFI filtration.  
(Source: own elaboration).

Womack and Jones (1994) highlighted that the transformation often run into stiff resistance from employees and functional units as well as from other companies in the stream. This solution is a hybrid between an organization in autonomous production units (APUs) and the concept of continuous improvement teams. According to Lillrank, (2001) continuous improvement teams are organized as a parallel system outside the formal line organization. In the Japanese organizational context it would be unacceptable to allow “the voluntary spirit” to spread into the formal work organization.

#### 4.1.3.2. Performance measurement system based on value streams

The following table shows details about the performance measurement system. It covers the most critical performance dimensions: motivation, quality, delay and cost. Every performance dimension has at least one result indicator (that defines what to achieve) and one process indicator (that defines how to achieve it), as suggested by De Haas et. al. (2000). In the following table the refreshment frequency of the different indicators is also described.



	<i>Motivation</i>	<i>Quality</i>	<i>Delay</i>	<i>Cost</i>
<b>Result indicator</b>	Number of improvement suggestions	End of line quality Customer ppms	Service level first equipment (%) Intertrading service level (%)	Productivity Direct labour efficiency
<b>Process indicator</b>	Audit 5S/ TPM (%)	TOP 3 reject		TOP 3 improductive Overall equipment effectiveness (OEE) and Pareto chart of causes
<b>Frequency</b>	24h	24h	24h	24h

Table 13. Value stream segment performance measurement system at SOGEFI filtration.  
(Source: Own elaboration).

The performance measurement system is structured in three layers. The third layer of indicators corresponds to the manufacturing lines indicators showed publicly to everyone. The second layer corresponds to the unit measurement that results from an aggregation of the different manufacturing lines performance. The first layer used by plant direction measures the performance of the complete value streams by aggregating the performance of the different units.

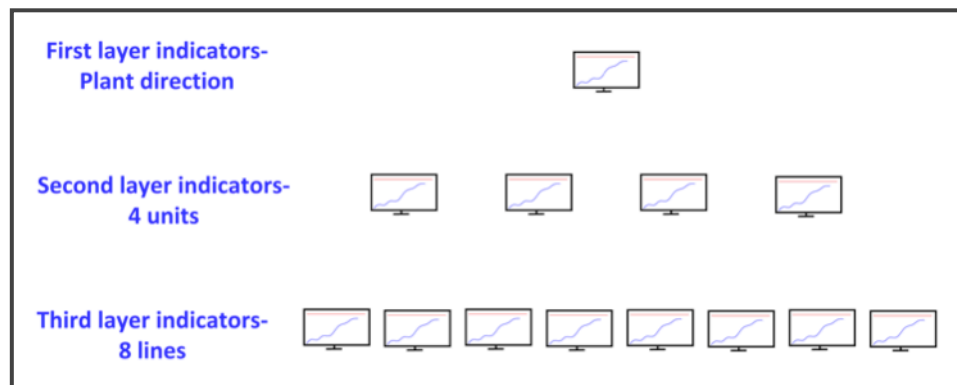


Figure 12. Structure of the indicators at SOGEFI filtration. (Source: own elaboration).

The third layers of indicators are the line indicators used in a daily basis for the daily meetings of the continuous improvement teams. The indicators are showed visually to everybody in each line.

Mr. Andion gave some details about the indicators they used and about the daily register of the losses that each line has:

*“We have visual panels in each line. A part of the panel is dedicated to the last 5S and TPM workshop and the audit that is performed every month by the operators. When they cannot solve problems themselves, they have a part of the*

*panel where they can write them or communicate improvement suggestions [...]*

*We also track the monthly number of suggestions done [...]* In the other part of the panel we have the QCDM of quality, cost, service level and motivation. As you can see there are typical productivity, quality and efficiency graphs. In this part we can see the top 3 of losses of efficiency and the associated PDCA's, so everybody can see the work that the teams are performing and that the teams are working to solve their daily problems. When there is customer non-conformity, we put a red label, for us this is very important. We also display in the panel the 8D analysing the incident. In this area, we put concrete projects or one workshop to solve one systemic problem. Finally in this part of the panel, there is a space for the teams daily meeting (Control Room). The team discuss about the different problems that they had the previous day. And put actions. When they cannot solve the problem in daily basis they bring the problems to the monthly GMC.

*The production of the different lines is registered. For example, all the quality failure modes are registered in each line, and the reason of every line stoppage is also codified in the document and also in the system. All the lines have this standard system. This information is introduced every day. After that, once per week, we put visually this graph in the line panel. For example in this case, we can see registered week by week the causes of stoppage. After in the GMC, the teams work on the TOP3”*

Ghislain Audion, SOGEFI Plant Manager

The third layer is composed by process-oriented indicators. In this case there is a focus on adherence to standards and gap reduction. They show the teams not just the result but how the things are done and how to improve.

Note that these indicators are non-financial and are organised by process or value-stream.

The second layer indicators, measure the performance of the different value stream segments in a monthly basis. It is important to note that these indicators are organized by value stream segment, not by product. For example injection process has its own process indicators measuring the performance of the Value Stream, not the performance of the different products go through this process. In this layer, the indicators are result indicators. They measure manpower efficiency and reject rate. Note that the indicators are not financial.

The first layer of indicators measures monthly plant performance. These indicators are by nature result indicators. Examples of indicators are productivity, manpower efficiency, end of line quality measurement, customer ppms, machine OEE and % of downtime due to machine breakdowns. Note these indicators are non-financial indicators. Additionally to these indicators there is a standard divisional Kaizen audit directed with 6 main focuses and measured every year. The investment needed for improving both result and process indicators are reported to the Divisional Kaizen Director. The focus of this audit is to measure not just result indicators but also process indicators, highlighting the importance for senior management on how the things are done to reach the results.

## PLANT RESULTS EVOLUTION 2006 - 2010

Indicator	2006	2007	2008	2009	2010
Productivity	78,15%	81,30%	85,20%	79,30%	83,20%
DL Efficiency	87,60%	84,00%	88,60%	86,40%	87,80%
% Improductive hours	12%	8%	6%	9%	7%
ROPN	55,00%	58,38%	62,73%	62,49%	63,97%
Reject rate	1,87%	1,63%	1,03%	1,07%	0,88%
N° CAC	46	50	35	28	16
Downtime			5,16%	6,19%	3,86%
OEE			79,00%	81,80%	89,10%
2009: complicated year due to the loss of sales and the integration of an old manufacturing line from other plant of the group that closed					

*Figure 9. First layer indicators, Plant indicators at SOGEFI Filtration. (Source: SOGEFI Filtration, translated from Spanish).*

SOGEFI FILTRATION		SOGEFI KAIZEN WAY			
MONTHLY KAIZEN NEWSLETTER AT SOGEFI CERDANYOLA					
N° 7 NOVEMBER 2010					
RESULTS OF THE MONTH OF OCTOBER					
INDICATORS	2009	OBJ 2010	OCT	2010	COMMENTS
Service level first equipment	98,9%	100,0%	99,8%	99,4%	
Inter trading service level	82,7%	98,0%	100,0%	98,9%	
N° customer complaints	35	30	3	16	
Internal reject level	1,07%	1,04%	0,85%	0,89%	
Productivity	79,3%	82,2%	84,0%	83,1%	
Direct labour efficiency	86,4%	87,0%	88,1%	87,6%	
Line performance (OEE)	81,8%	82,0%	90,5%	88,9%	
N° improvement suggestions	-	470	11	225	
Audits 5S / TPM	-	85%	85%	84%	
INFORMATION OF THE MONTH - VISITS - AUDITS					
<p>Visits information :</p> <p>On the 28th of October, HONDa visited us to solve an issue of packaging.</p> <p>On the 23rd of November, we will have a very important visit for the image of our company. We receive After-Market customers and collaborators of the Group.</p> <p>On the 25th of November, we will receive a team of the Purchasing Division of the Group.</p> <p>All this visits finish with a plant tour. So we want to thank you now for your collaboration.</p> <p>Thank you.</p>					
IMPROVEMENT SUGGESTIONS					
<p>We would like to highlight 2 smart improvement suggestions proposed by X and Y:</p> <p>With the aim of reducing the scrap when the paper 370082 is consumed, X proposes to monitor the first roll independently of the second roll. This allows to maintain the paper taut between both rolls, avoiding stoppages.</p> <p>It exists a continuous problem with the filter BF-0034-15 in the curve of the convoyer belt at the exit of the oven, in the Filter Element line. Y proposes to install a photosensor to detect the presence of a problem and to build a special cylinder in order to separate the filters.</p> <p>Congratulations to both !</p>					

Figure 13- First layer indicators at SOGEFI filtration. Monthly newsletter to communicate results to all the organization. (Source: SOGEFI Filtration, translated from Spanish).

The first layer indicators or plant results are also communicated to all the organization through the publication of a monthly newsletter. The plant manager explained that:

*“In order to communicate the results of the plant with indicators that all the organization can understand we have this newsletter. When one speak about operative result or operative performance it is difficult to communicate. The following indicators are simple and everybody understand, service level, intercompany service level, number of customer complaints, first time quality? , productivity, efficiency of manpower, the OEE, number of employee suggestions, the audit results in terms of 5S, TPM. We do not just put this information in the line panel; we also send this information to all the organization. Additionally, we communicate visits, trainings, some messages of the kaizen philosophy and we publish the recognition of the ideas of the operators highlighting two ideas per month.”*

Ghislain Audion, SOGEFI Plant Manager

#### 4.1.3.3. Formal meeting system

The establishment of a formal meeting system complements the setting up of the performance measurement system, by coordinating the monitoring of the value stream metrics which measure the performance of the teams at a group level. A formal meeting system standard for the Kaizen teams is applied based on the information provided by the performance measurement systems layer three and layer two.

The meetings and working sessions of the continuous improvement teams are highly standardizes (see next figure). The teams use problem solving tools in a ten minutes daily meeting in the shop floor for the daily problem-solving, called “Control Room”, and standard monthly meetings called

“GMC” for middle term continuous improvement. More challenging problems are analysed with special workshops or task forces by all the team.

**KAIZEN TEAMS STANDARD WORK**

**CONTROL ROOM**  
 Duration < 10 mn  
 Place: line, in front of the line panel  
 JMN: Line 3 - Line 4  
 PC: INY - Line 6  
 BV: Line 1 - Line 2 - Line 5  
 EG: Maintenance  
 Who: Kaizen Eng, Quality, Maintenance, JE/Supervisor/Team Leader, Operators  
 Do the line stop or not?  
 Teach operators to write down problems or needs in the panel during the shift.  
 Improvement suggestions reception.  
 Maintenance: after control room in front of the panel.

**GMC**  
 Duration: < 2 horas  
 Who: same as control room + invited persons depending on the problems and actions.  
 Line 2 - Line 3 - INY - Line 6 - Line 2 - Line 1: monthly  
 Line 5: 2 per month  
 Analysis of the reject TOP3 and improductive (5 why), actions follow up, actions definition.  
 Implementation of the actions < 1 month

**SS / TPM / IMPROVEMENT**  
 Monthly audit with standard format with line stop or not (PC/JMN/BV/EG)  
 Emission of improvement suggestion (only imprvement, not maintenance activities)  
 Decide who can do the improvement: line operators, team leader or maintenance.  
 Cleaniless standard and maintenance 1st level: The Kaizen engineers must ensure that the line leaders fill up the sheets and do well the cleaniless and mainance 1st level  
 Monthly graphic follow up of the results of the audits with objectives (BV/JMN/PC/EG)  
 Graphic of the management of emitted improvement suggestions ond suggestions implemented (BV/JMN/PC/EG)  
 List of the suggestions emitted / implemented with actions, dates, and responsables (BV/PC/JMN/EG)  
 Recognition of the best improvement suggestion of hte month in the newsletter (GA)

**PANEL REFRESHING**  
 Customer CAC, 8D, indicator Green/Red: TP, reception CAC and clousure of the 8D  
 QCD: monthly results + comments: GA  
 M: monthly with comments: PC/JMN/BV  
 Productivity/Efficiency/Quality: GA, monthly  
 Rejects/TOP3:                   Line 3/Line 4/Line 6/Line 2 NM  
   INY: PC date of the industrial reporting  
   Line 1/Line 5: BV with Line 5 every two months  
 PDCA GMC: montly: PC/JMN/BV

Figure 14. Standards of the continuous improvement teams at sogefi filtration. (Source: SOGEFI Filtration, translated from Spanish).

The objective of the daily meetings or “control room” is to define the abnormalities of the day before and the risk for the current day based on the information displayed in the production tracking boards.



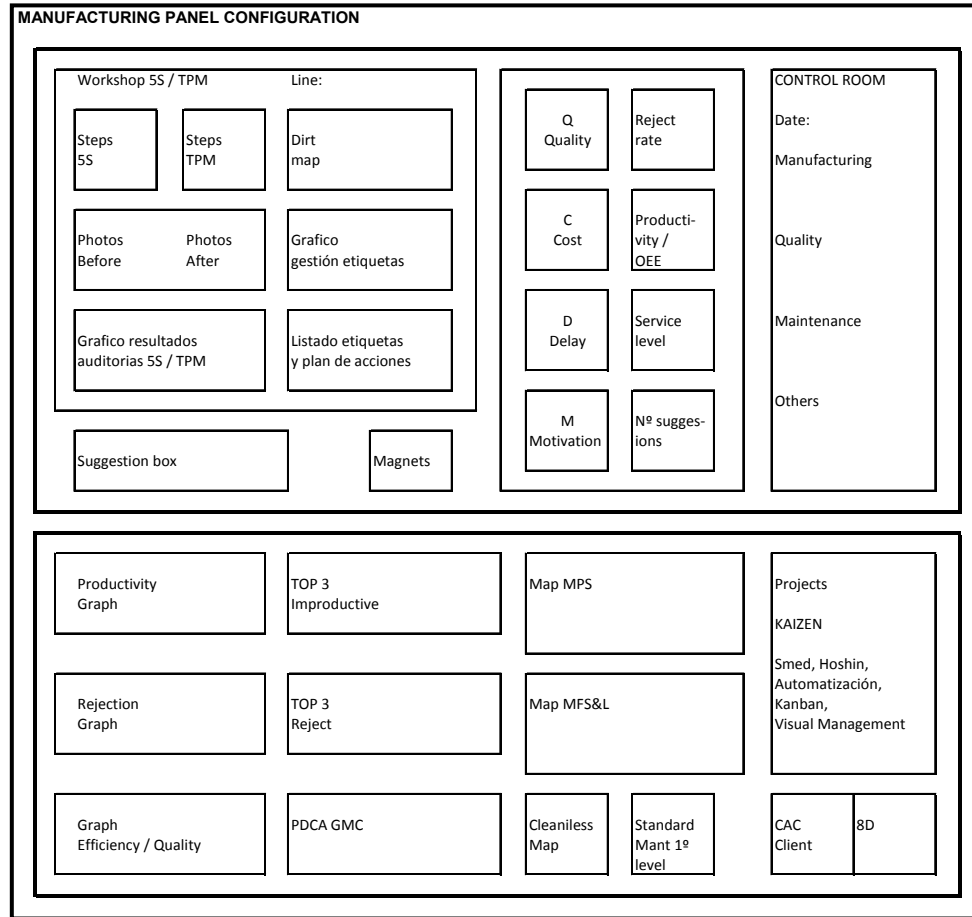


Figure 15- Performance measurement system that supports the daily meetings through a production tracking board at SOGEFI filtratrion. (Source: SOGEFI Filtration, translated from Spanish).

The monthly meetings have the objectives of planning, result indicators performance review and continuous improvement. More challenging problems are analysed with special workshops or task forces. The kaizen engineers report every week to the Plant Manager.

**LINE RESULTS EVOLUTION 2006 - 2010**

LINE 1	2006	2007	2008	2009	2010	Comments
DL Efficiency	90,50%	93,80%	95,60%	95,70%	99,00%	2011: Up dating of manufacturing times
Reject rate	3,38%	2,12%	1,08%	0,83%	0,79%	
Productivity	83%	93%	98%	99%	100%	

LINE 2	2006	2007	2008	2009	2010	Comments
DL Efficiency	97,10%	96,30%	98,00%	99,50%	97,70%	2010: Up dating of manufacturing times
Reject rate	4,71%	3,22%	1,70%	1,01%	0,48%	
Productivity	87%	97%	99%	100%	97%	

LINE 3	2006	2007	2008	2009	2010	Comments
DL Efficiency	92,70%	94,30%	97,80%	99,60%	89,1%	2010: Up dating of manufacturing times
Reject rate	2,07%	0,74%	0,04%	0,01%	0,03%	
Productivity	92%	97%	96%	97%	97%	

Injection	2006	2007	2008	2009	2010	Comments
DL Efficiency	70,30%	72,30%	76,10%	85,80%	81,2%	2010: Start up of a new process with high DL content
Reject rate	2,85%	2,68%	1,69%	1,15%	0,92%	

Figure 16. Performance measurement system that supports the monthly meetings by displaying monthly value stream segment performance at SOGEFI filtration. (Source: SOGEFI Filtration, translated from Spanish).

According the frequency of meetings Mr. Audion explained that:

*“Four years ago, when we started with the GMC, the frequency was weekly. Currently and due to the improvement of the results, we do it monthly. When we have, for example, a new line, a new product or a specific task force, we do it every week, after every two weeks and after once per month, depending on the evolution of the results of the lines”.*

Ghislain Audion, SOGEFI Plant Manager

PLANNING CONTROL ROOM 2011					SOGEFI KAIZEN WAY	
LINE	PILOTE	SHIFT	HOUR	LINE STOP	PARTICIPANTS	
Line 1	BV	TT	16h	YES	BV - FP - JRB - JP - OPE	
Line 2	BV	TM	10h15	NO	BV - NM - JLH - TP - CP	
Line 3	JMN	TM	8h30	NO	JMN - NM - JE INY - MR - CS - SN	
Line 4	JMN	TM	8h45	YES	JMN - NM - JP - OPE - SN	
INY	PC	TT	15h30	NO	PC - GT - JE INY - MR - EG - JLM	
PLEAT	BV	TM	9h45	NO	BV - JM - JP - EG	
Line 5	BV	TM	10h	NO	BV - JMR - FB - TP - EG	
Line 6	PC	TM	9h	YES	PC - NM - OPE - CP - JP	
PRODUCTION: GT - NM - JMR - JM LINE LEADERS: JLH - FP - CS - MM - DT - FB QUALITY: TP - MR - JP MAINTENANCE: EG - SN - CP - JRB - JLM						

Figure 17. Standards of the continuous improvement teams meetings at SOGEFI filtration. (Source: SOGEFI Filtration, translated from Spanish).

#### 4.1.4. Results

The result indicators show radical improvements. From 2007 to 2010 all the result indicators have improved dramatically, for example the line rejects have decreased by 45% and the customer rejects by 65%. The process indicators have increased dramatically as well, the divisional Kaizen audit results have increased from 48% to 70% from 2009 to 2011, situating the plant in the 5<sup>th</sup> position out of 12 plants in the group. One important benefit of the Continuous Improvement team's organization is the increase of the cross-training of the employees, not measured but according to the interviewer very significant. Individuals obtained more knowledge in their own process, because they were better able to see the bigger picture.

#### 4.1.5. Conclusions

The describe case corresponds to the lean transformation of the filter manufacturing plant of Sogefi Filtration at Cerdanyola del Vallès,

Barcelona. Data was collected through an interview of the operations director and a visit to the plant in December, 2010 and in 2011.

This case shows a study of a medium enterprise where the process of implementation of lean management principles in the plant is in the initial phase. An in depth reorganization of the plant in autonomous production units was not considered possible. The adopted solution consisted in maintaining a pure functional hierarchical organization, while the function of integrating the activity to the value streams was assigned to other organizational elements. These elements were continuous improvement groups, value stream based performance measurement and a formal meeting system. This solution resulted to be highly successful.

## ***4.2- CASE STUDY B- Delphi Diesel Systems***

***S.L, Sant Cugat.***

### **4.2.1. Characteristics of the case**

#### **4.2.1.1. The company**

Delphi is one of the world's largest automotive part manufacturers and has approximately 146,600 employees (Delphi, 2012). Delphi is a former General Motors company that became independent in 1999 and has been implementing the lean manufacturing concepts since the early 1990's. Delphi is considered an example of lean transformation of a big traditional company (Woolson and Husar, 1997). Delphi has been recognized with the Shingo Prize for operational excellence, also called "the Nobel Prize of manufacturing" by Business Week (2000), in twenty-seven plants. The Shingo prize recognizes organizations in the USA, Mexico and Canada for the successful implementation of world-class practices (Shingo, 2012). The policies and tools which are based on lean manufacturing are applied in all Delphi units and forms the Delphi Manufacturing System (DMS). The DMS is widely acknowledged. For example it is described by Liker, (1997) together with Daimler-Chrysler Operation System and Ford Production System. Some case studies of Delphi are found in (Mabry and Morrison, 1996; Salaiz, 2003; Nelson, 2004).

#### 4.2.1.2. Products and process

The describe case corresponds to Delphi Diesel Systems S.L. plant in Sant Cugat del Vallès, Barcelona. Data was collected through an interview with the operations director, informal interviews with APU managers and team leaders and a visit to the plant in March 2012.



*Figure 18- Delphi Diesel Systems, Sant Cugat plant. (Source: Delphi Diesel Systems S.L.)*

DDS Sant Cugat manufactures Diesel fuel injection pumps of two product groups, dfp1 and dfp3, for some of the main automotive customers (Delphi, 2012). The plant has been operating for fifty-five years and employs around one thousand people. DDS performs the machining and assembly of the pumps.

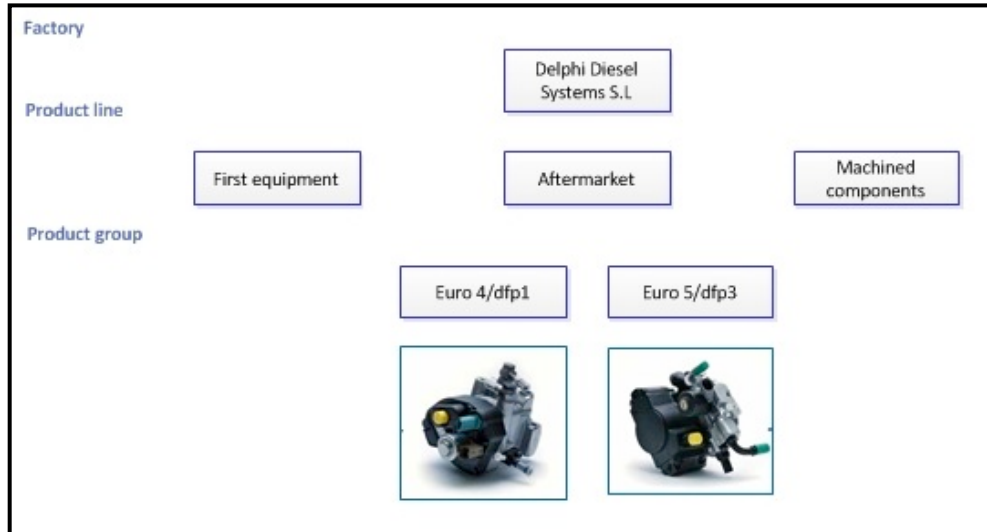


Figure 19. Product structure at DDS Sant Cugat. (Source: Own elaboration).

The assembling process is made in two lines for the dfp1 product group (assembly line 1 and assembly line 2 in next figure) and one line for dfp3 product group (assembly line 3 in next figure). The machining process of the different components is basically composed by a soft stage machining process, a heat treatment process and a hard stage process. The plant is characterized by its big dimension; process variety and process complexity (see next figure showing the process flow diagram. Dark blue corresponds to dfp3, light blue to dfp1).

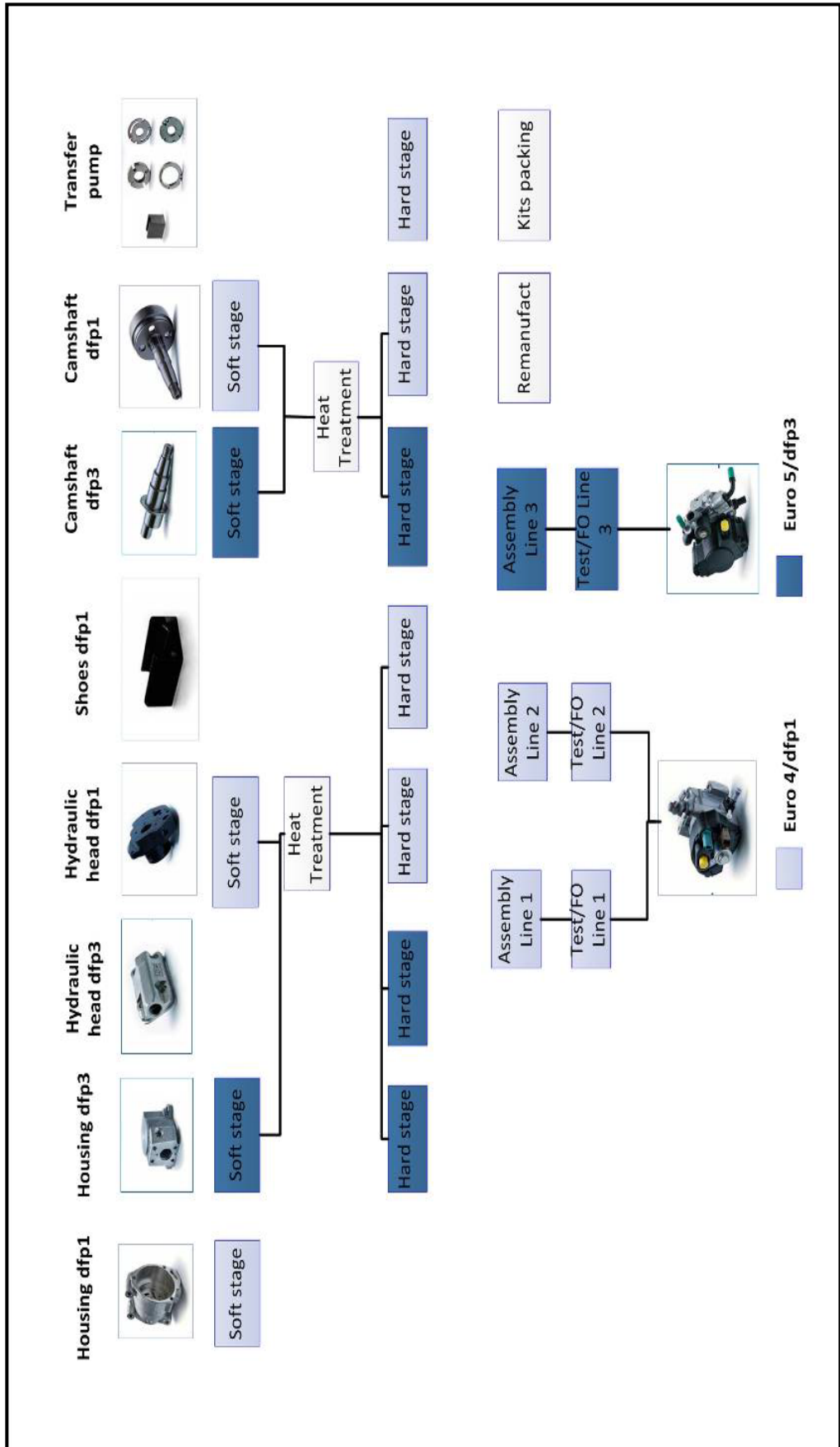


Figure 20. Process flow diagram at DDS Sant Cugat. (Source: Own elaboration).



#### **4.2.2. The production system**

DDS Sant Cugat has been applying the lean manufacturing principles for years. In 2002, DDS Sant Cugat was selected as model plant for the implementation of the DMS within the Diesel Division. The DMS was adapted to the needs of the division and published in Delphi's "Lean Toolbox". The DMS was later implemented in other plants of the group. The current top and intermediate managers of the plant participated in this process. According to Jaume Roquet, who is the operations director of the plant, the experience acquired by the current managers as lean leaders during the initial implementation of DMS is a key aspect of the more recent transformations. For DMS the focus of the organization to the production flow is a critical aim. According to DMS documentation, DMS is "*a Manufacturing System with an implementation process that recognizes the interdependencies of its elements and drives to flow manufacturing*". The application of the DMS at DDS Sant Cugat makes information and material flow through the different operations as follow. The demand is frozen, leveled by type, quantity and frequency over a monthly period of time. The tool used to level production mix in the shop floor is a Heijunka box in each of the main assembly lines. This enables the production to meet customer demand while avoiding batching. The machining processes produce the material needed to the assembly lines by following a pull system. Two tuggers move the material every forty-five minutes. The different operations

in the value stream are balanced and the cyclical work is decoupled from non-cyclical work to guarantee that the production flows in a constant pace.



Figure 21. Assembly line at DDS Sant Cugat. (Source: Photo done on a visit to Delphi Diesel Systems S.L.)

### **4.2.3. Organizational practices**

#### **4.2.3.1. Organizational units based on value streams**

The DMS also highlights the importance of having an organization based on the production flow. According to DMS documentation, *“We cannot separate Manufacturing, PC&L, ME, Purchasing, PE, HR, Sales, Business line... and so on because all functions must support manufacturing that is our core. All activity is connected and this focus will maximize the performance as an enterprise”*. The plant is divided into five autonomous production units (APUs) that are managed by an APU manager leading a team of 10-20

indirect employees and 100-250 direct workers. The APUs are structured as follows:

- Quality manager that leads a team formed by 4-6 quality engineers and 1-3 quality operators working in shifts.
- ME+Maintenance manager that leads a team of 5-10 ME+Maintenance engineers and 20-20 ME+Maintenance operators working in shifts.
- Shift leaders that lead teams of 4-5 team leaders and 20-70 operators in a shift.

The maximum amounts of resources are allocated within APUs. The APUs have decision and financial autonomy while strictly following the standards of Delphi and the plant. The role of central functions such as the Quality, ME, lean is to define and guarantee the correct use of standards across APUs and work in collaboration for special projects with the APUs. The aim of this organizational solution, according to the interviewee, is to focus the teams on the production flow, enhance entrepreneurship, teamwork, flexibility and problem-solving reactivity while preserving the technical knowledge and specialization of the functions.

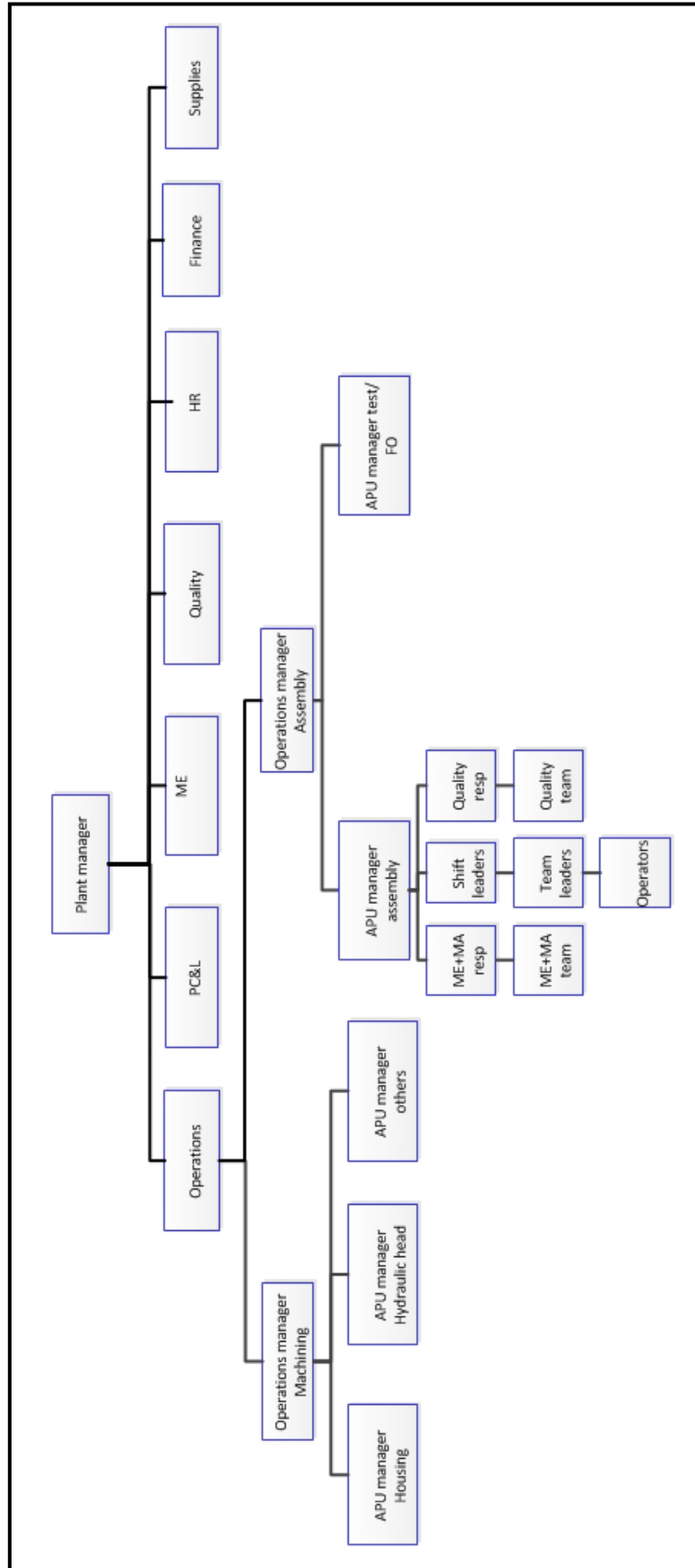


Figure 22. APU organization at DDS Sant Cugat. (Source: Delphi Diesel Systems S.L.)

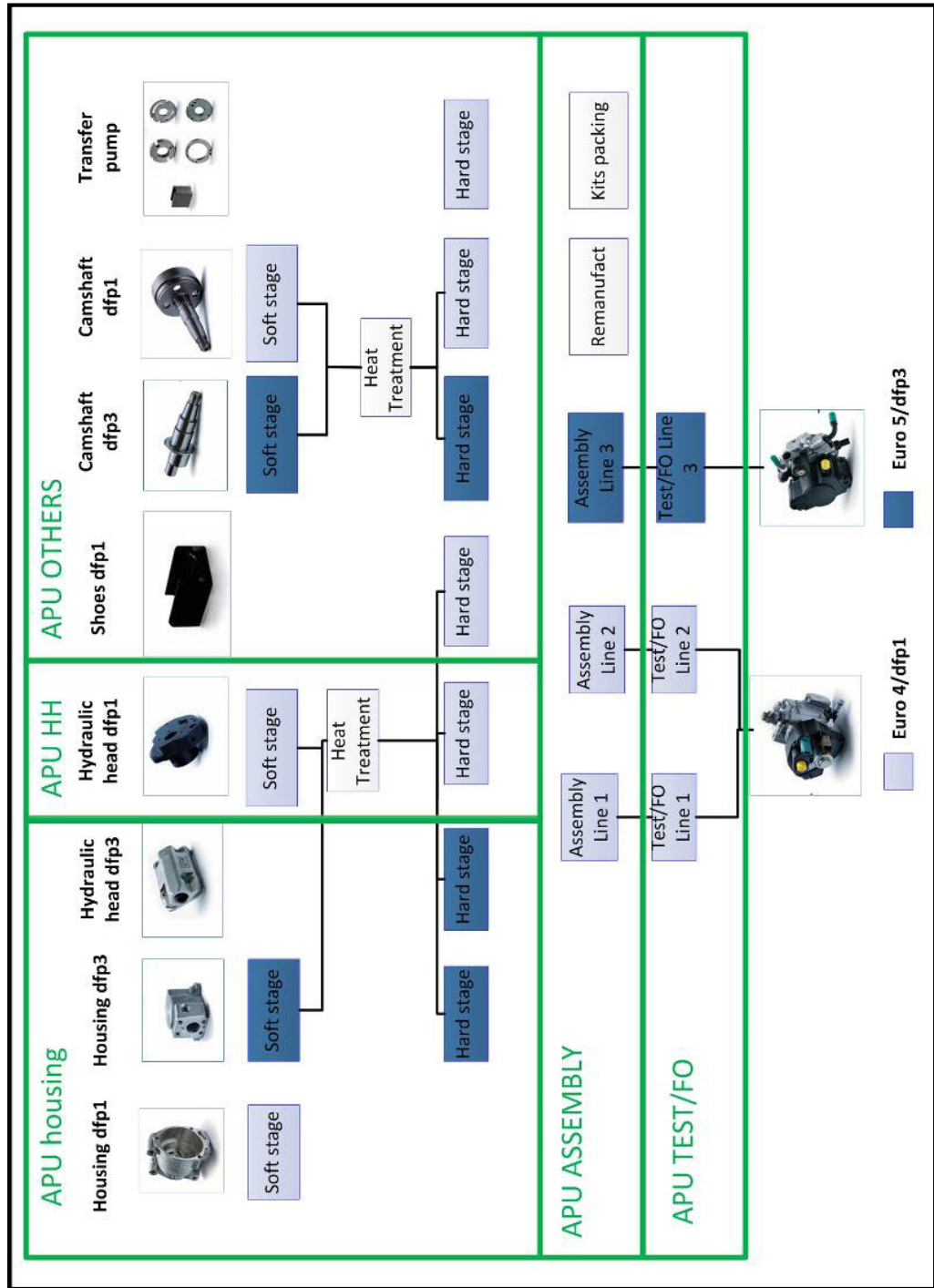


Figure 23. Differentiation among APUs at DDS Sant Cugat. (Source: Own elaboration)

#### 4.2.3.2. Performance measurement system based on value streams

In 2009, DDS Sant Cugat faced a new and demanding challenge. Due to the high demand the strategy of Delphi consists in taking as much advantage as possible of the capacity of the plant. To serve these objectives an integrated manufacturing performance and meeting system has been developed that gives great importance to the overall equipment effectiveness measure. The goal of the system is to strengthen the focalization of the activity on the value streams. According to the interviewee, Jaume Roquet, Operations Director “the performance measurement system and the meetings, for us constitute one system. It makes the teams focused on the aspects that will make a difference in the performance of the business.” The application was highly successful and allowed the plant to cope with the increasing customer demand through an increased focus of the organization on the volume performance dimension. This section describes first the new MPMS explaining the OEE measure in detail. After, the integration with the meeting system is described.

The performance management boards were changed by an IT supported near real-time manufacturing performance measurement system (MPMS) that was developed to fulfill the following needs:

- To simplify and integrate the performance measurement system in a single system and adapt the refreshment frequency to the frequency of the manufacturing process.
- To develop indicators that motivate continuous improvement of the decentralized teams not only showing the result but also helping to detect the root causes of the deviations and help to focus the efforts of the teams.
- To link the targets of the indicators with internal or external customer needs.

The following table shows details about the new MPMS. It covers the most critical performance dimensions: security, quality, volume and cost. Every performance dimension has at least one result indicator (that defines what to achieve) and one process indicator (that defines how to achieve it), as suggested by De Haas et. al. (2000). In the following table the refreshment frequency of the different indicators is also described.

	<i>Security</i>	<i>Quality</i>	<i>Volume</i>	<i>Cost</i>
<b>Result indicator</b>	Number lost work day cases	Number of external customer complaints (parts per million)	Premium freights (€) Number of stoppage hours to internal customer	Total accumulated expenses vs. financial budget Scrap cost (€)
<b>Process indicator</b>	The root cause analysis process has been done and is visible on the system (or not)	The root cause analysis process of the external customer complaints has been done and is visible on the system (or not)	Overall equipment effectiveness (OEE) and Pareto chart of causes in every machine	Expenses vs. target separated into maintenance, scrap and supplies
	Number and description of all kind of injuries/risks detected	Number and description of internal customer complaints (parts)	Pareto chart of scrap	Manpower utilization Pareto chart of losses
<b>Freq</b>	2h	2h	2h	24h

Table 14. The manufacturing performance measurement system at DDS Sant Cugat. (Source: Own elaboration).



The performance measurement system is structured in three layers. The third layer of indicators corresponds to the manufacturing lines indicators showed publicly to everyone. The second layer corresponds to the APUs measurement that results from an aggregation of the different manufacturing lines performance. The first layer used by plant direction measures the performance of the complete value streams by aggregating the performance of the different units.

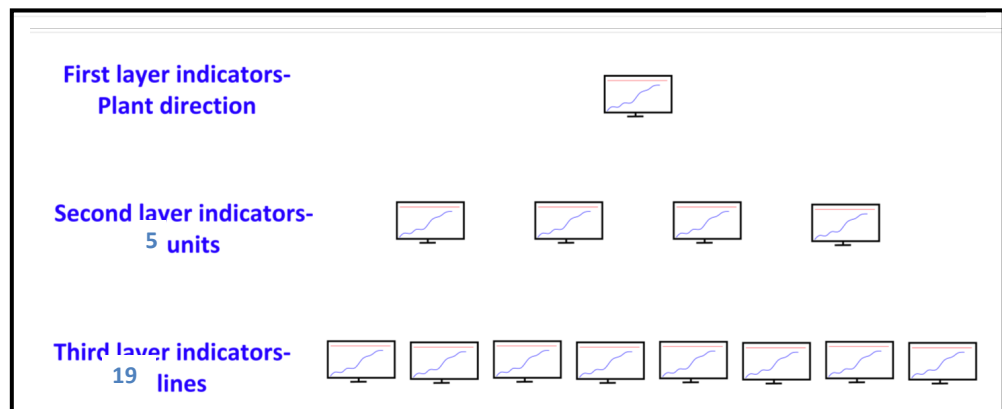


Figure 24. Structure of the indicators at DDS Sant Cugat. (Source: Own elaboration).

The OEE measure is explained in detail in the rest of this section. In DDS Sant Cugat's MPMS the OEE measure is critical due to the characteristics of the plant. The plant performs a high volume manufacturing process. Capacity utilization is of a high priority and stoppages or disruptions are expensive in terms of lost capacity. Dal et al. (2000) suggest that OEE measurement is best suited in those cases. Effectively the plant is characterized by:

- Dimension: 500 different machines that perform 150 different operations.

- Variety of manufacturing processes: drilling, electrochemical machining, heat treatment and surface hardening, turning, grinding, cleaning, assembly, test processes and painting processes.
- Variety of failure modes: Every machine has between 100 and 300 different causes that can stop production flow.

The result is that the production flow can be stopped by a very wide variety of causes. As suggested by Jonsson and Lesshammar (1999), such complexity makes it necessary to have a more detailed data collection for OEE measurement than a classification into the six big losses proposed by Nakajima (1988). The OEE is measured in 100% of the machines in the plant. The data is collected and introduced in a software system by two workers (see figure 24 for an example of collected information), following standardized routes, with a frequency of two hours (see figure 23). In order to know accurately the capacity losses, every possible failure mode is codified in every machine. The responsibilities of the workers that collect the data are also ensuring the quality of the data by teaching the workers how to use the codes in case of mistakes.

DELPHI		01/02/12		5291		120		AKOIN F120C		RIN - 2163	
Fecha:		Sección:		Fase:		Máquina:		Materi:		Mn No explicados	
Tc (seg/pieza)		piezas/hora		TNR		DESCRIPCIÓN DE PAROS		Otros /hac. cambiadas		Operario	
DM2		GMDAT		T Contratual		Causa 1		Causa 2		Causa 3	
SSY		JCB		T programado		Min	Cód	Sub cod	Min	Cód	Sub cod
NO FTQ						Cód	RF	H	Cód	RF	C
						Min	30	RF	Min	30	RF
						Cód	RF	H	Cód	RF	C
						Min	20	RF	Min	20	RF
						Cód	MP	E	Cód	MP	A
						Min	10	MP	Min	10	MP
						Cód	MP	E	Cód	MP	E
						Min	10	MP	Min	10	MP
						Cód	PRE	K	Cód	PRE	K
						Min	15	FM	Min	15	FM
						Cód	FM	B	Cód	FM	B
						Min	60	FM	Min	60	FM
						Cód	PRE	K	Cód	PRE	K
						Min	5	PRE	Min	5	PRE
						Cód	MP	E	Cód	MP	E
						Min	10	MP	Min	10	MP
						Cód	OP	A	Cód	OP	A
						Min	5	OP	Min	5	OP
						Cód	PRE	K	Cód	PRE	K
						Min	5	HTA	Min	5	HTA
						Cód	OP	A	Cód	OP	A
						Min	10	OP	Min	10	OP
						Cód	MP	E	Cód	MP	E
						Min	10	MP	Min	10	MP
						Cód	PRE	K	Cód	PRE	K
						Min	10	PRE	Min	10	PRE
						Cód	OP	A	Cód	OP	A
						Min	5	OP	Min	5	OP
						Cód	PRE	K	Cód	PRE	K
						Min	5	HTA	Min	5	HTA
						Cód	OP	A	Cód	OP	A
						Min	10	OP	Min	10	OP
						Cód	MP	E	Cód	MP	E
						Min	10	MP	Min	10	MP
						Cód	PRE	K	Cód	PRE	K
						Min	10	PRE	Min	10	PRE
						Cód	OP	A	Cód	OP	A
						Min	5	OP	Min	5	OP
						Cód	PRE	K	Cód	PRE	K
						Min	5	HTA	Min	5	HTA
						Cód	OP	A	Cód	OP	A
						Min	10	OP	Min	10	OP
						Cód	MP	E	Cód	MP	E
						Min	10	MP	Min	10	MP
						Cód	PRE	K	Cód	PRE	K
						Min	10	PRE	Min	10	PRE
						Cód	OP	A	Cód	OP	A
						Min	5	OP	Min	5	OP
						Cód	PRE	K	Cód	PRE	K
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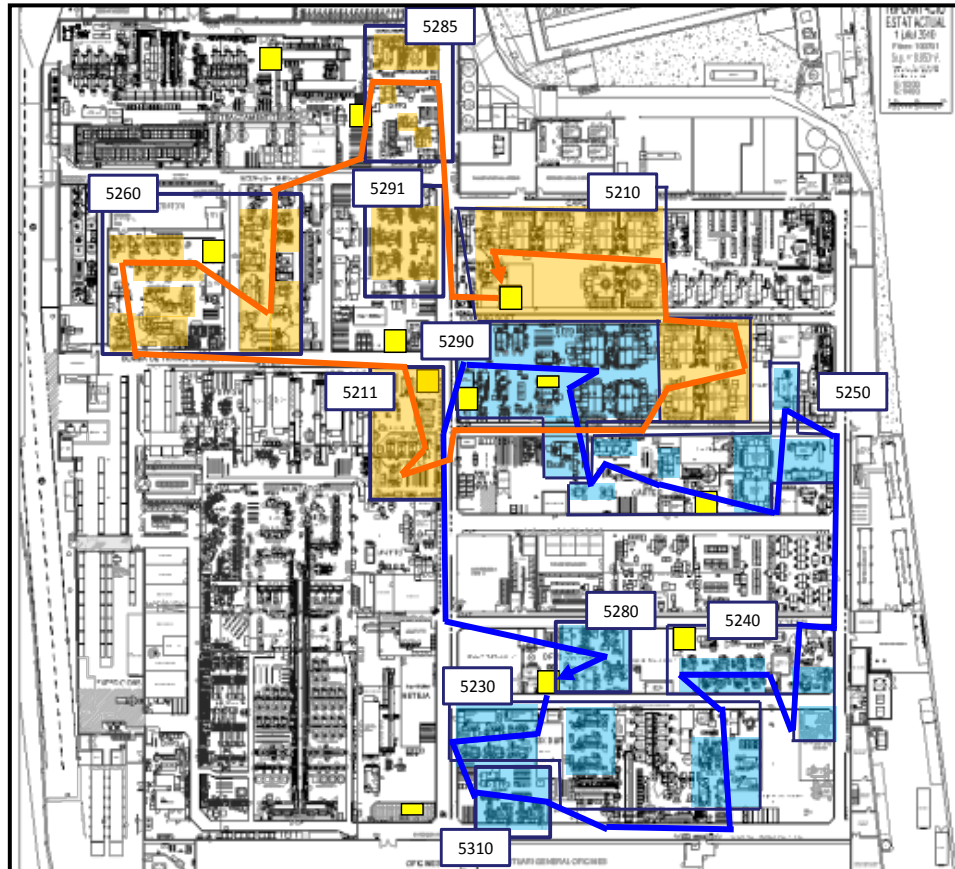
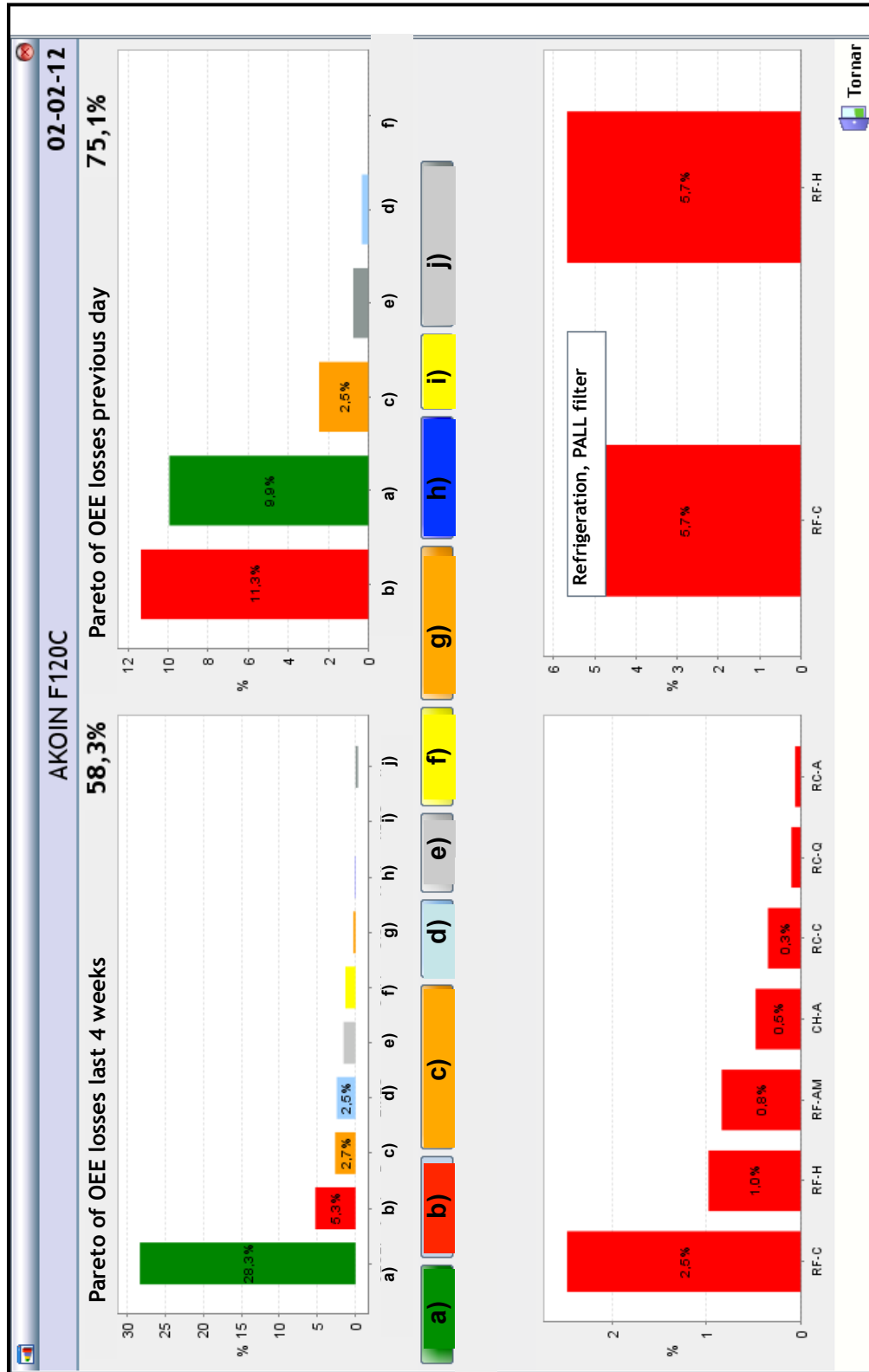


Figure 26. Routes of the two workers that collect data every two hours (blue route and orange route) at DDS Sant Cugat. (Source: Delphi Diesel Systems S.L.)

The information collected is then introduced in an IT system. This computer system allows everybody to have access to the information at any moment in any aggregation level. In the following picture there is an example of how the information is displayed. The system always shows the Pareto chart of the losses from last day and the last four weeks classified within the six big losses proposed by Nakajima (1988) (see next figure). Any big loss can be selected in order to have more detailed information about the exact reason of stoppage. For example in next figure the breakdown loss is selected (accounts of 6,3% of losses in the last four weeks and 11,3% in the previous day) and the Pareto of the exact causes are displayed.



a)-j) indicate: a) Idling and minor stoppage losses b) Breakdown losses c) Start-up losses d) Set-up losses e) Errors in the measure f) Quality defects g) Adjustment losses h)&i) Rework losses j) Reduced speed losses

Figure 27. Example of the OEE measure at DDS Sant Cugat. (Source: Delphi Diesel Systems S.L. translated to English.)

For OEE target setting, DDS Sant Cugat uses the concept of Operation Rate (OR) which is defined in internal manuals as the “minimum level of OEE to meet customer demand”. OEE performance lower than OR in one machine means a risk of stopping the complete flow of a product. The calculation of the operation rates is made based on the coming month’s demand, machines opening hours and machines cycle times with an OR-calculation standard tool (see next figure). The OR concept is used for target setting in the MPMS and gives the OEE measure a complete flow and customer orientation. The comparison of the OEE levels with the OR makes it possible for the decentralized teams to quickly identify bottlenecks and focus on the production flow and external customer needs.



by showing the information that must be checked (result indicators) and allowing the possibility of going into detail (process indicators). The meeting system applied in DDS Sant Cugat differentiates between daily meetings called “Daily stand-up meetings”, weekly and monthly meetings called “operating review meetings” and quarterly meetings called “top5 focus meetings”.

The objective of the daily meeting is to define the abnormalities of the day before and the risks for the current day based on the information provided by the result indicators compared to the planned performance in terms of security, quality, volume and cost. In case of abnormalities, the associated process indicator is checked in order to quickly understand and react to the problems. For example, OEE measure is only checked in case that the volume was lower than the customer needs. This meeting is performed every morning in the shop floor by the APU staff (APU manager, quality manager and manufacturing engineering manager). After the meeting the DDS Sant Cugat directors do a plant tour through the five APUs in order to quickly review the major abnormalities and risks. The manufacturing teams that work in shifts also perform the daily stand-up meetings but with a lower scope.



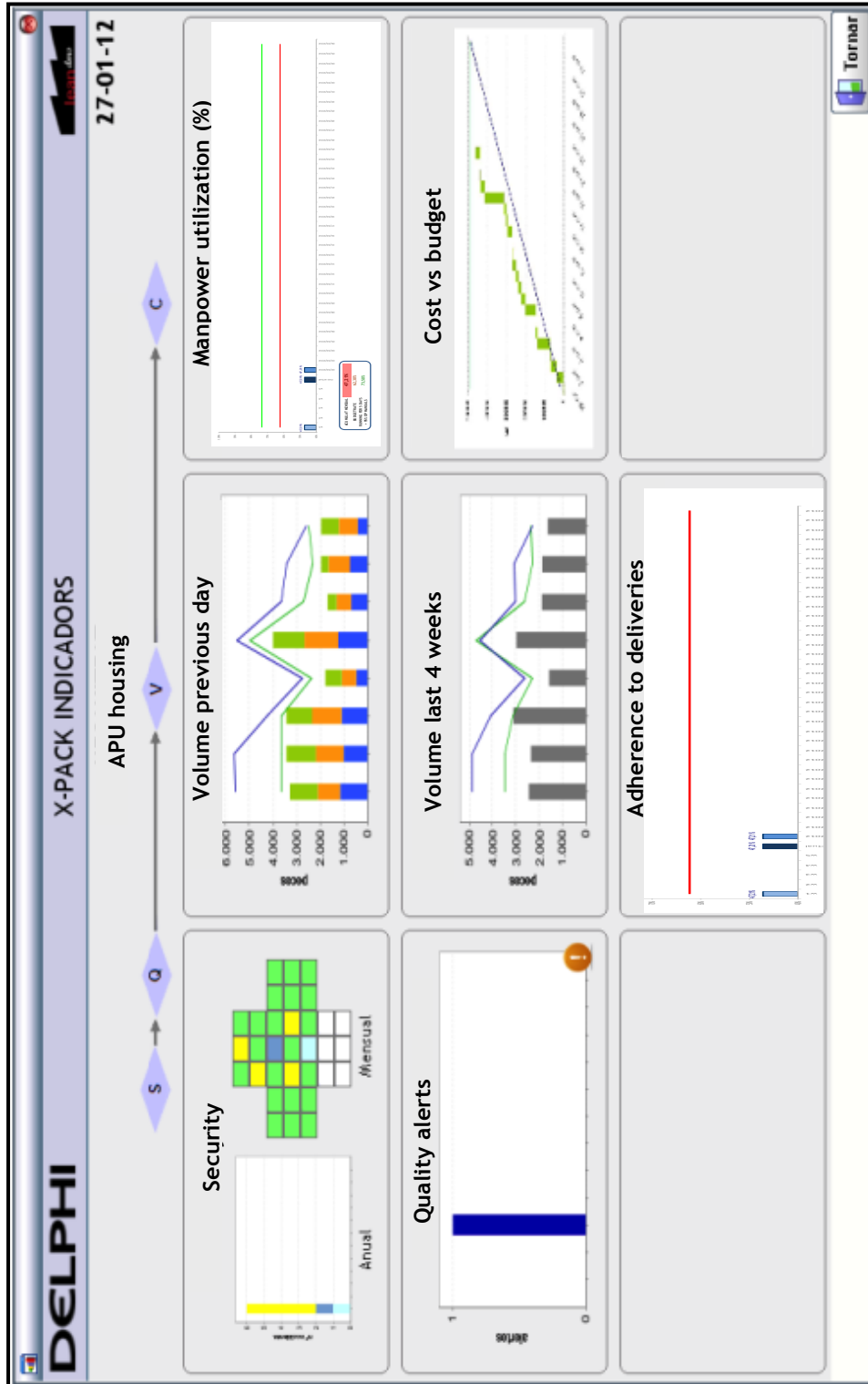


Figure 29. The manufacturing performance system that supports the daily stand-up meetings at DDS Sant Cugat. (Source: Delphi Diesel Systems S.L.)



*Figure 30. Example of a meeting area at DDS Sant Cugat where the daily stand-meetings are done. There are one per team leader team. (Source: Photo done on a visit to Delphi Diesel Systems S.L.)*

The operating review meetings have the objectives of planning, result indicators performance review and continuous improvement. These meetings are performed on a weekly basis by the APU staff. On a monthly basis the team presents their performance results and the action plan to the plant directors. The TOP 5 focus meeting is performed every quarter with the purpose of selecting the most important improvement projects. The APU staff define their performance dimension focus called “business problem” between security, quality, volume and cost (in order of importance). The definition of the “business problem” is based on result indicators with targets linked to internal and external customer needs. It is decided which the five most important projects are, that the team will focus on. These are called the “TOP5 priority projects” and they are focused on the performance

dimension that will have more impact on APU's internal and external performance as suggested by Skinner (1974). In next figure, there is an example of the TOP5 priority projects from the fourth quarter of 2011 (Q4 2011) listed in order of importance.


	QVC	Title (including target)	owner	achieved	saving (k€)	Status	
	1	V	OEE IMAS DFP1 (55% → 61%)	JR	55%	V	Repeat
	2	V	OEE IMAS AI DFP1 (60% → 68%)	PR	67%	V	100%
	3	V	OEE HO DFP3 hard stage (70% → 80%)	JR	80% (no FM)	V	100%
	4	V	ROF Heat Treatment founds	PR	100%	V 40k€/y	100%
	5	Q - C	Material reduction in jail by 15% (124keur current)	PR	99k eur	25k eur	100%

Figure 31. Example of APU TOP 5 focus meeting conclusions at DDS Sant Cugat from the fourth quarter of 2011 (Q4 2011). (Source: Delphi Diesel Systems S.L.)

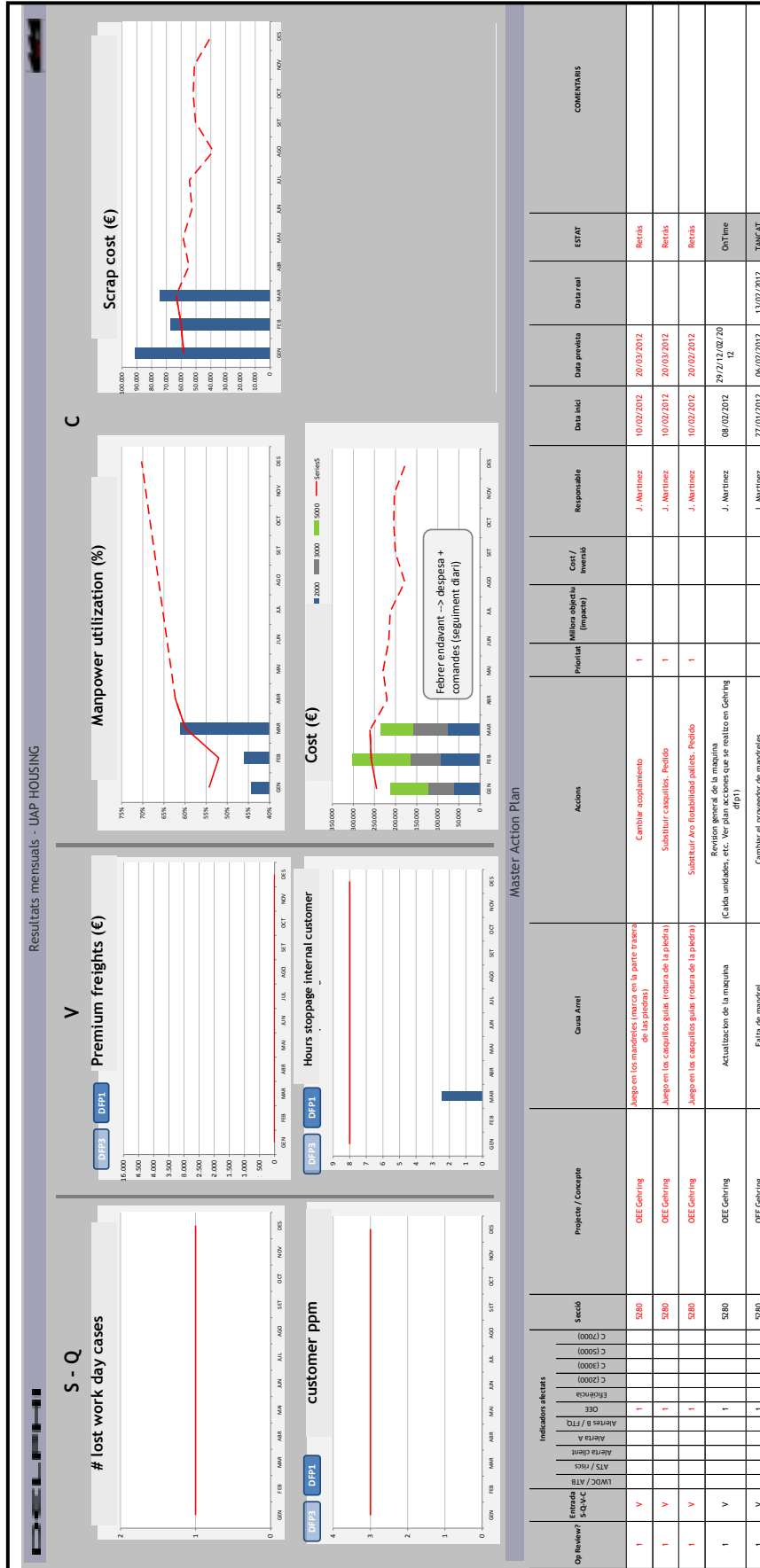


Figure 32. The manufacturing performance measurement system that supports the operating review meeting at DDS Sant Cugat. (Source: Delphi Diesel Systems S.L.)

#### **4.2.4. Results**

The solution presented in this case resulted in being highly successful, with an increase of OEE levels from 5% to 10% from January 2009 to January 2012. The following table shows how the current OEE values are very close to the design OEE. The design OEE is the OEE that the machine can perform based on the manufacturing process. Higher values than design OEE can only be achieved through a redesign of the machine.

<b><i>Manufacturing process</i></b>	<b><i>Number of machines</i></b>	<b><i>OEE average January 2012</i></b>	<b><i>Design OEE</i></b>
Drilling	10	65%	65%
Drilling	2	68%	70%
Heat treatment and surface hardening	1	97%	95%
Electrochemical machining	4	75%	80%
Grinding	7	85%	85%
Cleaning	3	95%	95%
Assembly	20	95%	95%
Test	10	80%	80%
Painting	1	90%	90%

*Table 15. OEE results vs design OEE values at DDS Sant Cugat. (Source: Delphi Diesel Systems S.L.)*

The result indicators also show radical improvements. The use of an integrated near real-time performance measurement and formal meeting

system made it possible for the APU teams to focus on the volume performance dimension and the aspects that would have a critical impact in the volume increase. From the first quarter of 2009 to the fourth quarter of 2012 there was an increase of volume of 120%, with no capital expenditure in new equipment, through bringing OEE values close to the design OEEs and several cycle time improvements. It must be noted that the new MPMS and the formal meeting system described in this case had an important contribution to this achievement but they are not the only factors that had influence in this achievement.

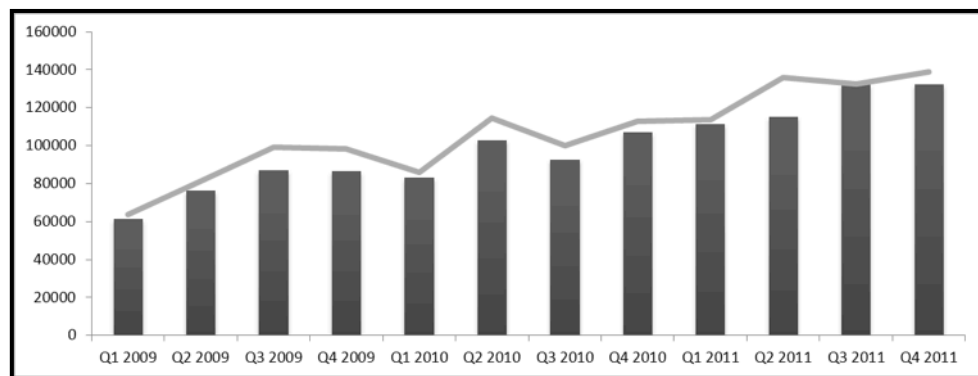


Figure 33. Volume evolution vs. target volume from 2009 to 2011 at DDS Sant Cugat.  
(Source: Delphi Diesel Systems S.L.)

#### **4.2.5. Conclusions**

This case shows a study of a plant that has been applying the concepts of organization in autonomous production units (APUs), value stream based performance measurement and meeting system for more than ten years. In 2009 DDS Sant Cugat faced a new and demanding challenge. Due to the high demand the strategy of Delphi consists in taking as much advantage as possible of the capacity of the plant. To serve these objectives the performance management boards were changed by an IT supported near

real-time manufacturing performance measurement system (MPMS) that gives great importance to the overall equipment effectiveness (OEE) measure. The information provided by the MPMS, which measures the performance of the APU teams at a group level, is used in a formal meeting system. According to the interviewee, Jaume Roquet, Operations Director “the organization in APUs, a real time robust measurement system and the meetings, for us constitute one system. It makes the teams to be focused on the aspects that will make a difference in the performance of the business.” The application was highly successful and allowed the plant to cope with the increasing customer demand.





## **4.3- CASE STUDY C- Plant X from the furniture industry**

### **4.3.1 Characteristics of the case**

#### **4.3.1.1. The company**

Plant X is part of a leading company of the furniture industry. Due to confidentiality no more information can be detailed in the company description.

#### **4.3.1.2. Products and processes**

The describe case corresponds to the lean transformation at Plant X. Data was collected through an interview with the lean manager, informal interviews with APU managers and team leaders and a visit to the plant in June 2011. Plant manufactures mostly customized products but also offers standard products. Due to confidentiality no more information can be detailed in the description of the products and processes.

### **4.3.2. The production system**

From 2008 to 2011 a deep transformation of the production system took place. The following key elements achieved a critical impact in terms of performance:

### 1) *Flow layout*

The plant has been transformed from a functional layout configuration (with machines which are grouped per technology) to one organization in a flow layout dedicated to one complete value stream. The material within the manufacturing cells organized in flow layout is minimal between operations. There is only one management point, which is in the end of each manufacturing cell. Due to the fact that every manufacturing cell performs one product group, the changeovers can be done in a simpler way and it is possible to produce smaller batches. Other advantages are reduction of complexity, stability, drastic improvement in inventory levels, lead time reduction, quality and flexibility while reducing machine utilization. According to Plant X's lean manager,

*“The plant is not designed for visits; it is designed for the value streams. Before we had a traditional workshop, the benefits have been enormous [...] The transformation has been key for us, because we can manufacture very customized and complex processes simple to manage. [...] The logic is: ¿What does my customer want? [...] the improvements have been clear in terms of productivity”*

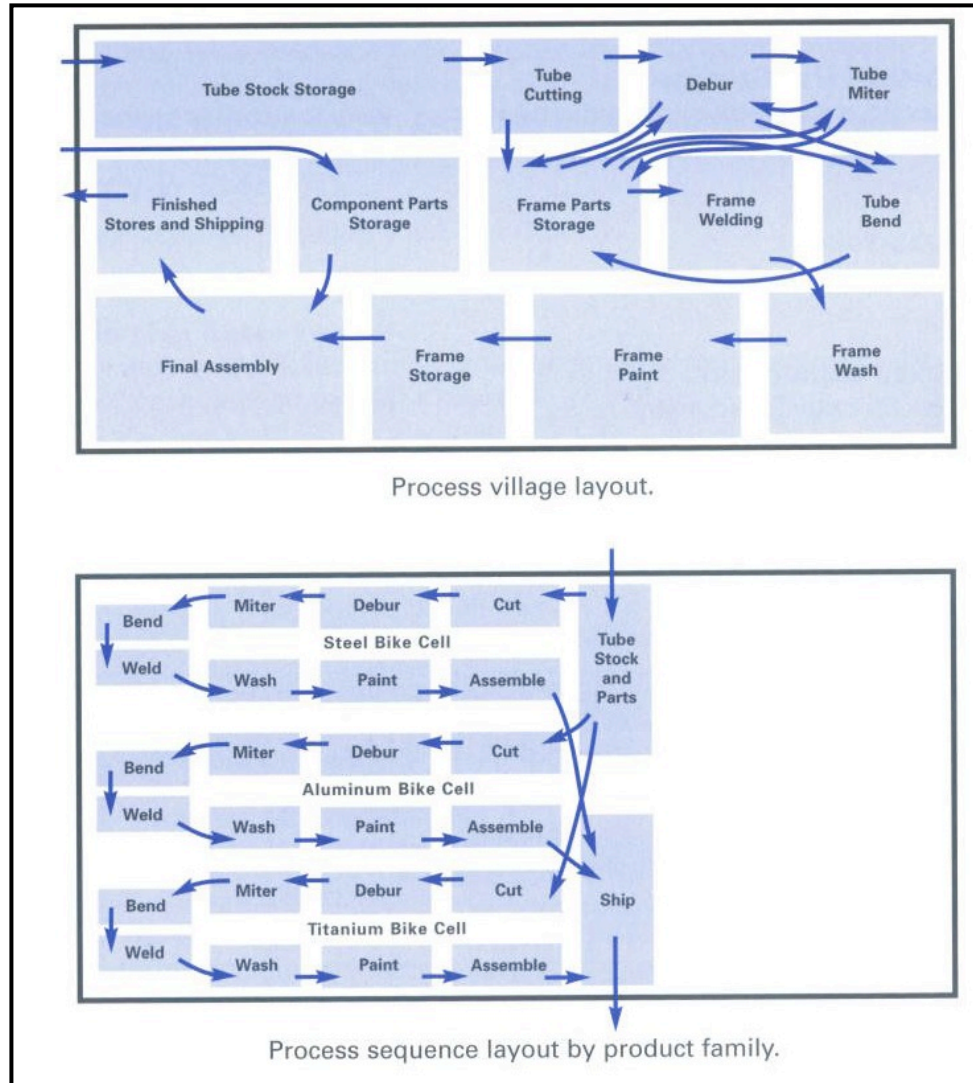


Figure 34- Example of transformation from a functional layout (process village layout) to a flow layout (process sequence layout by product family) similar than Plant X transformation. (Source: Marchwinski and Shook, 2003).

## 2) Standardization of the customized products operations

The majority of the products manufactured are customized; however the manufacturing process is totally standard. Every workplace has a standard work, with different production rhythms that does not vary whether the product is standard or customized. The workplaces of the flow layout lines have been redesigned grouping all the operations that are similar for all the products in specific workplaces. For example, in a cutting operation the

operator receives the material with the manufacturing order where the measure of the cut is specified. In operations where there are greater variations among products more workplaces are added depending on the complexity. In this way, during the industrialization the standard works of the workplaces that perform the customization are defined, balanced to the standard operations. Next figure shows an example of the tool used for line balancing; the Operator Balance Chart.

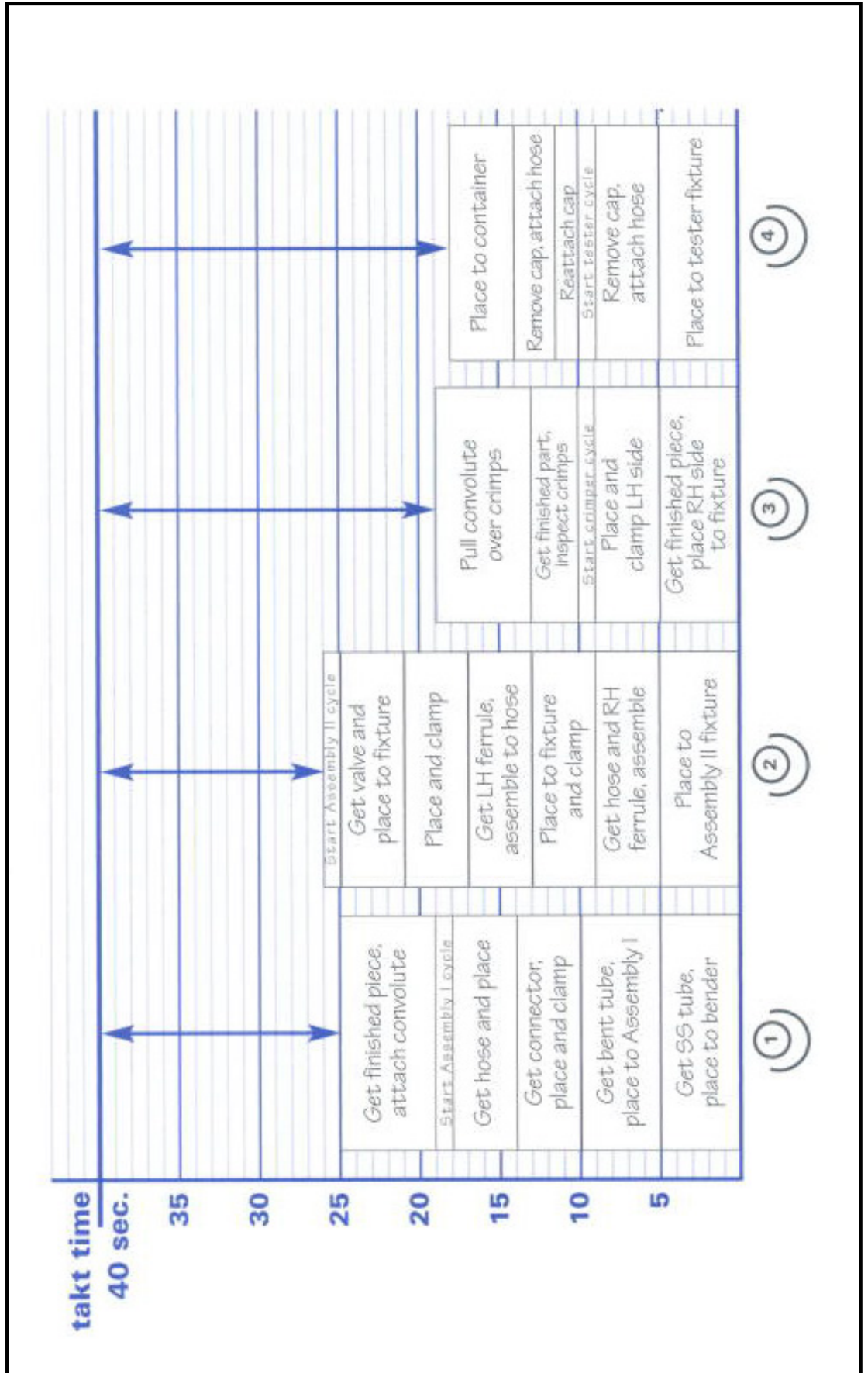


Figure 35- Example of line balancing with an operator balance chart similar to the one used at Plant X. (Source: Marchwinski and Shook, 2003).

### *3) Robust continuous flow scheduling*

Due to the product diversity, it is critical to have a robust scheduling system to guarantee the customer delivery. When a customer performs an order in a distribution center, the planner generate a customer delivery date and production date by means of an algorithm (taking into account the workload of the plant, customer location and transport routes). In this moment, the development and industrialization is started. The lead time for standard product is approximately 1 week and the average of the sector is 1 month. The lead-time for customized products is 3 weeks if it does not require design and 4-5 weeks if does require it. The products are produced the same day as they are shipped; the lead-time of the value stream manufacturing cells is lower than eight hours. The schedule of each product is made by means of an IT supported algorithm that groups the production orders of the day by colors in order to minimize the painting change over. Before printing the final sequence of the day, manufacturing can change the order of the orders.

#### **4.3.3. Organizational practices**

The profound transformation of the production system at Plant X is clearly based on value streams. The transformation has been accompanied by the adaption of the organizational practices to the production system and therefore to value streams. The following three organizational practices are differentiated:

#### 4.3.3.1. Organizational units based on the value streams

The plant is organized in four autonomous production units (APUs) in charge of each value stream manufacturing cell. The APUs integrate the functions of manufacturing, quality, lean/industrial engineering and maintenance. The focus is to integrate the quality and maintenance functions into the tasks of the operators and team leaders.

The operators are exclusive for every APU, it is considered more important that an operator is known by all the team, has experience in the quality criteria of the product group and polyvalence in all the processes in an APU than an specific knowledge in one operation.

*“ Due to the high product variety it can happen that the workload of an APU may be higher than in other [...] the experience taught us that moving operators from one APU to another is a tremendous loss of productivity and a quality risk. It is key to have operators that are polyvalent within one APU but when we exchange operators, we have problems [...] The “Tack time” can vary by 50% due to that fact. This used to be a common mistake”*

Plant X lean manager

In customized products, a very important part of the value stream is made in the design value stream (140 of 300 employees are indirect workers). In these processes, even though they have a high frequency (from 16 to 18 new industrializations of new products every day) one can lose the notion of the

value stream. To avoid that, the project manager coordinates the value stream of customized products (from customer needs, design value stream to delivery to the customer) and is accountable to the customers. The project manager is the person that is in charge of all the horizontal coordination from the functional departments located in Plant X. That person assures that the information flows to the customer; it is a figure with power and has exclusive resources assigned to the project. One important task of the project manager is to guarantee that the product is integrated in a standard and agile way to the production system. In that way, a new product should arrive to the manufacturing lines in the same manner as a standard product. Scheduled with the standard system, with the same production cycle as standard products and with the standard works defined.

*“When one product enters in the value streams the costs increase exponentially. With the product diversity that we have, we have to implement some lean tools before the products enters into the manufacturing lines. We have to work on the paper 85% of the industrialization and until 100% in the plant. That is something that we do very often, we are industrializing more than 10 new products every day. Some products have big variations and others are completely different.”*

Lean manager at plant x



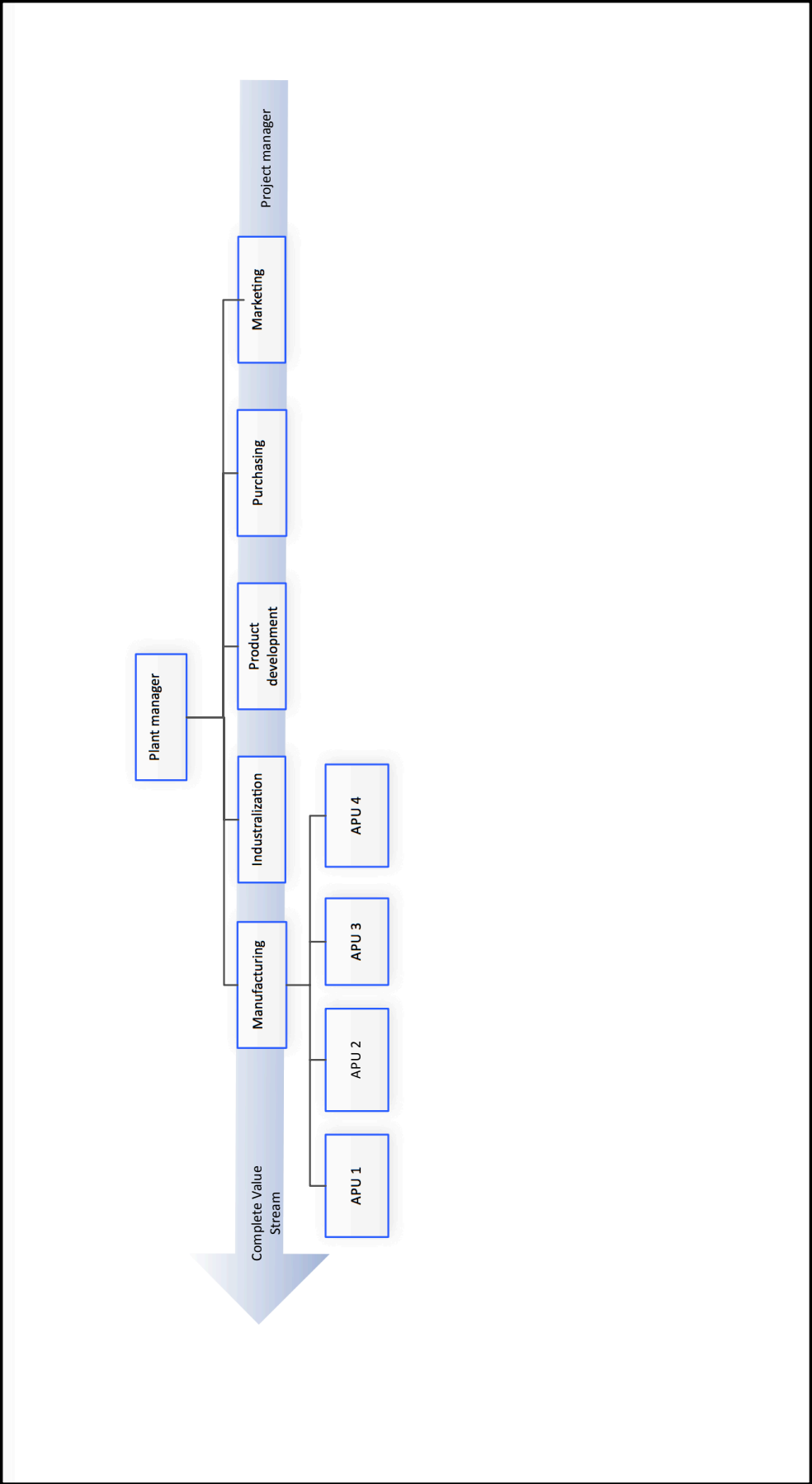


Figure 36. Organization at Plant X. (Source: Own elaboration).

#### 4.3.3.2. Performance measurement system based on value streams

The indicators are organized in the same manner as the APUs, by value stream, and posted visually in the shop floor on performance management boards with manual collection methods and daily update frequency. The performance measurement covers security, quality, volume and cost dimensions. Every performance dimension has at least one result indicator (that defines what to achieve) and one process indicator (that defines how to achieve it), as suggested by De Haas et. al. (2000). The performance management boards are composed by result indicators, process indicators and also information about continuous improvement activities. These measures are operational; the costs are not assigned to the value stream segments with value stream costing. In the following table the refreshment frequency of the different indicators is also described.

	<i>Security</i>	<i>Quality</i>	<i>Volume</i>	<i>Cost</i>
<i>Result indicator</i>	Number of accidents	Customer complaints	Service level	Productivity
				Material scrap
<i>Process indicator</i>		Rework pareto	OEE	
<i>Frequency</i>	24h	24h	week	month

Table 16. Value stream performance measurement system at Plant X. (Source: Own elaboration).

The performance measurement system is structured in three layers. The third layer of indicators corresponds to the manufacturing lines indicators showed publicly to everyone. The second layer corresponds to the APUs measurement that results from an aggregation of the different manufacturing lines performance. The first layer used by plant direction measures the performance of the complete value streams by aggregating the performance of the different units.

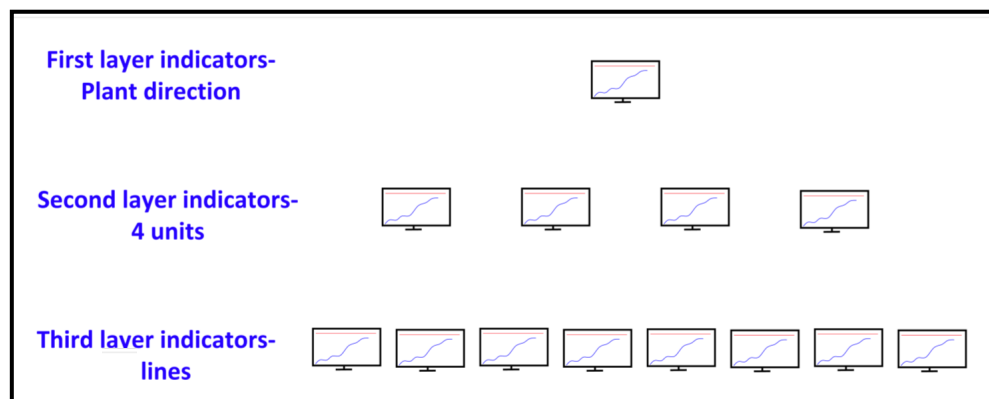


Figure 37- Structure of the indicators at Plant X. (Source: Own elaboration).

The third layer is composed by indicators of every continuous flow production line by means of a production analysis board similar to the one in the next figure. It is a way that everybody in a visual manner can see the problems. The refreshment frequency is hourly.



#### 4.3.3.3. Formal meeting system

A formal meeting system standard for the four APUs is applied based on the information provided by the value stream based performance management boards. The meeting system applied in Plant X differentiates between daily meetings and monthly meetings.

The objective of the daily meetings is to define the abnormalities of the day before and the risk for the current day based on the information provided by the performance management boards in the shop floor. The daily meetings are organized in a standard way across the corporation in four levels.

- Level 4: plant manager with pre-production and APU managers
- Level 3: APU manager with the functions integrated in the APU: lean, quality and engineering.
- Level 2: APU manager with team leaders
- Level 1: team leaders with operators.

The monthly meetings have the objectives of planning, result indicators performance review and continuous improvement. The second layer indicators that are used to support the monthly meetings are similar to the next figure.

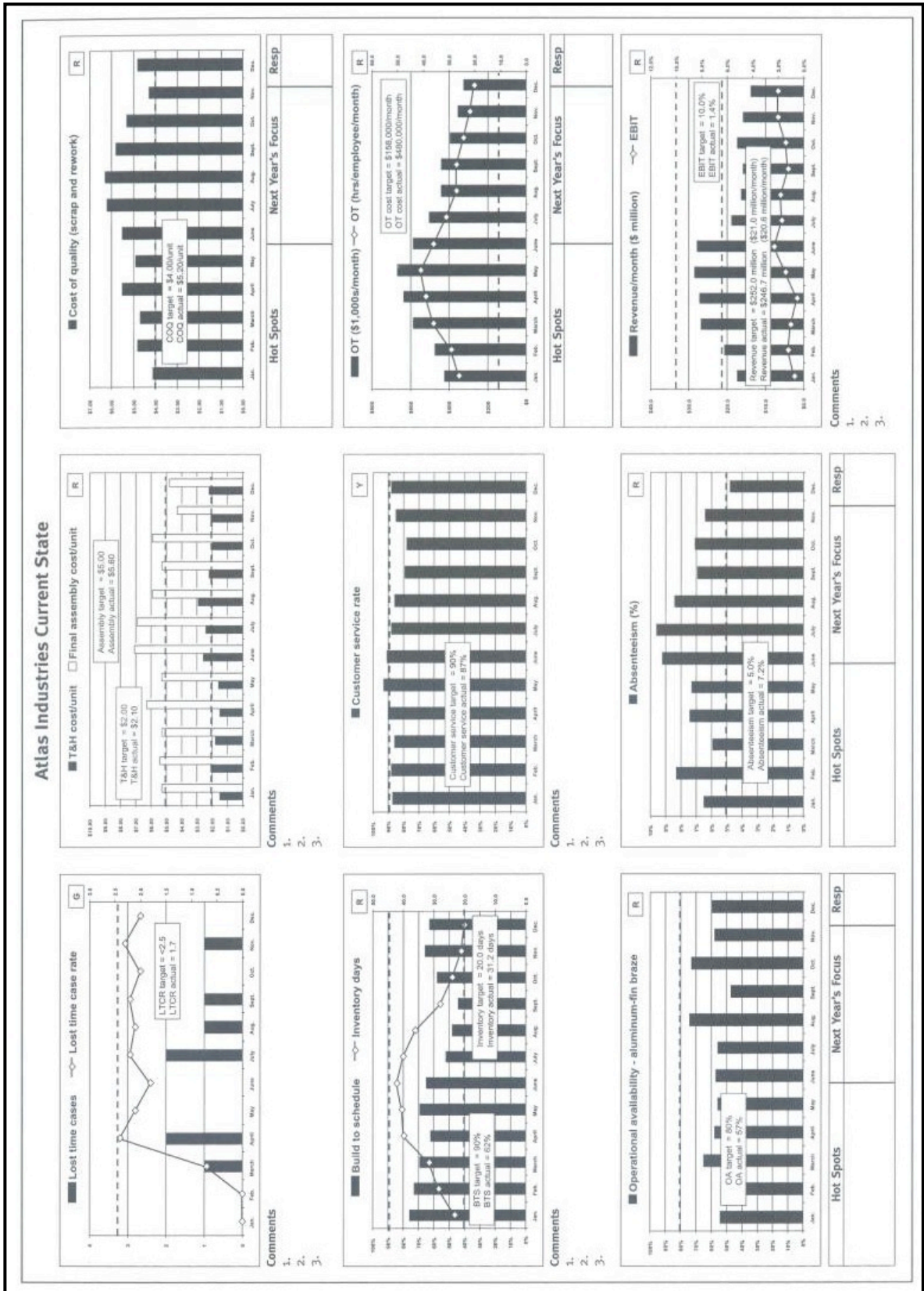


Figure 39- Example of performance measurement system similar the one used in Plant X.  
(Source: Marchwinski and Shook, 2003).

#### **4.3.4. Results**

The transformation described in this case was highly successful, the company increased market share by increasing flexibility offering totally personalized products, with a lead-time, which became four times shorter than the average of the sector. All of that with service levels of 97% and customer quality of 99%. The productivity increased with 10% between 2007 and 2011. The transformation of the production system resulted in a drastic reduction of the inventory levels, reduction of scrap material and reduction of the equipment necessary to support manufacturing. All those results were reached with minimal investments and without automations.

#### **4.3.5. Conclusions**

This case shows the lean transformation of a plant that was facing a market drop and aimed to increase market share by an enhanced competitiveness. To face these objectives, Company X performed a deep transformation of the production system in order to allow a wide variety of products with the best results and the minimum amount of complexity. This was done by arranging the complete layout, originally organized functionally, in a flow layout where a single manufacturing cell performed a complete value stream. The manufacturing cells were redesigned to standardize the operations for customized products and robust system to schedule the value streams was established. The transformation of the



production system has been accompanied by the adaptation of the organizational elements to the production system and therefore to the value streams through an organization in APUs, value stream based performance measurement and a formal meeting system.



## **4.4- CASE STUDY D- RENAULT engines plant, Valladolid**

### **The Renault production system (RPS)**

Renault S.A. is a French automaker which is present in 118 countries and employs 128.322 persons (Renault, 2012). Headquartered in Boulogne-Billancourt, Renault owns the Romanian automaker Automobile Dacia and the Korean automaker Renault Samsung Motors. Renault also owns subsidiaries RCI Banque (providing automotive financing) and Motrio (automotive parts). Its alliance with Nissan makes it fourth-largest automotive group.

The Renault Production System is widely acknowledged by its pioneer application of organizational units based on the production flow through team work and organization in “autonomous production units”. Freyssenet (1977) studied team work at Renault. According to the author, team work was first introduced in Renault in the 1970's by a few managers in an attempt to reform work and in particular assembly line work.

*"Team work is conceived of as polyvalent and multifunctional work undertaken by a team of 20 persons. The Unit is defined by the component, mechanism or subassembly that it makes. It is led by a Unit leader, who constitutes the first hierarchical level. It controls and analyses its own production parameters. It enters*

*into buyer supplier relations with the other teams upon which it depends, upstream and downstream in the production process. What is expected from this form of work organization is an ability to react to problems, an improvement in the quality of products and of the functioning of machines, a greater flexibility of production, a development of competencies, an increased interest in work, and finally the modification of hierarchical relationships. Freyssenet (1995) "*

Freyssenet (1995) concluded that while for Japanese automobile producers team work was and remains a means of getting employees to participate in improving productivity, quality and flexibility, rather than a means of responding to disaffection with industrial work (which is more the case today). According to the author, at Renault the theme of enriching work and offering a career path to workers remains one of the essential factors behind the choice of this form of work organization, even if other considerations and imperatives have arisen to embed it, redefine it and justify it for all.

Gorgeu and Matieu (2005) analyzed teamwork in French car manufacturing plants and those of their suppliers. According to the authors, the concept of autonomous production units started its application in France in 1990s first in Renault and after at Peugeot. During the 1990s, the introduction of 'autonomous production units' was aimed at reducing costs, increasing quality and shortening delivery deadlines. The objective was to reorganize the workers' responsibilities by integrating different tasks at different levels of responsibility in order to offer the workers the means of acquiring new skills and reinforcing their autonomy. Following their example, the

suppliers introduced the units very gradually as an experiment in a workshop or a new factory before generalizing the concept (Gorgeu and Matieu, 2005).

The Renault official webpage, Renault, (2012) describes the different responsibilities for the different manufacturing positions which are standard across the entire group:

- *Production department manager*: production department managers have a twofold responsibility. As members of the plant Management Committee, they help to draw up plant strategy and roll out that strategy in their sector. They are responsible for the performance and production level of their department. They have overarching knowledge of the manufacturing functions, manage projects and possess strong interpersonal and managerial skills.
- *Shop foreman*: shop foremen are an essential link in plant performance. Responsibilities range from applying production standards to staff development and involvement to real-life contribution to new projects.
- *BWT (Basic Work Team) leader*: the first management level in Renault's organization structure. The BWT leader coordinates the activity of a team of around 20 people (operators and technicians) and meets production objectives on a day-to-day basis.

- *Operator*: at the heart of the Renault production system. Job positions include: industrial operator, equipment operator, touch-up operator, machining specialist, tool grinder, maintenance professional, toolmaker/developer and fork-lift truck driver.

In order to convert actions to real and measurable activities linked robustly to the plant strategy, the RPS uses a performance measurement system based on the concept of strategy/policy development. The strategy/policy development has its origins in the concept of Hoshin Kanri. With the objective of aligning senior managers' strategic objectives with the organization, Ishikawa, (1985) diffused the strategic planning/strategic management methodology of Hoshin Kanri. It assumes daily controls and performance measures are in place: According to Akao, (1988), with Hoshin Kanri, the daily crush of events and quarterly bottom-line pressures do not take precedence over strategic plans; rather, these short-term activities are determined and managed by the plans themselves (Akao, 1988).

*"Each person is the expert in his or her own job, and Japanese TQC (Total Quality Control) is designed to use the collective thinking power of all employees to make their organization the best in its field [...] Top managers and middle managers must be bold enough to delegate as much authority as possible. That is the way to establish respect for humanity as your management philosophy. It is a management system in which all employees participate, from the top down and from the bottom up, and humanity is fully respected. Ishikawa, (1985)"*

The Strategy/Policy Development is explained in the Renault-Nissan consulting official webpage (Renault-Nissan Consulting, 2002). Note that Renault-Nissan consulting is a firm dedicated to support companies from different sectors to achieve operational excellence. It is not dedicated to spread the RPS, which is confidential. According to Renault-Nissan Consulting, (2012) the benefits of the The Strategy/Policy Deployment approach at Renault are:

- All departments aligned and focused to meet the common goals
- Provides a structured way to review the progress to these goals
- Objectives look beyond an annual planning cycle
- Key areas for improvements identified
- All the underlying objectives are attained and the higher goal is automatically achieved
- Creates and underpins a Continuous Improvement culture.

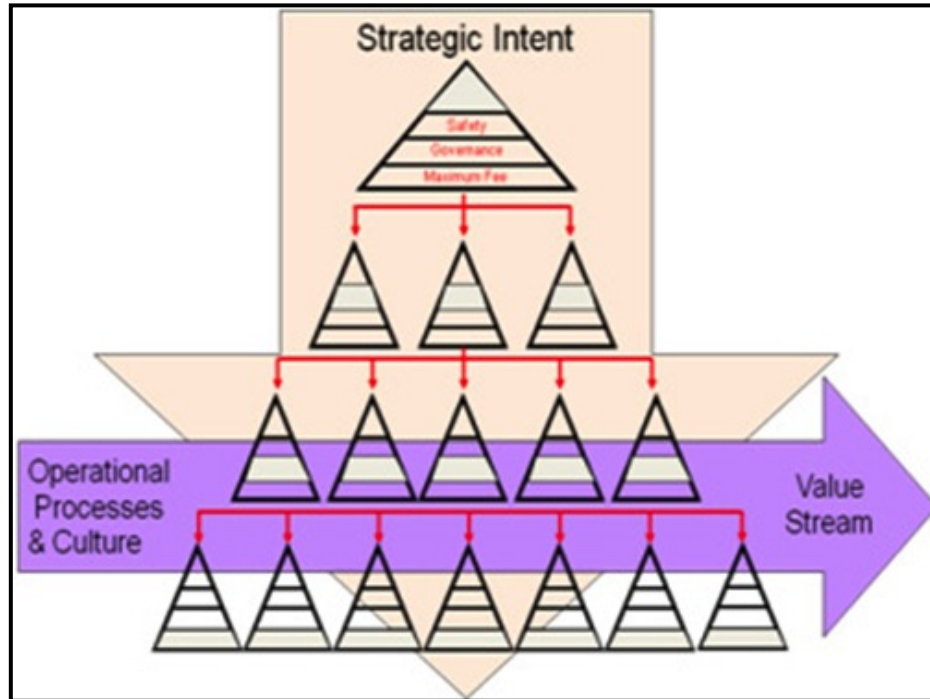


Figure 40. The Strategy/Policy Deployment according to Renault Nissan Consulting. (Source: Renault-Nissan Consulting, 2012)

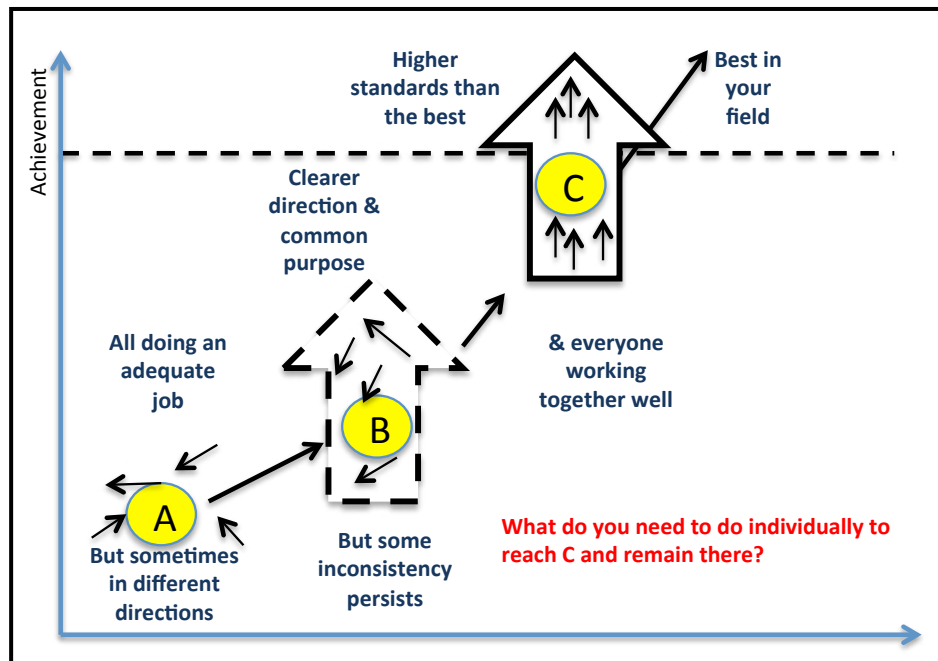


Figure 41. Benefits of the Strategy/Policy Deployment according to Renault. Nissan Consulting (Source: Adapted from Renault-Nissan Consulting, 2012)



#### **4.4.1. Characteristics of the case**

##### **4.4.1.1. The company**

This case takes place in the Valladolid Engines plant of Renault. Data was collected through an interview with the RPS manager, informal interviews with setters and a visit to the plant in June 2012. The factory started production in 1965 and has 1.713 employees (Renault, 2012). It is one of the most important engine plants in the group, it exported 85% of the production and accounted for 37% of the engines produced by Renault in 2009 (Renault, 2012).



*Figure 42- Renault Valladolid Engines plant. (Source: Renault Valladolid Engines)*

##### **4.4.1.2. Products and process**

Valladolid Engines manufactures petrol and diesel engines along with a range of powertrain parts including cylinder heads, crankcases and condors. The product range is composed by different versions of two diesel engines, K4 and K9 and two gasoline engines, H4 and H5 for medium duty and

heavy-duty applications. From March 2009 the H4J is manufactured exclusively in the plant for the entire group. The plant is characterized by its big dimension and product diversity. Valladolid Engines is divided into three departments separated physically.

- Engines 1 and engines 2: The machining of components. Six components are machined in separated manufacturing facilities and supply the material to the assembly lines as internal suppliers.
- Engines 3: The assembly of both gasoline and diesel engines is performed. It is composed by four continuous flow assembly lines that manufacture 4 products with a wide range of different part numbers.



*Figure 43. Valladolid Engines Plant. In the aerial photo it can be seen that the three departments are physically separated (Source: Renault, 2012)*

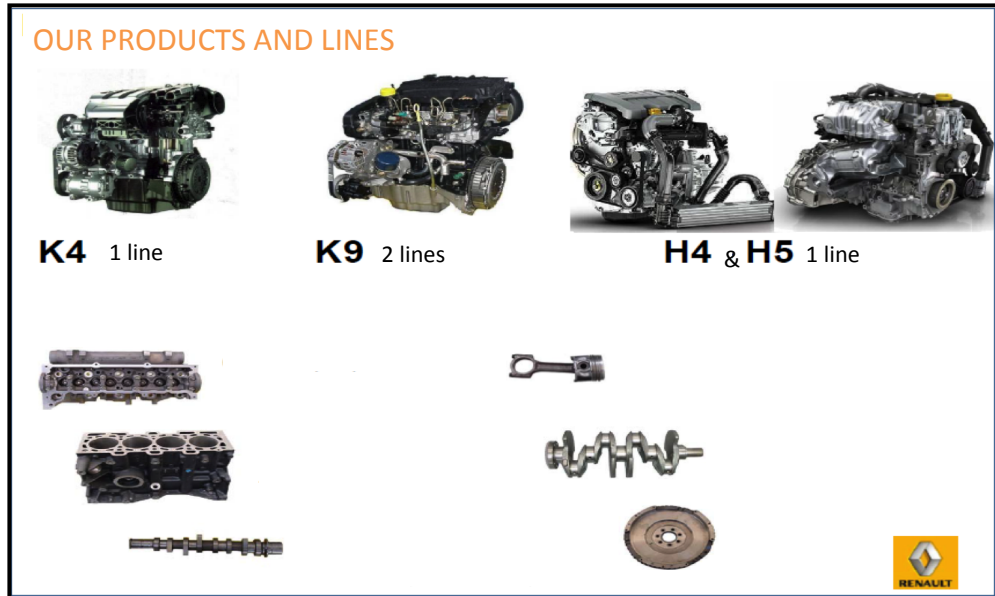


Figure 44- Manufactured products at Valladolid engines (Source: Renault Engines Valladolid. Translated to English)

#### **4.4.2. The production system**

The Renault Production System (RPS), which was inspired in the Nissan Production Way, was developed when the alliance Renault Nissan started. According to internal documentation:

*“To manufacture one product without defects and deliver it on time is the first commitment for Renault with the customer. The Renault Production System (RPS), inspired in the Nissan production system, responds to this double exigency. That system, which is the means for progress in the engines plant, guarantees that all the Renault factories worldwide work in the same manner, achieving an adjusted production and an excellent final product.”*

According to the interviewee, the contribution of the RPS was to give coherence to all the different systems or tools that they applied, for instance:

workplace standardization, team work, quality circles or Kaizen groups. The systems and tools were gradually adapted to the SPR. Nowadays the SPR is a mature production system which is highly standardized across all Renault facilities around the world. Effectively according to the interviewee:

*“The RPS is exactly the same in all facilities of the group... This is the advantage of having a strong production system... I went to two plants when they were acquired... and... they used very different systems... today there is no difference with any other plant in the group, they use the same system”*

Javier Sáinz Velicia, New projects and SPR manager at Valladolid  
Engines

The RPS highlights the importance of organizing the plants in manufacturing cells with a layout in continuous flow that manufacture a product group from beginning to end. Effectively, the layout in the sub plants is organized in continuous flow, with minimum inventory levels between operations. Due to the fact that every line manufactures a product group, the changeovers can be done in an easier way. Other advantages are the management simplicity, lead time reduction, quality and flexibility, with the disadvantage of lower machine utilization. In this case, the product has a big dimension, which makes it a simple solution to organize the production around a moving line in continuous flow.



*Figure 45- Continuous flow organization of the production lines at Valladolid engines.  
(Source: Automocionqualiauto, 2012)*



*Figure 46- Continuous flow organization of the production lines at Valladolid engines.  
(Source: elmundo, 2012)*





*Figure 47- Plant photo during the visit at Valladolid Engines. It can be observed the continuous flow organization of the production lines (Source: plant photo during the visit).*

In order to manage the wide product diversity, the components that customize the engine come sequenced to the lines through an automatic system that is standard across the group. The RPS has a central team in France that gives assessment to the implementation to all the plants of the group.

#### **4.4.3. Organizational practices**

The RPS also highlights the importance of adapting the organizational practices to the production flow and in consequence to value streams. According to RPS documentation: *“The effectiveness of the system is based in the persons, the commitment, the rigor and the responsibility of everyone involved in the product, from initial conception to delivery to the customer”*.

#### 4.4.3.1. Organizational units based on the value streams

According to the interviewee team work started in the plant in the 1970s and it was evolved in 1990 into an organization in “autonomous production units”. The autonomous units are called Basic Work Teams (BWTs). The hierarchy within the plant consisted of five layers: plant manager, production department manager, shop foreman, basic work team leader and operators. The plant is organized in three sub plants managed by a workshop manager that has the functions of quality, manufacturing engineering and maintenance integrated.

Each department is divided into different lines organized in continuous flow. The lines are delimited into different BWTs that are responsible of one segment of the line. The BWTs are the core of the organization. The BWTs are managed by a team leader and a team of operators. The BWTs work in different shifts and are composed by the same team. For example in one line segment there could be 3 BWTs, one in the morning, afternoon and night shift. The BWTs are ranked into one maturity level taking into consideration factors such as whether the standards are in place, the policompetence of the teams, and the continuous improvement until the maximum level when the BWT is considered a Benchmark. This classification is considered very important for the RPS and is kept as confidential information. The BWT level is audited by the RPS team. However, BWTs are also cross-audited among the different plants to guarantee consistency in the grading and ensure the benchmark across the group. According to the interviewee:

*“I do not think that applying standards that are the same in the entire group limits the innovation of the teams... when you use standards is when you see opportunities for improvement easier and change the standard. This system allows encouraging the teams to innovate... First the focus is on applying the standards... then improve them... and change the standards...”*

Javier Sáinz Velicia, New projects and SPR manager at Valladolid

Engines

With this kind of organization all the Kaizen activities that take place in a line segment level are made by the BWTs.

#### 4.2.3.2. Performance measurement system based on value streams

The performance measurement system at Valladolid Engines is done through an “annual progress plan” that is standard across the group. It is inspired of the concept of Hoshin Kanri. The “annual progress plan” was established in the beginning of the 1990s. The idea is to deploy a yearly plant strategy into the metrics and objectives of the BWTs in order to ensure that everybody work with shared objectives and priorities. The next table shows details about the “annual progress plan” performance measurement system for year 2012. It covers the most critical performance dimensions in terms of: human development, quality, volume and cost. Every performance dimension has at least one result indicator (that defines what to achieve) and one process indicator (that defines how to achieve it). In the following table the refreshment frequency of the different indicators is also described.



<i>Performance dimension</i>	Human development	Quality	Volume	Cost
<i>Objective</i>	Grow competence and motivation	Satisfy the customer		Ensure free cash flow
<i>Result indicator</i>	Number of accidents	Customer rejects (ppms)		Cost vs. budget Productivity
<i>Process indicator</i>	5S follow up Maturity level	Number of workplaces with quality risks Competences Alternative failure modes First time quality		Cost reduction plan follow up Kaizen plan follow up Cost training adherence
<i>Freq</i>	1 month	1 month	1 month	1 month

Table 17. The manufacturing performance measurement system at Valladolid engines. (Source: Own elaboration).

The performance measurement system is structured in three layers. The third layer of indicators corresponds to the elemental work unit's indicators showed publicly to everyone. The second layer corresponds to the department measurement that results from an aggregation of the different manufacturing lines performance. The first layer used by plant direction measures the performance of the complete value streams by aggregating the performance of the different departments.

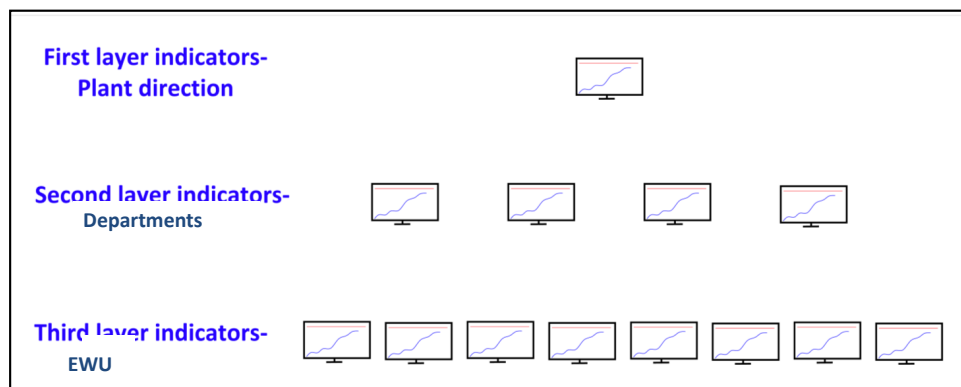


Figure 48. Structure of the indicators at Valladolid Engines. (Source: own elaboration).

#### 4.2.3.3. Meeting system

The establishment of a formal meeting system complements the setting up of the performance measurement system by coordinating the monitoring of the value stream metrics which measure the performance of the teams at a group level. A formal meeting system is applied which is standard for the BWT's. It is based on the information provided by the "Annual progress plan". The meeting system is standard across the group and differentiates between daily meetings and monthly meetings. The objective of the daily

meeting is to define the abnormalities of the day before and the risks and planning for the current day. The monthly meetings objective is to review the metrics monthly to ensure that performance is trending in the right direction. The definition of the strategy and objectives is annually made by plant directors.

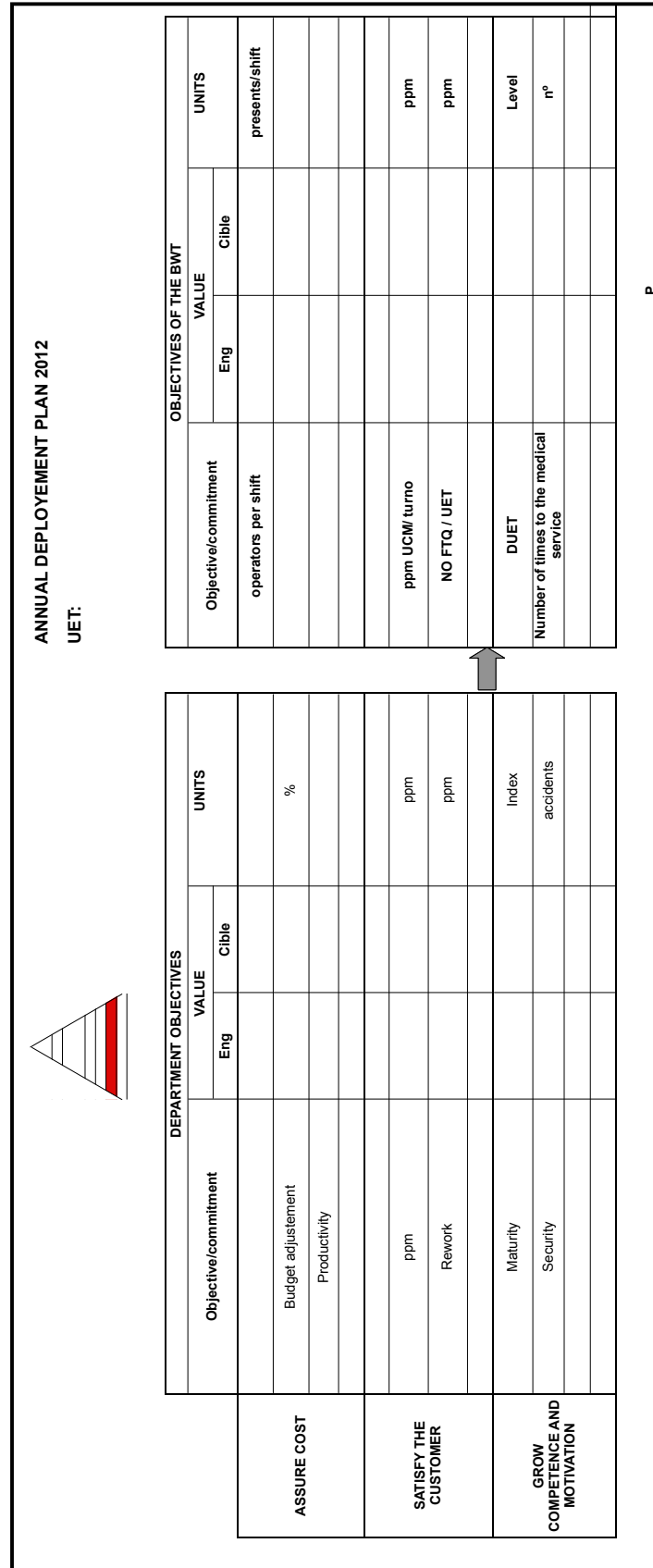


Figure 49. The manufacturing performance measurement system that supports the monthly operating review meetings at Valladolid engines (1/3). (Source: Renault Engines Valladolid. Translated to English).

LEVEL																																							
Better than Cible			Between Eng and Cible			Worse than Eng			LEVEL																														
HISTORIC DATA										Planning and results																													
										2009			2010			2011			Jan			Feb			Mar			Apr			May			Jun			Jul		
Elementos control / RESULTADO										Piloteaje																													
Action Plan										Cible			Eng			Real			Cible			Eng			Real			Cible			Eng			Real					
Cost plan										Cible			Eng			Real			Cible			Eng			Real			Cible			Eng			Real					
										Cible			Eng			Real			Cible			Eng			Real			Cible			Eng			Real					
										Cible			Eng			Real			Cible			Eng			Real			Cible			Eng			Real					
Kaizen plan										Cible			Eng			Real			Cible			Eng			Real			Cible			Eng			Real					
										Cible			Eng			Real			Cible			Eng			Real			Cible			Eng			Real					
										Cible			Eng			Real			Cible			Eng			Real			Cible			Eng			Real					
Cost training										Cible			Eng			Real			Cible			Eng			Real			Cible			Eng			Real					
										Cible			Eng			Real			Cible			Eng			Real			Cible			Eng			Real					
										Cible			Eng			Real			Cible			Eng			Real			Cible			Eng			Real					
Budget adjustment										Cible			Eng			Real			Cible			Eng			Real			Cible			Eng			Real					
										Cible			Eng			Real			Cible			Eng			Real			Cible			Eng			Real					
										Cible			Eng			Real			Cible			Eng			Real			Cible			Eng			Real					
Productivity										Cible			Eng			Real			Cible			Eng			Real			Cible			Eng			Real					
										Cible			Eng			Real			Cible			Eng			Real			Cible			Eng			Real					
										Cible			Eng			Real			Cible			Eng			Real			Cible			Eng			Real					
ENSURE CASH FLOW										Cible			Eng			Real			Cible			Eng			Real			Cible			Eng			Real					
										Cible			Eng			Real			Cible			Eng			Real			Cible			Eng			Real					
										Cible			Eng			Real			Cible			Eng			Real			Cible			Eng			Real					

Figure 50. The manufacturing performance measurement system that supports the monthly operating review meetings at Valladolid engines (2/3). (Source: Renault Engines Valladolid. Translated to English).

		LEVEL									
		Better than. Eng. cible	Between Eng. and Cible	Worse than. Eng. Cible							
		HISTORIC DATA			Planning and results						
SATISFY THE CUSTOMER	Workplaces with problems	Cible									
		Eng									
		Real									
	Competences	Cible									
		Eng									
		Real									
	Alternative modes	Cible									
		Eng									
		Real									
	Training	Cible									
	Eng										
	Real										
GROW COMPETENCE AND MOTIVATION	Quality ppm	Cible									
		Eng									
		Real									
	Rework	Cible									
		Eng									
		Real									
	Security label	Cible									
		Eng									
		Real									
	5S	Cible									
	Eng										
	Real										
Maturity level	Cible										
	Eng										
	Real										
Security	Cible										
	Eng										
	Real										

Figure 51. The manufacturing performance measurement system that supports the monthly operating review meetings at Valladolid engines (3/3). (Source: Renault Engines Valladolid. Translated to English).

#### **4.4.4. Results**

This case shows a company that it is widely acknowledged by its very pioneer and mature lean transformation at a group level. The organizational practices described started its application more than 20 years ago. This has positioned the plant into a reference of excellence both internally and externally. Its excellence in terms of quality, profitability and innovation resulted in an increasing market share within the Renault group. In 2009 it accounted for 40% of the engines manufactured by Renault group and it is now one of the biggest engine manufacturing plants in Europe. List of awards in (Renault, 2012):

##### *External awards*

- Finalist European Quality Award (EFQM) in 2002 and 1999.
- Castilla y Leon Foundation for Enterprise excellence award innovative enterprise in 2008
- Castilla y Leon Foundation for Enterprise excellence award in health and safety prevention.
- “*Expansión y empleo*” award in innovation and human resources in 2004

##### *Internal awards*

- Renault award in profitability in 2006 and 2007
- Renault award in management quality in 2009

- Renault special awards in innovation and creativity in 2002, 2005, 2007 and 2009.

This excellence is achieved through the Renault Production System. According to the interviewee there is a direct link between quality and profitability results among plants that are more mature in the production system than others.

#### **4.4.5. Conclusions**

The described case corresponds to the lean transformation of the engine plant or RENAULT, Valladolid, Spain. Data was collected through an interview to the Renault Production System manager and a visit to the plant in June, 2012. The adopted solution consists in the application of a production system that emphasizes the importance of the focus on the production flow. The solution consisted on a layout organization in continuous flow and the adaption of the organizational practices to the production lines; in consequence to the value streams by means of: (1) The establishment of organizational units based on the value streams at a team leader level and (2) The establishment of a performance measurement and meeting system based on value streams aimed to align the plant strategy with the teams' objectives. This solution resulted to be highly successful in the described case.



## 5-DISCUSSION, CONCLUSIONS AND REFLECTIONS

In this, the last chapter, we summarize the conclusions of the thesis and make some reflections. We make some suggestions of future research and we end with some final words.

## **5.1. Discussion**

In this thesis it is investigated which practices lean enterprises adopt to focus on value streams. To do it, an exploratory case study of four plants that successfully performed a lean transformation with significant performance improvements is presented. The plants belong respectively to Delphi Diesel Systems, Sogefi Filtration and a company within the furniture industry. In this section, we present a discussion of the main conclusions and contributions that can be drawn.

### *Organizational units based on value streams*

Regarding the establishment of organizational units based on value streams, the companies under study have in common that they link their organizational structure to value streams. The objective is to concentrate the effort of the teams on value stream performance instead of the performance of individual people or functions.

Company X put autonomous production units (APUs) in charge of each value stream. This was made possible by arranging the complete layout, originally organized functionally, in a flow layout where a single manufacturing cell performed a complete value stream.

The DDS Sant Cugat case is an example of how to establish APUs based on the value streams when the dimension, process complexity and variety are big. The solution was to separate the value stream in segments and grouping the different segments in APUs. It is in line with approaches such

as “plant within a plant” (Skinner, 1994) and “the mini-company” (Suzaki, 1993).

The case at Renault is a combination of the concepts applied in Plant x and DDS Sant Cugat. Due to its big dimension, the facility was divided into three physically separated departments. Within the departments the layout is organized in continuous flow from beginning to end of the door-to-door value stream. The organizational units are established at a team leader level dividing the value streams into value streams segments.

Sogefi filtration shows a case of a medium size enterprise where the lean transformation began and an in depth reorganization of the plant in APUs was not considered possible. The solution consisted in maintaining a pure functional hierarchical organization. The function of integrating the activity to the value streams was assigned to continuous improvement teams in charge of value stream segments. The solution at Sogefi is a hybrid between an organization in APUs and the concept of continuous improvement teams. This approach is supported by the literature. Lillrank (2001) describes continuous improvement teams organized as a parallel system outside the formal line organization.

#### *Performance measurement system based on value streams*

In relation to the establishment of a performance measurement system based on value streams, the companies under study have in common that they measure the performance in a value stream perspective. They all

measure and display visually in the shop floor the most critical operational performance dimensions in terms of: security/human development, quality, volume/delivery and cost/productivity. The companies also put an emphasis on operational process indicators by measuring not only what to achieve but also how to achieve it. However, the concept of value stream costing was only present in the DDS Sant Cugat case where the APUs have financial autonomy and most of the cost are measured daily and assigned to the value stream segments. Differences were also found in how the information was collected and visually shown in the shop floor.

In Sogefi, Company X and Valladolid engines the indicators are posted in performance management boards with manual collection methods and daily update frequency. In the case of DDS Sant Cugat, due to the characteristics of the plant, big dimension, process variety and process complexity, exact information refreshed with high frequency is found necessary. This was achieved by an IT supported near real time manufacturing performance measurement system (MPMS).

#### *Formal meeting system*

Regarding the adoption of a formal meeting system, the studied plants established a formal meeting system based on the information provided by the value stream based performance measurement system. They all put in place a meeting system that differentiates between daily meetings and monthly meetings.

The objective of the daily meetings, which are held in the shop floor, is to discuss the value streams' abnormalities of the day before and the risk for the current day. The monthly meetings or operating review meetings have the objectives of planning, result indicators performance review and continuous improvement. Differences were found in the way the continuous improvement projects were selected. The decision is based on the performance dimension that will have more impact on internal and external performance. This decision was made by plant directors in Sogefi filtration and Company X. In DDS Sant Cugat, it was made by the APUs in the TOP 5 focus meeting performed every quarter. At Valladolid engines the use of Hoishin Kanri concept aimed to align the plants yearly strategy with the teams' objectives and project selection.

The interviewed managers highlighted that the adaption of organizational practices to value stream focus were central into their transformation. Effectively, Sogefi initiated its transformation by adapting the organizational practices to value stream focus in a functional organization. DDS Sant Cugat brought a mature transformation further by developing a value stream based IT supported near real time MPMS. Plant X performed the transformation by rearranging the layout into single manufacturing cells that perform complete value streams. The organizational practices were adapted to the manufacturing cells and subsequently to value streams. Valladolid engines show a case of a company that it is widely acknowledged by its very pioneer and mature lean transformation at a group level. The organizational practices described started its application more than 20 years

ago. This has positioned the plant into a reference of excellence both internally and externally.

## **5.2. Reflections on the results**

All the companies under analysis adopted the three organizational practices intended to focus on value streams presented in this thesis. The adoption of these practices was standard and consistent across the different organizational units within the studied plants. However, the application of the concepts strongly depended on the specific circumstances of the plants such as size, complexity and transformation maturity. The table below gives a summary of the organizational practices found in the studied companies to focus on value streams.

	<i>Sogefi filtration</i>	<i>DELPHI Diesel Systems</i>	<i>Plant X from furniture sector</i>	<i>RENAULT engines</i>
<i>(1) The establishment of organizational units based on the value streams</i>	Continuous improvement teams in charge of value stream segments.	Autonomous production units in charge of value stream segments	Autonomous production units in charge of a value stream.  Complete value stream manager for customized products	Autonomous production units in charge of value stream segments
<i>(2) The use of a value stream based performance measurement system</i>	Value stream segment performance management boards with operational measures.	Value stream segment near-real time manufacturing performance measurement system with operation measures and value stream costing.	Value stream performance management boards with operational measures.	Value stream segment performance management boards with operational measures.
<i>(3) The adoption of a formal meeting system</i>	Daily stand up meetings in the shop floor  Monthly operating review meetings	Daily stand up meetings in the shop floor  Weekly operating review meetings  Quarterly TOP 5 focus meetings	Daily stand up meetings in the shop floor  Monthly operating review meetings	Daily stand up meetings in the shop floor  Monthly operating review meetings

Table 18. The use of organizational practices to focus on value streams. (Source: own elaboration).

The following two organizational practices were found in the studied companies:

- The establishment of organizational units based on the value streams
- The use of a value stream based performance measurement system

We find a high occurrence of these practices in the literature. We didn't see controversy regarding their relevance. There is an agreement in the literature that these organizational practices are very important to focus on a common objective. In particular, the literature on lean manufacturing stresses the importance of realigning these organizational practices with a value stream perspective.

The third practice under consideration, the adoption of a formal meeting system, has also been identified in the studied companies. However, do not clearly support the importance of this factor. It has been mentioned only sporadically. In effect, the literature on lean manufacturing does not stress the importance of a formal meeting system.

In short, the three organizational practices considered was indeed very important at the studied companies, and the consulted managers also validate that finding.



### **5.3. Reflections on the research process**

A multiple exploratory case study design was selected in this thesis. Based on the research methodology design the four individual case studies were originally organized with the same structure and content. However, due to confidentiality issues, some differences can be observed in the level of detail of the different case studies. In the cases at DDS Sant Cugat and Sogefi filtration the content was revised, corrected and approved with no confidentiality issues. In the case at Plant X and Renault Valladolid engines, the case was revised, corrected and approved with a significant reduction on confidential content. We compensated the content with content available in external sources such as publications and official web pages. It is the authors' opinion that the confidentiality issues are not a constraint to correctly support the resolution of the stated research question and sub questions.

### **5.4. Implications**

#### **5.4.1. Theoretical contribution**

This research provides an exploratory contribution in the fields of organizational practices involved in the transition to lean enterprise. Leading authors highlight the importance of value stream focus from a conceptual point of view. Works dealing on the topics of value stream management, organizational focus, performance measurement or meeting systems are present in the literature. However, no research was found in the literature

about the organizational practices lean enterprises adopt to obtain the value stream focus. This research addresses this shortcoming. At the same time, four case studies illustrate the commonality of the application of general concepts and the particular solutions adopted in each different case.

To the best of the authors' knowledge, this thesis is the first attempt to explore how lean enterprises use organizational elements to focus on value streams. It is expected that researchers will find this thesis as a contribution to the Operations Management literature, in particular to the Value Stream concept literature (e.g. Womack and Jones, 1994; Hines and Rich, 1997; Hines *et al.*, 1998; Hines *et al.*, 2002, Hines *et al.*, 2004; Ward and Graves, 2004; McNair *et al.*, 2006; Maskell and Kennedy, 2007; Stenzel, 2007; Zokaei and Hines, 2007).

#### 5.4.2. Managerial contribution

For the management community, this thesis provides concepts and application examples that can be used in other real practical cases. The cases refer to plants with different sizes, sectors, complexity and lean transformation maturity. It shows that in the studied companies the described principles and practices led to improvements in terms of customer quality, delivery and operational cost. It is thought that the concepts presented in this thesis may be applicable in other companies at various levels of lean maturity or at separate points in their own respective transformation plan. However, as drawn from the literature and the cases,

that does not mean that the lean transformation of the organizational practices is an easy task. Transitions from functional organizations may face stiff resistance (Womack and Jones, 1994).

### **5.5. Research Limitations and avenues for future research**

We think that the described principles provide insights about the organizational practices used by lean enterprises to focus on value streams. However, this research is based on a limited number of cases and provides, in consequence, provisional insights. Considering the limited amount of research on the subject, this kind of exploratory research is considered to be appropriate. Further research is needed to verify our findings. A quantitative analysis based on an appropriate sample of multi-site cases is foreseen. We now outline a series of testable propositions, which arise from this exploratory investigation.

- *Testable proposition 1:* Lean enterprises establish organizational units based on value streams to focus on value streams.
- *Testable proposition 2:* Lean enterprises use value stream indicators to focus on value streams.
- *Testable propositions 3:* Lean enterprises establish formal meeting systems to discuss value stream issues to focus on value streams.

Future research could include the study of the contextual factors and the assessment of the relationship among the three analyzed organizational practices and their combined effects; to assess whether these practices are complementary and which are the synergies and why do they exist. Moreover, the many different approaches adopted by different companies require best-in-class multiple case study examination to determine if one-best-way exists. An exploratory investigation in service sectors is another potential future research.

The case studies suggest that a lean leadership is a key ingredient for the transformation of the organizational practices. Therefore, other possible further research is the investigation of the link between the presented concepts and top management lean leadership.

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## **7. APPENDIX**



<b>Appendix</b>	
<b>Paper title</b>	<i>Organizational practices lean enterprises adopt to focus on value streams</i>
<b>Authors</b>	<i>Jordi Olivella and Ruben Gregorio</i>
<b>Publication</b>	In second revision in an International Journal.



# Organizational practices lean enterprises adopt to focus on value streams: an exploratory investigation

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**Abstract:** *The purpose of this paper is to investigate which practices lean enterprises adopt to focus on value streams. An exploratory case study of four plants is developed. The four plants have successfully performed a lean transformation with significant performance improvements, and belong respectively to Delphi Diesel Systems, Sogefi Filtration, a company within the furniture industry and Renault. The organizational practices associated with value stream focus identified are: (1) the establishment of organizational units based on value streams; (2) the use of a performance measurement system based on value streams, and (3) the adoption of a formal meeting system. These organizational practices were found in all four of the studied companies. The adoption of these practices was standard and consistent across the different organizational units within the studied plants. However, the application of the concepts strongly depended on the specific circumstances of the plants such as size, complexity and lean transformation maturity. This exploratory research provides a contribution in the fields of organizational practices involved in the transition to lean enterprise. Managerial implications consist of the possible application of the described practices to other cases and situations.*

**Keywords-** Value stream, lean, performance measurement system, meeting system

## 1. Introduction

Lean management strategy has been widely adopted by manufacturing companies. It is broadly used, in particular, by the automobile industry to achieve high performance standards (Hines *et al.*, 2004). A consequence of the decision to adopt lean management is the use of the tools and the implementation of the practices. A deeper adoption requires organizational changes, based in principles as waste reduction and customer focus (Womack and Jones, 1994). These concepts may surprise somebody who does not know the business world, who might ask himself how it can be possible that organizations do things that are not needed instead of doing things that are of the customers' interest. It is clear that, at least in general terms, this is not done on purpose. A job is done because it is thought to be useful, as we can deduce from the rationality of the persons involved. However, in complex value streams, the perceptions about what is needed and what will generate customer value are in some cases wrong (Zokaei and Hines, 2007). In fact, not needed activities do take place and often the needs of the final clients are not taken enough into account.

To avoid these situations, focusing on value streams has been considered to be a key success factor (e.g. Womack and Jones, 1994; Hines *et al.*, 1998; Liker, 2004). In an outstanding precedent of this idea, Skinner (1974) proposed that manufacturing plants should focus on a limited, concise and manageable set of products, technologies, volumes and markets. More recently, Womack and Jones (1994) stated that different value creating activities can be performed together, but this effort will require a new organizational model: the lean enterprise. According to Womack and Jones (1994), getting managers to think in terms of the value stream is the critical first step to achieving a lean enterprise. However, no research was found about the organizational practices lean enterprises adopt to obtain the value stream focus. This research addresses this shortcoming. The purpose of this paper is to perform an exploratory investigation about which practices lean enterprises adopt to focus on value

streams with data collected from four plants that successfully performed a lean transformation. The key research question we aim to answer is: *Which are the practices that lean enterprises adopt to focus on value streams?* Exploratory research relies on theoretical concepts to guide the design and data collection (Yin, 2003). Based on the literature, three organizational practices associated with value stream focus were identified and adopted as a guide to focus the scope of the research:

- The establishment of organizational units based on the value streams, as mentioned by Womack and Jones (1994), Hines et al. (1998) and Liker (2004); to concentrate the efforts of the teams on the value stream performance rather than performance of individual people or functions.
- The establishment of a performance measurement system based on value streams, as mentioned by Maskell and Kennedy (2007) and Liker (2004); to measure the most critical value stream factors (such as quality, delivery, flexibility and cost).
- The establishment of a formal meeting system (Maskell and Kennedy, 2007); to coordinate the monitoring of the value stream metrics which measure the performance of the teams at a group level. The objective is to prioritize the corrective actions and the continuous improvement planning with a value stream perspective.

This research provides an exploratory contribution in the field of organizational practices involved in the transition to lean enterprise. Four case studies illustrate the commonality of the application of general concepts and the particular solutions adopted in each different case. For the management community, this paper provides concepts and application examples that can be used in other real practical cases. The cases refer to plants with different sizes, sectors, complexity and lean transformation maturity. It shows that in the studied companies the described principles and practices led to improvements in terms of customer quality, delivery and operational cost.

Regarding the research methodology, since there was no previous empirical knowledge addressing the purpose of this paper, it was considered best to prioritize the search for a deep and qualitative understanding of the phenomena under study. To do it we use qualitative methodologies and, in particular, a multiple exploratory case study research methodology. When a researcher is delving into the how and why of a set of events, the case study offers advantages not found in more quantitative research tools (Yin, 1994). Qualitative data allows the researcher to more fully explore complex relationships between variables in their natural setting. A limited number of cases will be addressed. According to Piercy and Rich (2009), the use of single or small numbers of case studies as knowledge building tools is increasing prevalent in the operations management literature. Yin (1994) identified five components of research design that are important for case studies: the study's questions; its propositions, if any; its unit of analysis; the logic linking the data and the propositions and the criteria for interpreting the findings. Within this paper, we seek to answer the following key research question: *Which are the practices that lean enterprises adopt to focus on value streams?*

A multiple exploratory case study was performed. The criteria for selecting each case company were driven by the research objectives rather than random sampling, as proposed by Yin (1994). This study is centered on data collected from Spanish manufacturing plants serving as original and aftermarket suppliers. The companies selected successfully performed a lean transformation with significant performance improvements. In order to minimize the cultural aspects, an important selection aspect was that the plants must work in a global or at least European perspective. The companies were selected from a range of different manufacturing sectors, plant sizes and process complexity with the aim to increase the



external validity, that is, the possibility that the conclusions also apply in other manufacturing industry settings.

<i>Plant</i>	<i>Product</i>	<i>Plant size</i>	<i>Process complexity</i>	<i>Interviewee</i>
Sogefi filtration	Filters	Medium	Medium	Plant manager
Delphi Diesel Systems S.L.	Diesel injection pumps	Large	High	Operations director
Plant X	Furniture	Medium	Medium	Lean manager
Renault Engines	Engines	Large	High	Lean manager

*Table 1- Selected companies for the study*

The reliability and validity of case research data is enhanced by a well-designed research protocol (Yin, 1994). The core of the protocol is the set of questions to be used in interviews (Voss *et. al.*, 2002). A well-designed protocol is particularly important to ensure a cross-comparative research study. A common set of semi-structured interview questions was prepared. The questions were reviewed and given feedback on by experts in the field. The interviewees were operations directors, lean managers or plant managers. The length of the semi-structured interviews and site visits varied from 3 to 6 hours. When developing the research protocol and instruments it is important to address triangulation (McCutcheon and Meredith, 1993). Data was also collected through direct observations made under the study visits to the companies and unstructured interviews with middle managers. We also collected documentation in form of photographs, brochures, company documents and information from the Internet (independent as well as provided from the case companies). All the interviews have been recorded to reduce the observer's biases. The four individual case studies were organized with the same structure and were revised, corrected and accepted by the studied organizations. This was done to reduce errors in the interpretation of the collected data.

The outline of the paper is as follows: Section 2 is devoted to the literature review, in Section 3 the four case studies are explained and finally, in Section 4 we present the conclusions, implications and future research.

## **2. Literature review**

### *Organizational focus*

In a seminal article, Skinner (1974) suggested that factories can be more focused by grouping various products and resources into several manufacturing units with each unit focusing on a limited, concise, and manageable set of products, technologies, volume and markets. According to Skinner (1974), "... let each manufacturing unit work on a limited task instead of the usual complex mix of conflicting objectives, products, and technologies ...". This should lead to the "focused factory". However, Skinner states that if it is not possible to focus the whole factory, one should adopt the "plant within a plant" (PWP) notion. PWP is achieved by dividing the existing facility into organizationally and physically separated sections. He states that each PWP should have its own facilities within which it can concentrate on its particular manufacturing task, using its own work force management approaches, production control and organization structure. Wheelwright (1984) found that companies with fewer product lines were found to be more profitable than companies with more product lines. Bozarth and Edwards (1997) found that PWPs might not be entirely successful at buffering plants from the negative impact of diverse market requirements. A similar concept of the

PWP is the mini-company process. The term “mini company” was coined by Suzaki (1993). The mini-company is based on work groups who are responsible for their supplier-client relationships. Later work by de Leede and Looise (1999) and de Leede *et al.* (2002) performed descriptive case studies of the concept. In order to divide a facility into physically separated sections, cellular manufacturing propose to divide physically a large job shop into numerous small production cells (Greene and Sadowski, 1984). Each cell is designed to efficiently produce common types or shapes of parts having similar machine, operation, and fixture requirements. Griffiths *et al.* (2000) claims that customer-focused manufacturing is achieved through manufacturing cells where all the resources are focused on one customer, instead of a product or product family. However the objective of cellular manufacturing is not to organize the shop floor from a customer perspective but to eliminate or minimize complexity and to improve productivity. Pattanaik and Sharma (2009) state that as some of the lean manufacturing concepts are different from that of cellular manufacturing, some new cell design methodology is required. In order to synchronize all the cells in a value stream they propose as a central concept the rate at which work progresses through the factory is called flow rate or Takt. Plant within a plant (Skinner, 1974), mini company (Suzaki, 1993) and cellular manufacturing (Greene and Sadowski, 1984) are outstanding precedents that aim to minimize complexity and to enhance the focus of the organization to a common objective. These concepts point out the convenience of focusing the organization in a set of activities, but not necessarily to the value stream.

#### *Value stream management*

Value stream concept was introduced more recently by Hines and Rich (1997) and further developed as a tool by Rother and Shook (2003). Value stream is defined as the sequence of activities that are made from the reception of the customer order to the delivery of the product or service (Womack and Jones, 1994). When we in this paper refer to the value stream we mean the “door-to-door” production flow inside the plant. Some authors propose methods to improve the value stream mapping tool by helping to focus on the final customer (e.g: Hines *et al.*, 1998; Zokaei and Hines, 2007). Other examples of applications of the Value Stream Mapping tool in various sectors in manufacturing and services are largely reported in the literature. However, some authors view the value stream as a central and more strategic concept for the lean transformation. Hines *et al.* (1998) developed the value stream mapping approach into a more strategic and holistic method called value stream management with more focus on human resources. Value stream management was defined as a strategic and operational approach designed to help a company or a complete supply chain to achieve a lean status (Hines *et al.*, 1998). According to Womack and Jones (1994) the lean enterprise is a new organizational model. The value stream is what defines the lean enterprise. The lean enterprise is a group of individuals, functions and legally separate but operationally synchronized companies. Getting managers to think in terms of the value stream is the critical first step to achieving a lean enterprise. According to Liker (2004) someone with real leadership skills and a deep understanding of the product and process must be responsible for the process of creating value for customers and must be accountable to the customers.

#### *Performance measurement systems and meeting systems*

Within the lean manufacturing context a manufacturing measure is a standard that defines performance criteria for manufacturing processes so that everyone in the organization are working towards the same goal (Khadem *et al.*, 2008). Lewis and Slack (2003) mentioned five types of performance objectives based on cost, flexibility, speed, dependability and quality. According to Neely *et al.* (1997) if performance indicators are not well designed, it can result in dysfunctional behaviors, encouraging individuals to make the wrong decisions. According to Imai (1986) two types of performance indicators can be distinguished: result

indicators and process indicators. According to De Haas *et al.* (2000) the “what to achieve?” question has to be answered in terms of result indicators, while the “how to achieve?” question needs to be tackled in terms of process indicators. Ishikawa (1985) diffused the strategic planning/strategic management methodology of Hoshin Kanri. It assumes daily controls and performance measures are in place. Some authors have done research on performance indicators that measure in a value stream perspective. Liker (2004) suggests to eliminate the old metrics and to measure a variety of value stream metrics. According to Maskell and Baggaley (2006) continuous improvement (CI) is motivated and tracked by using value stream performance boards. Typically these visual boards are updated weekly and used by the value stream CI team to identify improvement areas, initiate PDCA projects, and monitor their progress. Richey (1996) observed that winners of the 1996 Shingo prize for manufacturing excellence primarily used a visual performance management system on the shop floor. Stenzel (2007) define value stream costing as the process of assigning the actual expenses of an enterprise to value streams, rather than to products, services, or departments. According to Maskell and Kennedy (2007), companies using lean accounting have better information for decision making; have simple and timely reports that are clearly understood by everyone in the company; understand the true financial impact of lean changes; and focus the business around the value created for the customers. They propose the box score to present a threedimensional view of the value stream’s performance, operational performance, capacity information and financial performance. According to Cottyn *et al.* (2011) the application of information technology and lean principles have for a long time been seen as mutually exclusive, but both approaches are more and more claimed to be interdependent and complementary.

The establishment of a formal meeting system complements the setting up of the performance measurement system. Meetings can only be effective with the appropriate information. Gathering information would make no sense if it is not clearly established what will be done with it. According to Maskell and Kennedy (2007) all routine meetings are held and decision making is discussed around the visual performance that measure the value stream performance boards in the shop floor. According to Fletcher and Taplin (1997), with the emphasis on cross functional teams, natural work groups and continuous improvement task forces, companies must learn how to formally plan and review the activities of these emerging horizontal organizations. Operating review meetings emphasize planning, performance review and continuous improvement (Fletcher and Taplin, 1997). The philosophical core of the operating review meetings is an emphasis on the future, not the past. During these meetings, the focus is kept solely on interdepartmental key performance indicators (KPI)s. They suggest as main point of the meetings procedures to (1) Hold regular meetings, (2) Set an established agenda (3) Review exceptions and commitments, (4) Make performance improvement plans (5) Document meeting action items.

Leading authors highlight the importance of value stream focus from a conceptual point of view (e.g. Womack and Jones, 1994; Hines *et al.*, 1998; Liker, 2004). Works dealing with the topics of value stream management, organizational focus, performance measurement or meeting systems are present in the literature. However no research was found in the literature about the organizational practices lean enterprises adopt to obtain the value stream focus. This research addresses this shortcoming.

### **3. Cases studies**

#### **Case A- Sogefi filtration plant of Cerdanyola del Vallès**

Sogefi is an Italian Group with a global presence that employs 6,200 people worldwide (Sogefi, 2012). The case takes place at Sogefi filtration plant in Cerdanyola del Vallès. This is a medium size plant that manufactures filter elements and complete modules for automotive

and heavy duty applications. The production process is composed by an injection process, a pleating process and an assembly process. The lean production system called “*The Sogefi Kaizen Way*” was introduced globally in 2009.

The process of implementation of lean management principles in the plant is in the initial phase. An in depth reorganization of the plant in autonomous production units was not considered possible. The adopted solution consisted in maintaining a pure functional and hierarchical organization. The function of integrating the activity to the value streams was assigned to other organizational practices. These practices were continuous improvement groups, value stream based performance measurement and a formal meeting system. This solution resulted to be highly successful. From 2007 to 2010 the result indicators had improved dramatically, the line rejects had decreased by 45%, the customer rejects by 65% and the productivity had raised by 6% (Olivella and Gregorio, 2012).

#### *Organizational units based on value streams*

Sogefi is organized functionally which means that the resources of each function report to the functional director. The interviewee, Ghislain Audion, Sogefi plant manager, believes in the organization based on the value streams. In spite of this, an in depth reorganization of the plant was not considered possible because the lean transformation was in such an early stage. Effectively, he said: “*I was professionally developed at Valeo, I have developed organizations in Autonomous Production Units. When I arrived I tried to do exactly the same here but it did not work, so I had to rethink about how to organize the teams following the principles of team work, policompetence and use of lean tools [...] We did not reach to create totally autonomous units with all the functions integrated [...] However the focus of the teams is the production line, not the Unit or the Group, in a completely transversal way, this is the main success factor*”.

The organizational solution on how to strengthen the focus on value streams is based on the “Continuous Improvement Teams”. The value streams are separated physically into eight segments and the different segments are grouped in four “Continuous improvement teams” (one in the pleating process, one in the injection process and two in the assembly process). The teams are lead by Kaizen engineers with full time dedication and composed by part-time resources from manufacturing, quality, manufacturing engineering and maintenance functions. Line operators or other support functions are integrated in the teams when needed. The “Continuous Improvement teams” act in an autonomous manner, not just in the kaizen-continuous improvement but also in daily problem-solving activities.

#### *Performance measurement system based on value streams*

The performance measurement is based on value stream segments. For example, the injection process has its own result and process indicators measuring the performance of the value stream segment, not the performance of all the different products that go through this process. The indicators are posted visually in the shop floor on performance management boards (see figure 1) with manual collection methods and daily update frequency. The performance measurement system covers motivation, quality, delay and cost performance dimensions (see table 2). These measures are operational; the costs are not assigned to the value stream segments with value stream costing. The boards show result indicators, process indicators and information about continuous improvement activities. The result indicators are communicated every month, showing the latest performance of the complete value streams and the value stream segments.

	<i>Result indicator</i>	<i>Process indicator</i>	<i>Frequency</i>
Motivation	Number of improvement suggestions	Audit 5S/ TPM (%)	24h
Quality	End of line quality Customer ppms	TOP 3 reject	24h
Delay	Service level first equipment (%) Intertrading service level (%)		24h
Cost	Productivity Direct labour efficiency	TOP 3 non-productive Overall equipment effectiveness (OEE) and Pareto chart of causes	24h

Table 2- Sogefi's value stream segment performance measurement system. Source: Own elaboration.

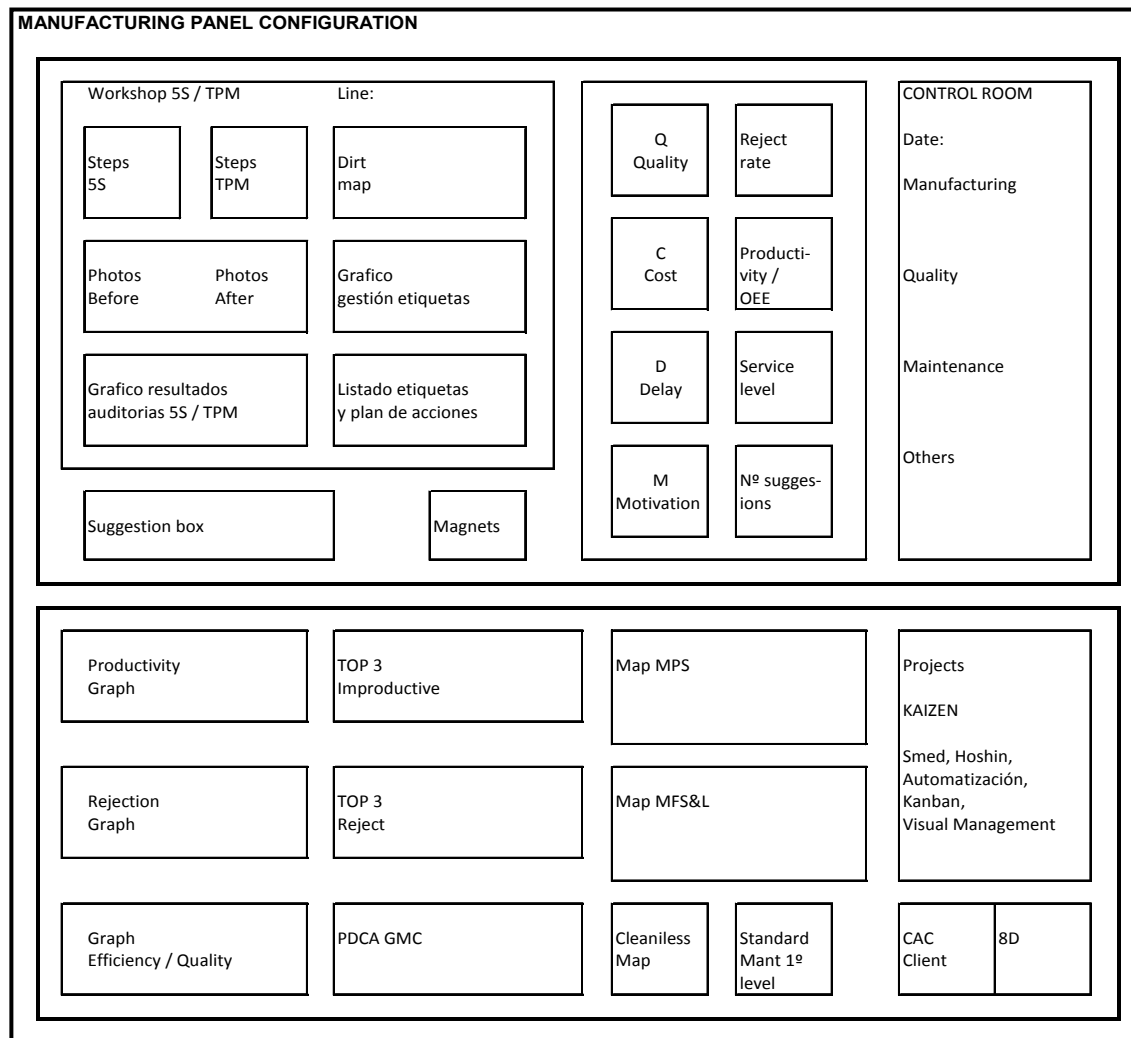


Figure 1- Performance management board at Sogefi filtration Cerdanyola del Vallès

### Formal meeting system

A standard formal meeting system for the four “Continuous Improvement Teams” was applied based on the information provided by the value stream based performance management boards. It differentiates between daily meetings called “control room”, and

monthly meetings. The objective of the “*control room*” is to define the abnormalities of the day before and the risk for the current day. The monthly meetings have the objectives of planning, result indicators performance review and continuous improvement. More challenging problems are analyzed with special workshops or task forces.

#### Case B- Delphi Diesel Systems S.L. plant in Sant Cugat

Delphi is one of the world's largest automotive part manufacturers and has approximately 146,600 employees (Delphi, 2012). Delphi is considered an example of lean transformation of a big traditional company (Woolson and Husar, 1997). The company has been recognized with the Shingo Prize for excellence in manufacturing in twenty-seven plants (Shingo, 2012). The Delphi Manufacturing System (DMS) is widely acknowledged. For example it is described by Liker (1997) together with Daimler-Chrysler Operation System and Ford Production System. For DMS the focus of the organization to the production flow is a critical aim. According to DMS internal documentation, DMS is *"a Manufacturing System with an implementation process that recognizes the interdependencies of its elements and drives to flow manufacturing"*.

The plant analyzed is in Sant Cugat, Spain and it manufactures diesel fuel injection pumps for some of the main automotive companies (Delphi, 2012). It has been operating for more than fifty years and employs around one thousand people. Delphi Sant Cugat performs the machining and assembly of the pumps. The plant has been applying the concepts of organization in autonomous production units (APUs), value stream based performance measurement and meeting system for more than ten years. In 2009 DDS Sant Cugat faced a new and demanding challenge. Due to the high demand the strategy of Delphi consisted in taking as much advantage as possible of the capacity of the plant. To serve these objectives the performance management boards were replaced by an IT supported near real-time manufacturing performance measurement system (MPMS) that gives great importance to the overall equipment effectiveness (OEE) measure. The information provided by the MPMS, which measures the performance of the APU teams at a group level, is used in a formal meeting system. According to the interviewee, Jaume Roquet, Operations Director *"the organization in APUs, a real time robust measurement system and the meetings, for us constitute one system. It keeps the teams focused on the aspects that will make a difference in the performance of the business."* The application was highly successful and allowed the plant to cope with the increasing customer demand. This was possible through an improved performance in terms of OEE leading to an increase of volume by 120% between 2009 and 2012 with no capital expenditure in new equipment. The manufacturing cost was reduced by 15% between 2009 and 2012.

#### *Organizational units based on value streams*

DMS highlights the importance of having an organization based on value streams. According to DMS's documentation, *"We cannot separate Manufacturing, PC&L, ME, Purchasing, PE, HR, Sales, Business line... and so on because all functions must support manufacturing that is our core. All activity is connected and this focus will maximize the performance as an enterprise"*. It was not possible to establish APUs based on complete value streams because the dimension, complexity and variety of the process was too large for having a focused organization around one complete value stream. The adopted solution was to physically separate the value streams in seventeen segments and grouping the different segments in five APUs (three in the machining process and two in assembly) following ideas such as “plant within a plant” (Skinner, 1994) and “the mini-company” (Suzaki, 1993). The APUs are managed by an APU manager leading a team of 10-20 indirect employees and 100-250 direct workers. The APUs integrate the functions of manufacturing, quality, manufacturing engineering and maintenance.

*Performance measurement system based on value streams*

The performance measurement is organized in the same manner as the APUs, by measuring the performance of an aggregation of value stream segments. The near real-time performance is posted visually in every value stream segment through an IT supported manufacturing performance measurement system (MPMS). The MPMS covers the most critical performance dimensions (security, quality, volume and cost) (see table 3 and figure 2). Every performance dimension has at least one result indicator and one process indicator. The APUs have financial autonomy and most of the cost (maintenance, labor, scrap, tools, outside services and supplies) are measured daily and assigned to the value stream segments using value stream costing. Machine, direct materials, and facility costs are not assigned to the value stream segments. The MPMS gives great importance to the OEE measure. This measure is critical due to the characteristics of the plant; big dimension, process variety and process complexity. Capacity utilization is of high priority and stoppages or disruptions are expensive in terms of lost capacity. The OEE is measured in 100% of the machines in the plant. The data is collected and introduced in a software system by two workers, following standardized routes, with a frequency of two hours. In order to know the exact capacity losses, every possible failure mode is codified in every machine.

	<i>Result indicator</i>	<i>Process indicator</i>	<i>Frequency</i>
Security	Number of “lost work day cases”	The root cause analysis process has been done and is visible in the system Number and description of all kind of injuries/risks detected	2h
Quality	Number of external customer complaints (parts per million)	The root cause analysis process of the external customer complaints has been done and is visible in the system (or not) Number and description of internal customer complaints (parts) First time quality rate and Pareto chart of causes	2h
Volume	Premium freights (€)  Number of stoppage hours to internal customer  Number of parts produced (only daily)	Overall equipment effectiveness (OEE) and Pareto chart of causes in every machine	2h
Cost	Total accumulated expenses vs. financial budget Scrap cost (€) Manpower utilization vs. financial budget (theoretical hours/real hours)	Expenses vs. target separated into maintenance, scrap and supplies Pareto chart of scrap Manpower utilization Pareto chart of losses	24h

*Table 3- Value stream segment performance measurement system at Delphi diesel systems.  
Source: Own elaboration.*



Figure 2- Near real-time manufacturing performance measurement system at Delphi diesel systems. Source: Delphi Diesel systems S.L.

### Formal meeting system

A standard formal meeting system for the five APUs is applied. It is based on the information provided by the value stream based manufacturing performance measurement system (MPMS). The MPMS supports the meetings by showing the information, aggregated into an APU level, that must be checked (result indicators) and allowing the possibility of going into detail (process indicators). The meeting system differentiates between daily meetings called “Daily stand-up meetings”, weekly and monthly meetings called “operating review meetings” and quarterly meetings called “top5 focus meetings”. The objective of the “Daily stand-up meetings” is to define the abnormalities of the day before and the risk for the current day. The operating review meetings have the objectives of planning, result indicators performance review and continuous improvement. These meetings are performed on a weekly basis by the APU staff. On a monthly basis the team presents their performance results and the main projects status to the plant directors. The TOP 5 focus meeting is performed every quarter. The APU staff define their performance dimension focus called “business problem” between security, quality, volume and cost (in order of importance) and prioritize the “TOP5 priority projects” that will have more impact on the performance.

### Case C- Plant X from the furniture industry

Plant X is part of a leader company of the furniture industry. The plant manufactures mostly customized products but also offers standard ones. This case shows the lean transformation of a plant that was facing a market drop and aimed to increase their market share by an enhanced competitiveness. To face these objectives, Company X performed a deep transformation of the production system in order to cope with a wide diversity of products with the best results and the lowest operational complexity. The layout, originally functionally organized, was transformed so that single manufacturing cells perform complete value streams. Standard methods were established for all tasks necessary to perform both standardized and customized products. A robust system to schedule the value streams was established. According to Plant X’s lean manager, “The plant is not designed for visits; it is designed for value streams. The transformation has been key for us, because we can manufacture very customized products



*with a process that is simple to manage.*” The transformation of the production system has been accompanied by the adaptation of the organizational practices to the production system and therefore to the value streams through an organization in APUs, value stream based performance measurement and a formal meeting system. The solution was highly successful, the company increased the market share by increasing flexibility offering totally personalized products, with a lead time which became four times shorter than the average of the sector. All of that with service levels of 97% and customer quality of 99%. The productivity increased with 10% between 2007 and 2011.

*Organizational units based on value streams*

The plant is organized in four APUs in charge of each value stream manufacturing cell. The APUs integrate the functions of manufacturing, quality, lean/industrial engineering and maintenance. However, in customized products, a very important part of the value stream is made in the design value stream (140 of 300 employees are indirect workers). In these processes, even though they have a high frequency (from 16 to 18 new industrializations of new products every day) one can lose the notion of the value stream. To avoid that, the project manager coordinates the value stream of customized products (from customer needs, design value stream to delivery to the customer) and is accountable to the customers.

*Performance measurement system based on value streams*

The indicators are organized in the same manner as the APUs, by value stream, and posted visually in the shop floor on performance management boards with manual collection methods and daily update frequency. The performance measurement covers security, quality, volume and cost dimensions (see table 4). These measures are operational; the costs are not assigned to the value stream segments with value stream costing. The performance management boards are composed by result indicators, process indicators and also information about continuous improvement activities. The result indicators of the plant are posted in the entrance.

	<i>Result indicator</i>	<i>Process indicator</i>	<i>Frequency</i>
Security	Number of accidents		24h
Quality	Customer complaints	Rework pareto	24h
Volume	Service level	OEE	week
Cost	Productivity Material scrap		month

*Table 4- Value stream performance measurement system at Plant X. Source: Own elaboration.*

*Formal meeting system*

A formal meeting system standard for the four APUs is applied based on the information provided by the value stream based performance management boards. The meeting system applied in Company X differentiates between daily meetings and monthly meetings. The objective of the daily meetings is to define the abnormalities of the day before and the risk for the current day based on the information provided by the performance management boards in the shop floor. The monthly meetings have the objectives of planning, result indicators performance review and continuous improvement.

### Case C- Renault Engines Plant, Valladolid

Renault S.A. is a French automaker, which is present in 118 countries and employs 128.322 persons (Renault, 2012). Its alliance with Nissan makes it the fourth-largest automotive group. The Renault Production System is widely acknowledged by its pioneer application of organizational units based on the production flow through teamwork and organization in “autonomous production units” (e.g. Freyssenet, 1999; Gorgeu and Matieu 2005). The RPS also highlights the importance of adapting the organizational practices to the production flow and in consequence to value streams. According to RPS documentation: *“The effectiveness of the system is based in the persons, the commitment, the rigor and the responsibility of everyone involved in the product, from initial conception to delivery to the customer”*.

This case takes place in the Valladolid Engines plant of Renault. Data was collected through an interview with the RPS manager, informal interviews with setters and a visit to the plant in June 2012. The factory started the production in 1965 and has 1.713 employees (Renault, 2012). It is one of the most important engine plants in the group, it exported 85% of the production and accounted for 37% of the engines produced by Renault in 2009 (Renault, 2012).

This case shows a company that is widely acknowledged by its very pioneer and mature lean transformation at a group level. The adopted solution consists in the application of a production system that emphasizes the importance of the focus on the production flow. The solution consisted on a layout organization in continuous flow and the adaption of the organizational practices to the production lines; in consequence to the value streams by means of: (1) The establishment of organizational units based on the value streams at a team leader level and (2) The establishment of a performance measurement and meeting system based on value streams aimed to align the plant strategy with the teams’ objectives. This solution resulted to be highly successful in the described case. The organizational practices described started its application more than 20 years ago. This has positioned the plant into a reference of excellence both internally and externally. Its excellence in terms of quality, profitability and innovation resulted in an increasing market share within the Renault group. In 2009 it accounted for 40% of the engines manufactured by Renault group and it is now one of the biggest engine manufacturing plants in Europe.

#### *Organizational units based on value streams*

According to the interviewee team work started in the plant in the 1970s and it was evolved in 1990 into an organization in “autonomous production units”. The autonomous units are called Basic Work Teams (BWTs). The plant is organized in three sub plants managed by a workshop manager that has the functions of quality, manufacturing engineering and maintenance integrated. Each department is divided into different lines organized in continuous flow. The lines are delimited into different BWTs that are responsible of one segment of the line. The BWTs are the core of the organization. The BWTs are managed by a team leader and a team of operators. The BWTs are ranked into one maturity level taking into consideration factors such as whether the standards are in place, the policompetence of the teams, and the continuous improvement until the maximum level when the BWT is considered a Benchmark. This classification is considered very important for the RPS and is kept as confidential information. The BWT level is audited by the RPS team. However, BWTs are also cross-audited among the different plants to guarantee consistency in the grading and ensure the benchmark across the group.

*Performance measurement system based on value streams*

The performance measurement system at Valladolid Engines is done through an “annual progress plan” that is standard across the group. The inspiration comes from the concept of Hoshin Kanri. The “annual progress plan” was established in the beginning of the 1990s. The idea is to deploy a yearly plant strategy into the metrics and objectives of the BWTs in order to ensure that everybody work with shared objectives and priorities. The next table shows details about the “annual progress plan” performance measurement system for year 2012. It covers the most critical performance dimensions in terms of: human development, quality, volume and cost. Every performance dimension has at least one result indicator (that defines what to achieve) and one process indicator (that defines how to achieve it). In the following table the refreshment frequency of the different indicators is also described.

	<i>Result indicator</i>	<i>Process indicator</i>	<i>Frequency</i>
Human development	Number of accidents	5S follow up Maturity level	1 month
Quality	Customer rejects (ppms)	Number of workplaces with quality risks Competences Alternative failure modes First time quality	1 month
Volume	Service level		
Cost	Cost vs. budget Productivity	Cost reduction plan follow up Kaizen plan follow up Cost training adherence	1 month

*Table 5- Value stream performance measurement system at Renault Engines. Source: Own Elaboration.*

*Formal meeting system*

A formal meeting system is applied which is standard for the BWT’s. It is based on the information provided by the “Annual progress plan”. The meeting system is standard across the group and differentiates between daily meetings and monthly meetings. The objective of the daily meeting is to define the abnormalities of the day before and the risks and planning for the current day. The monthly meetings objective is to review the metrics to ensure that performance is trending in the right direction. The definition of the strategy and objectives is annually made by plant directors.



#### **4. Conclusions, Implications and Future Research**

In this paper it is investigated which practices lean enterprises adopt to focus on value streams. To do it, an exploratory case study of four plants that successfully performed a lean transformation with significant performance improvements is presented. The plants belong respectively to Delphi Diesel Systems, Sogefi Filtration and a company within the furniture industry.

Regarding the establishment of organizational units based on value streams, the companies under study have in common that they link their organizational structure to value streams. The objective is to concentrate the effort of the teams on value stream performance instead of the performance of individual people or functions. Company X put autonomous production units (APUs) in charge of each value stream. This was made possible by arranging the complete layout, originally organized functionally, in a flow layout where a single manufacturing cell performed a complete value stream. The DDS Sant Cugat case shows an example of how to establish APUs based on the value streams when the dimension, process complexity and variety are big. The solution was to separate the value stream in segments and grouping the different segments in APUs. It is in line with approaches such as “plant within a plant” (Skinner, 1994) and “the mini-company” (Suzaki, 1993). The case at Renault is a combination of the concepts applied in Company X and DDS Sant Cugat. Due to its big dimension, the facility was divided into three physically separated departments. Within the departments the layout is organized in continuous flow from beginning to end of the door-to-door value stream. The organizational units are established at a team leader level dividing the value streams into value streams segments. Sogefi filtration shows a case of a medium size enterprise where the lean transformation began and an in depth reorganization of the plant in APUs was not considered possible. The solution consisted in maintaining a pure functional hierarchical organization. The function of integrating the activity to the value streams was assigned to continuous improvement teams in charge of value stream segments. The solution at Sogefi is a hybrid between an organization in APUs and the concept of continuous improvement teams. According to Lillrank, (2001), continuous improvement teams are organized as a parallel system outside the formal line organization.

In relation to the establishment of a performance measurement system based on value streams, the companies under study have in common that they measure the performance in a value stream perspective. They all measure and display visually in the shop floor the most critical operational performance dimensions in terms of: security/human development, quality, volume/delivery and cost/productivity. The companies also put an emphasis on operational process indicators by measuring not only what to achieve but also how to achieve it. However, the concept of value stream costing was only present in the DDS Sant Cugat case where the APUs have financial autonomy and most of the cost are measured daily and assigned to the value stream segments. Differences were also found in how the information was collected and visually shown in the shop floor. In Sogefi, Company X and Renault Engines the indicators are posted in performance management boards with manual collection methods and daily update frequency. In the case of DDS Sant Cugat, due to the characteristics of the plant, big dimension, process variety and process complexity, exact information refreshed with high frequency is found necessary. This was achieved by an IT supported near real time manufacturing performance measurement system (MPMS).

Regarding the adoption of a formal meeting system, the studied plants established a formal meeting system based on the information provided by the value stream based performance measurement system. They all put in place a meeting system that differentiates between daily meetings and monthly meetings. The objective of the daily meetings, which are held in the shop floor, is to discuss the value streams’ abnormalities of the day before and the risk for the

current day. The monthly meetings or operating review meetings have the objectives of planning, result indicators performance review and continuous improvement. Differences were found in the way the continuous improvement projects were selected. The decision is based on the performance dimension that will have more impact on internal and external performance. This decision was made by plant directors in Sogefi filtration and Company X. In DDS Sant Cugat, it was made by the APUs in the TOP 5 focus meeting performed every quarter. At Renault engines the use of Hoishin Kanri concept aimed to align the plants yearly strategy with the teams' objectives and project selection.

In overall, the studied companies highlighted that the adaption of organizational practices to value stream focus were central into their transformation. Effectively, Sogefi initiated its transformation by adapting the organizational practices to value stream focus in a functional organization. DDS Sant Cugat brought a mature transformation further by developing a value stream based IT supported near real time MPMS. Plant X performed the transformation by rearranging the layout into single manufacturing cells that perform complete value streams. The organizational practices were adapted to the manufacturing cells and subsequently to value streams. Renault engines show a case of a company that it is widely acknowledged by its very pioneer and mature lean transformation at a group level. The organizational practices described started its application more than 20 years ago. This has positioned the plant into a reference of excellence both internally and externally.

The companies under analysis all adopted the three organizational practices presented in this paper, which are intended to focus on value streams. The adoption of these practices was standard and consistent across the different organizational units within the studied plants. However, the application of the concepts strongly depended on the specific circumstances of the plants such as size, complexity and transformation maturity. The main information obtained is summarized in Table 5.

	<i>Sogefi filtration</i>	<i>DELPHI Diesel Systems</i>	<i>Plant X from furniture sector</i>	<i>RENAULT engines</i>
<b>(1) The establishment of organizational units based on the value streams</b>	Continuous improvement teams in charge of value stream segments.	Autonomous production units in charge of value stream segments	Autonomous production units in charge of a value stream.  Complete value stream manager for customized products	Autonomous production units in charge of value stream segments
<b>(2) The use of a value stream based performance measurement system</b>	Value stream segment performance management boards with operational measures.	Value stream segment near-real time manufacturing performance measurement system with operation measures and value stream costing.	Value stream performance management boards with operational measures.	Value stream segment performance management boards with operational measures.
<b>(3) The adoption of a formal meeting system</b>	Daily stand up meetings in the shop floor  Monthly operating review meetings	Daily stand up meetings in the shop floor  Weekly operating review meetings  Quarterly TOP 5 focus meetings	Daily stand up meetings in the shop floor  Monthly operating review meetings	Daily stand up meetings in the shop floor  Monthly operating review meetings

Table 6- The use of organizational practices to focus the organization on value streams

This research provides an exploratory contribution in the fields of organizational practices involved in the transition to lean enterprise. Leading authors highlight the importance of value stream focus from a conceptual point of view. Works dealing on the topics of value stream management, organizational focus, performance measurement or meeting systems are present in the literature. However, no research was found in the literature about the organizational practices lean enterprises adopt to obtain the value stream focus. This research addresses this shortcoming. At the same time, four case studies illustrate the commonality of the application of general concepts and the particular solutions adopted in each different case.

For the management community, this paper provides concepts and application examples that can be used in other real practical cases. The cases refer to plants with different sizes, sectors, and complexity and lean transformation maturity. It is shown that the described principles and practices led to major performance improvements in terms of customer quality, delivery and operational cost in the studied companies with minimum investment. It is thought that the concepts presented in this paper may be applicable in other companies at various levels of lean maturity or at separate points in their own respective transformation plan. However, as drawn from the literature and the cases, that does not mean that the lean transformation of the organizational practices is an easy task. Transitions from functional organizations may face stiff resistance (Womack and Jones, 1994).

We think that the described principles provide insights about the organizational practices used by lean enterprises to focus on value streams. However, this research is based on a limited number of cases and provides, in consequence, provisional insights. Considering the limited amount of research on the subject, this kind of exploratory research is considered to be appropriate. Further research is needed to verify our findings. A quantitative analysis based on an appropriate sample of multi-site cases is foreseen. We now outline a series of testable propositions, which arise from this exploratory investigation.

- *Testable proposition 1:* Lean enterprises establish organizational units based on value streams to focus on value streams.
- *Testable proposition 2:* Lean enterprises use value stream indicators to focus on value streams.
- *Testable propositions 3:* Lean enterprises establish formal meeting systems to discuss value stream issues to focus on value streams.

Future research could include the study of the contextual factors and the assessment of the relationship among the three analyzed organizational practices and their combined effects; to assess whether these practices are complementary and which are the synergies and why do they exist. Moreover, the many different approaches adopted by different companies require best-in-class multiple case study examination to determine if one-best-way exists. An exploratory investigation in service sectors is another potential future research.

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<b>Appendix</b>	<b>B</b>
<b>Paper title</b>	<b>A case study of an integrated manufacturing performance measurement- and meeting system</b>
<b>Authors</b>	<i>Jordi Olivella and Ruben Gregorio</i>
<b>Publication</b>	Accepted for publication after minor revisions at the Journal of Manufacturing and Technology Management.



# ***A case study of an integrated manufacturing performance measurement- and meeting system***

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## **Abstract:**

**Purpose:** The purpose of this paper is to expose an integrated manufacturing performance measurement and meeting system.

**Design/methodology/approach:** This paper is based on an exploratory case study carried out at Delphi Diesel Systems plant in Sant Cugat (Spain).

**Findings:** A novel practice is presented that consists of an integrated manufacturing performance measurement and formal meeting system, designed and used as a single system. This paper suggests that an integrated manufacturing performance measurement and meeting system can be useful to strengthen the focus of the activity on value streams performance.

**Research limitations/implications:** Considering the limited amount of research on the subject this kind of exploratory research is considered to be appropriate. However, this research has one main limitation; this study is applied in a single manufacturing plant and provides in consequence tentative and provisional insights. Further research should be conducted using multiple industries in order to verify our findings.

**Originality/value:** The practice exposed has not been presented previously in the literature. The results obtained in the analyzed case suggest that it is a promising approach that deserves more application and research. For the management community, this paper provides a new way of designing and using manufacturing performance measurement systems.

**Keywords:** Performance measurement, meeting system, OEE, lean, IT, MPMS, APU, Delphi, value stream.

**Paper type:** Research paper

## **1. Introduction**

In complex value streams, the perceptions about what is needed and what will generate customer value are, in some cases, wrong. In fact, not needed activities do take place and sometimes the needs of the final clients are not taken into account. To avoid these situations, focusing the organization on value streams has been considered to be a key success factor (e.g. Womack and Jones, 1994; Liker, 2004). In an outstanding precedent of this idea, Skinner (1974) proposed that manufacturing plants should focus on a limited, concise and manageable set of products, technologies, volumes and markets. Womack and Jones (1994) stated that value creating activities can be joined, but this effort will require a new organizational model: the lean enterprise. Prioritizing the value stream focus is a strategic decision for the lean transformation that implies to appropriately adapt day to day practices. Maskell and Kennedy (2007) propose to realign the performance measurement system in a value stream perspective.

The literature describes several methods for developing a manufacturing performance measurement system (MPMS). What is characteristic about many of these methods is the focus on developing performance metrics and a an MPMS based on the firm's strategy and

processes (Bourne *et al.*, 2000). Bourne *et al.*, (2000) addresses the issues met when designing, implementing, using and continuously updating performance measurement systems in manufacturing companies. Some case studies of this are found in the literature. Lohman, (2003) presents a case study of the design of a performance measurement system. Gomes *et al.* (2005) performed an empirical investigation of the performance measurement practices in manufacturing firms, however in the literature reviewed there were no papers found exploring how to integrate performance measurement and a formal meeting system. Adopting a formal meeting system complements the setting up of a formal meeting system.

The purpose of this paper is to expose an integrated manufacturing performance measurement and meeting system. Since the approach is new and the authors did not find previous empirical knowledge, it was felt best to gain a deep understanding of what was happening. It was necessary to take a significant amount of time in field research. A case study was conducted since such research is most appropriate in the early stages of research on a topic (Eisenhardt, 1989). This paper is based on an exploratory case study carried out at the Sant Cugat (Spain) plant (DDS Sant Cugat in the rest of the paper) of Delphi Diesel Systems, a division of Delphi Automotive PLC (Delphi in the rest of the paper). Data was collected through an interview with the operations director, informal interviews with APU managers and team leaders and the direct analysis of the plant, all this carried on in March 2012. According to Piercy and Rich (2009) "The use of single or small numbers of case studies as knowledge building tools is increasing prevalent in the operations management literature". Single case study approaches cannot offer generalizability in the statistical sense (Yin, 1994). They are however capable of developing and refining generalizable concepts and frames of reference (Pettigrew, 1985). A thorough analysis of a single situation may lead to discovery of non obvious relationships. The lack of generality in the single-case studies is compensated by an additional level of detail. To overcome the weakness of a single-method design, data has been gathered through triangulation from multiple sources, using three different data collection methods (observations, semi-structured interviews and company documentation). Interviews provide depth, subtlety, and personal feeling. Documents provide facts, but are subject to the dangers of selective survival. Direct observation gives access to group processes and can reveal the discrepancies between what is said and what is actually done (Pettigrew, 1990).

The outline of the paper is as follows: Section 2 is devoted to the literature review, focusing on MPMS and formal meeting system. After, the characteristics of the company and the MPMS application at DDS Sant Cugat is explained, explaining in detail the overall equipment effectiveness measure and the integration with the formal meeting system. Finally we present the results and conclusions.

## **2. Literature review**

The performance measurement revolution started in the late 1970s and early 1980s with the dissatisfaction of traditional backward-looking accounting systems (Nudurupati and Bititci, 2005). However, the implementation and use of performance measurement has received considerable attention in the recent years (Nudurupati and Bititci, 2005). Neely *et al.* (2005) described performance measurement as a set of metrics used for quantifying both the efficiency and effectiveness of an action. Within the lean manufacturing context a manufacturing measure is a standard that defines performance criteria for manufacturing processes so that everyone in the organization is working towards the same goal (Khadem *et al.*, 2008). Lewis and Slack (2003) mentioned five types of performance objectives based on cost, flexibility, speed, dependability and quality. According to Tangen (2004), the most well-known performance measurement system is probably the balanced scorecard system, developed and promoted by Kaplan and Norton (1992). The balanced scorecard proposes that a company should use a balanced set of measures that allows top managers to take a quick but



comprehensive view of the business. However, according to Ghalayini et al. (1997), the main weakness of this approach is that it is primarily designed to provide senior managers with an overall overview of the performance. Thus, it is not intended for (nor is it applicable to) the factory operations level. Further, they also argue that the balanced scorecard is constructed as a monitoring and controlling tool rather than an improvement tool. In order to address the reciprocal relationship between the stakeholder and the organization, Neely *et al.* (2001) describes a new measurement framework that is called the performance prism. The framework can be used by management teams to influence their thinking about what the key questions are that they want to address when seeking to manage their business (Neely *et al.*, 2001). Gomes and Yasin (2011) present an approach to performance measurement and management for SMOs with global business aspirations. The approach presented offers practicing managers a systematic and practical approach to performance measurement, management and improvement. According to Keegan *et al.* (1989), most performance measurement systems used in firms include too many different measures which makes it difficult to understand the “big picture”. Schmenner and Vollmann (1994) performed an empirical study concluding that most of the studied companies seriously needed to consider changing their performance measurements. They argued that most organizations were using wrong measures and failing to use the correct measurements in correct ways. According to Neely *et al.* (1997), if performance indicators are not well designed, it can result in dysfunctional behaviours, encouraging individuals to make the wrong decisions. Cooper and Kaplan (1988) stated that a good system is a system that provides accurate, timely feedback to managers on their performance. According to Cooper and Kaplan (1988) the frequency of reported information should follow the cycle of the production process. In departments producing hundreds of parts per hour, the materials per-unit, labor, machine time and utility consumptions should be reported daily or even hourly. According to Jonsson and Lesshammar (1999) no matter what the objective of the system is, a complete MPMS needs to be comprehensive and cover the most critical performance dimensions of the organization. According to Nudurupati and Bititci (2005) the major barrier identified for implementation and use of performance measurement is the lack of IT platforms and people’s behaviour when dealing with information. Cecelja (2002), states that there are a number of different methods by which shop-floor data collection can be performed. The simplest, and cheapest, is paper recording and manual storage. This method makes it fairly difficult to use and analyze the data; hence there is a greater probability that the data will not be used to improve the process, making the exercise pointless. The second method is paper recording and input into an MRP system. Although this is cheap to perform, it is labor intensive, resulting in a time lag, low accuracy and is also difficult to analyze. Finally, dedicated shop-floor data collection systems can be implemented that are very flexible, very accurate, and allow the possibility of providing information in real time.

Some authors have done research on performance indicators for lean production. According to Cottyn *et al.* (2011) the application of information technology and lean principles have for a long time been seen as mutually exclusive, but both approaches are more and more claimed to be interdependent and complementary. Lean advocates have the idea of putting in place a simplified information management system (Houy, 2005). They consider that organizations based on continuous flow should limit information needs to local communication between upstream and downstream production units. In their view, it is preferable for employees to search for the information they need and when they need it, rather than configuring software to provide information that is repeated at predetermined times (Cottyn *et al.*, 2011). However, it is not obvious how firms should measure their manufacturing performances (Jonsson and Lesshammar, 1999). In complex manufacturing processes the support of IT in the MPMS can trigger, feed or validate the Lean decision-making and continuous improvement process by always basing the decisions on the production flow. Sánchez and Pérez (2001) state that lean production implies decentralization of responsibilities to production line workers and a decrease of hierarchic levels within the company. According to the authors, the efficient

operation of a lean organization requires the diffusion of information to all levels. This is also highlighted by Womack *et al.* (1990) and Womack and Jones (1996). The aim is to deliver timely and useful information down to the production line. The content of that information must be as much strategic as operational (Sánchez and Pérez, 2001). According to Imai (1986) two types of performance indicators can be distinguished: result-oriented performance indicators or result indicators and process-oriented performance indicators or process indicators. According to De Haas *et al.* (2000) the “what to achieve?” question has to be answered in terms of result indicators, while the “how to achieve?” question needs to be tackled in terms of process indicators. De Toni and Tonchia (1996) state that the pursue of excellence and the organizational change required by lean production leads to a management-by-process organization, and that management by process influences the performance measurement system. The authors state that management by process can be considered as links in a customer/supplier chain, even within firms, separating process and result performances. De Toni and Tonchia (1996) separate between internal and external performances; the latter are the only ones directly perceived by the customers. Maskell (1991) suggests a model that works with the relationship between the financial system and lean production which is known as lean accounting. Maskell (1991) stated that a good measurement system should be related to the manufacturing strategy, include non-financial measures, vary between locations, change over time, be simple and easy, give fast feedback and aim to teach rather than to monitor. Richey (1996) observed that winners of the 1996 Shingo prize for manufacturing excellence primary used a visual performance management system on the shop floor.

The OEE measure is accepted by management consultants as a primary performance metric (Hansen, 2001). The OEE measure, applied by autonomous small groups on the shop-floor together with quality control tools, is an important complement to the traditional top-down oriented performance measurement systems (Jonsson and Lesshammar, 1999). OEE is defined as a measure of total equipment performance, that is, the degree to which the equipment is doing what it is supposed to do (Williamson, 2006). Many companies routinely hit capacity constraints and immediately consider adding overtime for existing workers, hiring workers for new shifts, or buying new production lines to boost their production capacity (Muchiri and Pintelon, 2008). For such companies, the OEE tool can help them to optimize the performance of the existing capacity (Muchiri and Pintelon, 2008). The OEE measure is a bottom-up approach where an integrated workforce strives to achieve overall equipment effectiveness by eliminating the six big losses (Nakajima, 1988): (1) Breakdown losses (2) Set-up and adjustment losses (3) Idling and minor stoppage losses (4) Reduced speed losses (5) Quality defects and rework losses (6) Start-up losses. According to Jonsson and Lesshammar (1999) the data collection of the OEE should be at such detailed level that it fulfils its objectives without being unnecessarily demanding of resources. Sometimes the process itself is so complex that it is impossible to avoid a detailed data collection (Jonsson and Lesshammar, 1999). The data collection can then be facilitated by measuring the actual time after each downtime and speed loss, instead of measuring the frequency of these losses (Jonsson and Lesshammar, 1999). The most important objective of OEE is not to get an optimum measure, but to get a simple measure that tells the production personnel where to spend their improvement resources (Jonsson and Lesshammar, 1999). According to Schonberger (1986), in conventional manufacturing, down time is a serious problem only for bottleneck equipment. One effect of buffer stock removal, a Just in Time technique, is to turn all work centers into bottlenecks so they receive problem-solving attention. With Just in Time concentrating on offering goods on demand with no big inventory, the OEE measure become important to ensure that every operation within the value stream is running correctly. However, Scott and Pisa (1998) pointed out that the gains made in OEE, while important and ongoing, are insufficient. It is necessary to focus one’s attention beyond the performance of individual tools towards the performance of the whole factory. The ultimate objective is a

highly efficient integrated system, not brilliant individual tools. Scott and Pisa (1998) coined the term “overall factory effectiveness” (OFE), which is about combining activities and relationships between different machines and processes, and integrating information, decisions and actions across many independent systems and subsystems. Jonsson and Lesshammar (1999) agree with that idea and agree that OEE is a measure of internal efficiency. OEE does not measure the strategy, flow orientation and external effectiveness dimensions to any great extent. More recently Gomes et. al., (2007) introduced and tested a similar concept to the OFE; the Manufacturing Operational Effectiveness (MOE) indicator.

The establishment of a formal meeting system complements the setting up of a MPMS that covers the most critical performance dimensions (such as quality, delivery, flexibility and cost). According to Dani (2010) there is a belief at Toyota that reports and meetings that occur away from the actual site of the work being discussed will lead to incorrect assumptions and conclusions. According to Maskell and Kennedy (2007) all routine meetings are held and decision making is discussed around the visual performance that measure the value stream performance boards in the shop floor. However in the literature reviewed there were no papers found exploring how to integrate performance measurement and a formal meeting system. According to Fletcher and Taplin (1997), with the emphasis on cross functional teams, natural work groups and continuous improvement task forces, companies must learn how to formally plan and review the activities of these emerging horizontal organizations. Operating review meetings emphasize planning, performance review and continuous improvement (Fletcher and Taplin, 1997). The philosophical core of the operating review meetings is an emphasis on the future, not the past. During these meetings, the focus is kept solely on interdepartmental key performance indicators (KPI)s (Fletcher and Taplin, 1997). They suggest as main point of the meetings procedures to (1) Hold regular meetings, (2) Set an established agenda (3) Review exceptions and commitments, (4) Make performance improvement plans (5) Document meeting action items. Another meeting system reported in the literature is the continuous improvement meetings. These meetings are not studied in this paper because they are performed outside the formal meeting context. According to Lillrank, (2001) continuous improvement teams are organized as a parallel system outside the formal line organization. In the Japanese organizational context it would be unacceptable to allow “the voluntary spirit” to spread into the formal work organization. According to Skinner (1974) managers need to know: "What must we be especially good at? Cost, quality, lead times, reliability, changing schedules, new-product introduction or low investment?". His beliefs were based on the idea that various competitive dimensions (such as quality, delivery, flexibility, and cost) imply trade-offs. Skinner (1974) described the focused plant as one that can become a competitive weapon because its' entire apparatus is focused on accomplishing the particular manufacturing task demanded by the company's overall strategy and marketing perspective.

### **3. Characteristics of the case**

Delphi is one of the world's largest automotive part manufacturers and has approximately 146,600 employees (Delphi, 2012). Delphi is a former General Motors company that became independent in 1999 and has been implementing the lean manufacturing concepts since the early 1990's. Delphi is considered an example of lean transformation of a big traditional company (Woolson and Husar, 1997). Delphi has been recognized with the Shingo Prize for operational excellence, also called “the Nobel Prize of manufacturing” by Business Week (2000), in twenty-seven plants. The Shingo prize recognizes organizations in the USA, Mexico and Canada for the successful implementation of world-class practices (Shingo, 2012). The policies and tools which are based on lean manufacturing are applied in all Delphi units and forms the Delphi Manufacturing System (DMS). The DMS is widely acknowledged. For example it is described by Liker, (1997) together with Daimler-Chrysler

Operation System and Ford Production System. Some case studies of Delphi are found in (Mabry and Morrison, 1996; Salaiz, 2003; Nelson, 2004).

DDS Sant Cugat manufactures Diesel fuel injection pumps of two product groups, dfp1 and dfp3, for some of the main automotive customers (Delphi, 2012). The plant has been operating for fifty-five years and employs around one thousand people. DDS performs the machining and assembly of the pumps. The assembling process is made in two lines for the dfp1 product group (assembly line 1 and assembly line 2 in figure (1)) and one line for dfp3 product group (assembly line 3 in figure (1)). The machining process of the different components is basically composed by a soft stage machining process, a heat treatment process and a hard stage process. The plant is characterized by its big dimension; process variety and process complexity (see Figure 1 showing the process flow diagram. Dark blue corresponds to dfp3, light blue to dfp1).

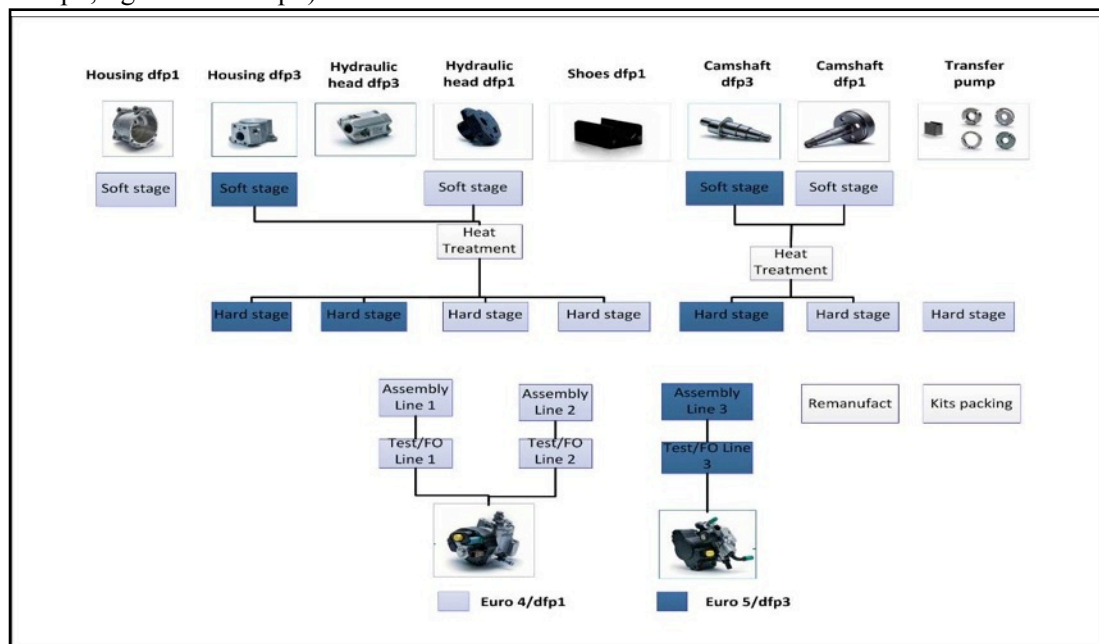


Figure 1- Process flow diagram. Source: Own elaboration

DDS Sant Cugat has been applying the lean manufacturing principles for years. In 2002, DDS Sant Cugat was selected as model plant for the implementation of the DMS within the Diesel Division. The DMS was adapted to the needs of the division and published in Delphi's "Lean Toolbox". The DMS was later implemented in other plants of the group. The current top and intermediate managers of the plant participated in this process. According to Jaume Roquet, who is the operations director of the plant, the experience acquired by the current managers as lean leaders during the initial implementation of DMS is a key aspect of the more recent transformations. For DMS the focus of the organization to the production flow is a critical aim. According to DMS documentation, DMS is "a Manufacturing System with an implementation process that recognizes the interdependencies of its elements and drives to flow manufacturing". The application of the DMS at DDS Sant Cugat makes information and material flow through the different operations as follow. The demand is frozen, leveled by type, quantity and frequency over a monthly period of time. The tool used to level production mix in the shop floor is a Heijunka box in each of the main assembly lines. This enables the production to meet customer demand while avoiding batching. The machining processes produce the material needed to the assembly lines by following a pull system. Two tuggers move the material every forty-five minutes. The different operations in the value stream are balanced and the cyclical work is decoupled from non-cyclical work to guarantee that the production flows in a constant pace.

The DMS also highlights the importance of having an organization based on the production flow. According to DMS documentation, *“We cannot separate Manufacturing, PC&L, ME, Purchasing, PE, HR, Sales, Business line... and so on because all functions must support manufacturing that is our core. All activity is connected and this focus will maximize the performance as an enterprise”*. The plant is divided into five autonomous production units (APUs) that are managed by an APU manager leading a team of 10-20 indirect employees and 100-250 direct workers. The APUs have decision and financial autonomy while strictly following the standards of Delphi and the plant. The aim of this organizational solution is to focus the teams on the production flow, enhance entrepreneurship, team work, flexibility and problem-solving reactivity while preserving the technical knowledge and specialization of the functions.

#### **4. The new integrated manufacturing performance measurement and meeting system**

In 2009, DDS Sant Cugat faced a new and demanding challenge. Due to the high demand the strategy of Delphi consists in taking as much advantage as possible of the capacity of the plant. To serve these objectives an integrated manufacturing performance and meeting system has been developed that gives great importance to the overall equipment effectiveness measure. The goal of the system is to strengthen the focalization of the activity on the value streams. According to the interviewee, Jaume Roquet, Operations Director *“the performance measurement system and the meetings, for us constitute one system. It makes the teams focused on the aspects that will make a difference in the performance of the business.”* The application was highly successful and allowed the plant to cope with the increasing customer demand through an increased focus of the organization on the volume performance dimension. This section describes first the new MPMS explaining the OEE measure in detail. After, the integration with the meeting system is described.

##### **The new near real time manufacturing performance measurement system**

The performance management boards were changed by an IT supported near real-time manufacturing performance measurement system (MPMS) that was developed to fulfill the following needs:

- (1) To simplify and integrate the performance measurement system in a single system and adapt the refreshment frequency to the frequency of the manufacturing process.
- (2) To develop indicators that motivate continuous improvement of the decentralized teams not only showing the result but also helping to detect the root causes of the deviations and help to focus the efforts of the teams.
- (3) To link the targets of the indicators with internal or external customer needs.

Table 1 shows details about the new MPMS. It covers the most critical performance dimensions: security, quality, volume and cost. Every performance dimension has at least one result indicator (that defines what to achieve) and one process indicator (that defines how to achieve it), as suggested by De Haas *et. al.* (2000). In the following table the refreshment frequency of the different indicators is also described.

	<i>Result indicator</i>	<i>Process indicator</i>	<i>Refreshment frequency</i>
Security	Number lost work day cases	The root cause analysis process has been done and is visible on the system (or not) Number and description of all kind of injuries/risks detected	2h
Quality	Number of external customer complaints (parts per million)	The root cause analysis process of the external customer complaints has been done and is visible on the system (or not) Number and description of internal customer complaints (parts) First time quality rate and Pareto chart of causes	2h
Volume	Premium freights (€)  Number of stoppage hours to internal customer  Number of parts produced (only daily)	Overall equipment effectiveness (OEE) and Pareto chart of causes in every machine	2h
Cost	Total accumulated expenses vs. financial budget Scrap cost (€) Manpower utilization vs financial budget (theoretical hours/real hours)	Expenses vs. target separated into maintenance, scrap and supplies Pareto chart of scrap Manpower utilization Pareto chart of losses	24h

*Table 1- The manufacturing performance measurement system. Source: Own elaboration.*

The OEE measure is explained in detail in the rest of this section. In DDS Sant Cugat's MPMS the OEE measure is critical due to the characteristics of the plant. The plant performs a high volume manufacturing process. Capacity utilization is of a high priority and stoppages or disruptions are expensive in terms of lost capacity. Dal et al. (2000) suggest that OEE measurement is best suited in those cases. Effectively the plant is characterized by:

- 1) *Dimension*: 500 different machines that perform 150 different operations.
- 2) *Variety of manufacturing processes*: drilling, electrochemical machining, heat treatment and surface hardening, turning, grinding, cleaning, assembly, test processes and painting processes.
- 3) *Variety of failure modes*: Every machine has between 100 and 300 different causes that can stop production flow.

The result is that the production flow can be stopped by a very wide variety of causes. As suggested by Jonsson and Lesshammar (1999), such complexity makes it necessary to have a more detailed data collection for OEE measurement than a classification into the six big losses proposed by Nakajima (1988). The OEE is measured in 100% of the machines in the plant. The data is collected and introduced in a software system by two workers (see figure 2 for an example of collected information), following standardized routes, with a frequency of two hours (see figure 3). In order to know accurately the capacity losses, every possible failure mode is codified in every machine. The responsibilities of the workers that collect the data are also ensuring the quality of the data by teaching the workers how to use the codes in case of mistakes.

DELPHI		01/02/12		Sección:		5291		Fase:		120		Máquina:		AKOIN F120C		Matrícula:		RIN - 2163		
Tc (seg/pieza)	PRODUCCIONES piezas/hora				TNR	DESCRIPCIÓN DE PAROS												Min No explicados	OEE 24h (%)	OEE TR (%)
	DAIZ	GMDAT	SSY	JCB		Causa 1			Causa 2			Causa 3			Operario					
06 =07	67,0	106,0	106,0	106,0		Min	Cód	Sub cod	Min	Cód	Sub cod	Min	Cód	Sub cod		4758	0	0,0%	0,0%	
07 =08	0					30	RF	H	30	RF	C				4758	0	0,0%	0,0%		
08 =09	14					30	RF	H	30	RF	C				4758	-1	26,1%	26,1%		
09 =10	45				10				20	RF	C	5	MP	A	6880	0	83,8%	100,5%		
10 =11	45					10	MP	E							6880	0	83,8%	83,8%		
11 =12	54														6880	0	100,5%	100,5%		
12 =13	54														6880	0	100,5%	100,5%		
13 =14	45					10	MP	E							6880	0	83,8%	83,8%		
14 =15	45					10	PRE	K							4032	0	83,8%	83,8%		
15 =16	40					15	FA	B							4032	0	74,4%	74,4%		
16 =17	0					60	FA	B							4032	0	0,0%	0,0%		
17 =18	54														4032	0	100,5%	100,5%		
18 =19	54														4032	0	100,5%	100,5%		
19 =20	40				10	5	PRE	K							4032	0	74,4%	89,3%		
20 =21	54					10	MP	E	5	MP	F				4032	0	100,5%	100,5%		
21 =22	40					5	OP	A	5	PRE	K				4032	0	74,4%	74,4%		
22 =23	44					5	OP	A	5	PRE	K				3098	1	81,9%	81,9%		
23 =00	54														3098	0	100,5%	100,5%		
00 =01	54														3098	0	100,5%	100,5%		
01 =02	54														3098	0	100,5%	100,5%		
02 =03	40				10	5	PRE	K							3098	0	74,4%	89,3%		
03 =04	50					5	HTA	F							3098	-1	93,1%	93,1%		
04 =05	30					10	OP	A	10	PRE	K				3098	7	55,8%	55,8%		
05 =06	40					10	MP	E							3098	5	74,4%	74,4%		
TM	257	0	0	0	0	10									TM	-2	59,8%	61,1%		
TT	327	0	0	0	0	10									TT	0	76,1%	77,7%		
TN	366	0	0	0	0	10									TN	11	85,1%	87,0%		
TOTAL	950	0	0	0	0	30									TOTAL	9	73,7%	75,2%		
																Entregas (piezas)	950			
																% No Explicados	0,7%			
																OEE (24h)	73,7%	TARGET		
																OEE (TR)	75,2%	80%		

Figure 2- Example of the OEE information collection. Source: Delphi Diesel Systems S.L. translated to English NO TRADUÏT

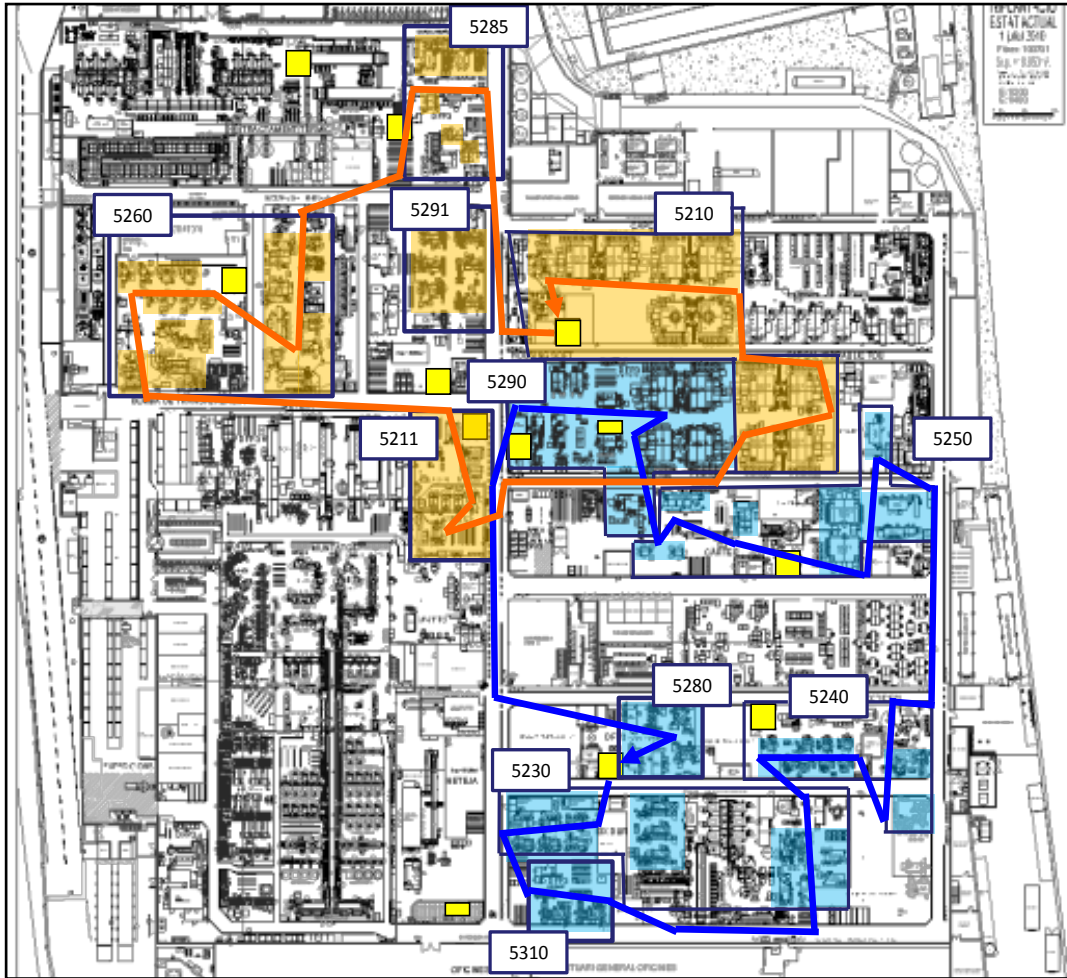


Figure 3- Routes of the two workers that collect data every two hours (blue route and orange route).  
 Source: Delphi Diesel Systems S.L.

The information collected is then introduced in an IT system. This computer system allows everybody to have access to the information at any moment in any aggregation level. In the following picture there is an example of how the information is displayed. The system always shows the Pareto chart of the losses from last day and the last four weeks classified within the six big losses proposed by Nakajima (1988) (see figure 4). Any big loss can be selected in order to have more detailed information about the exact reason of stoppage. For example in figure 4 the breakdown loss is selected (accounts of 6,3% of losses in the last four weeks and 11,3% in the previous day) and the Pareto of the exact causes are displayed.



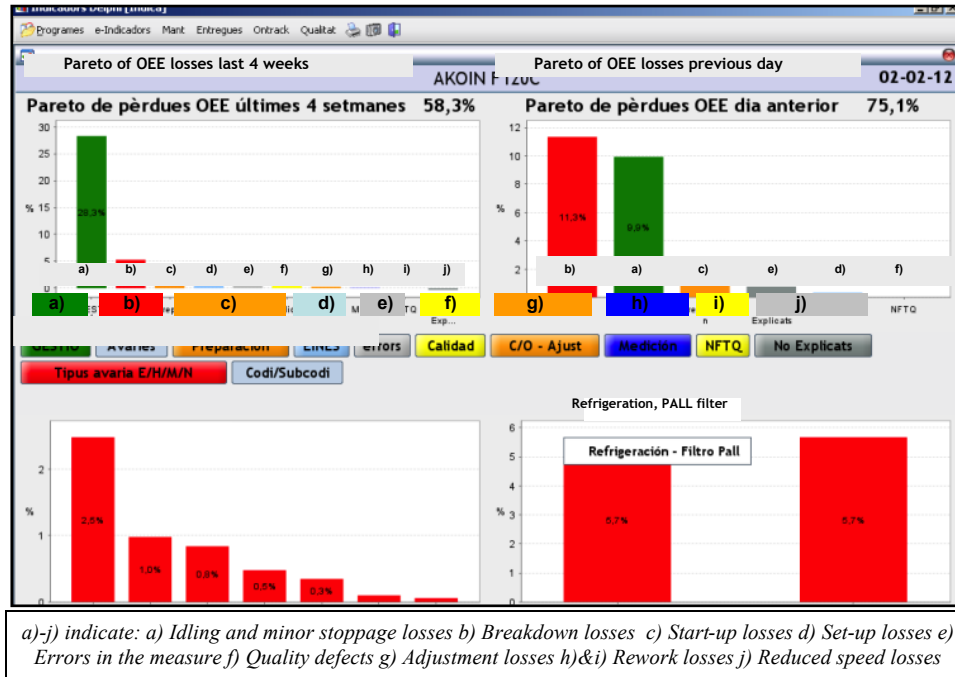


Figure 4- Example of the OEE measure. Source: Delphi Diesel Systems S.L. translated to English.

For OEE target setting, DDS Sant Cugat uses the concept of Operation Rate (OR) which is defined in internal manuals as the “*minimum level of OEE to meet customer demand*”. OEE performance lower than OR in one machine means a risk of stopping the complete flow of a product. The calculation of the operation rates is made based on the coming month’s demand, machines opening hours and machines cycle times with an OR-calculation standard tool (see Figure 5). The OR concept is used for target setting in the MPMS and gives the OEE measure a complete flow and customer orientation. The comparison of the OEE levels with the OR makes it possible for the decentralized teams to quickly identify bottlenecks and focus on the production flow and external customer needs.

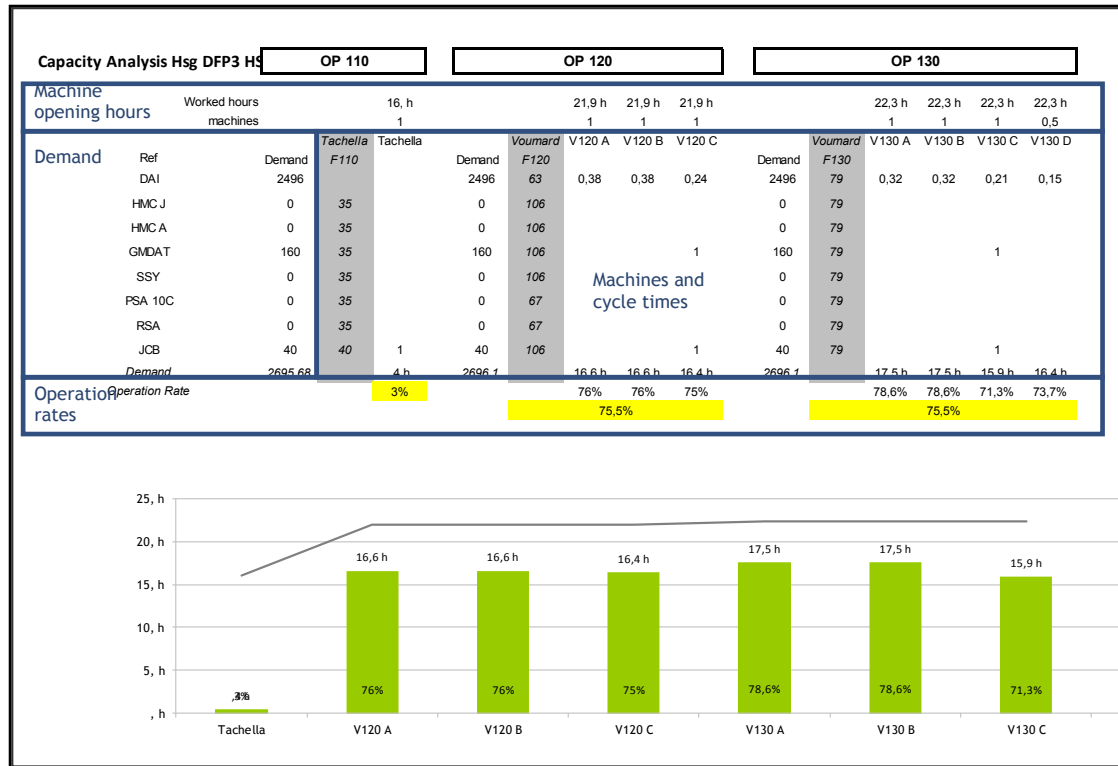


Figure 5-Example of operation rate calculations. Source: Delphi Diesel Systems S.L.

### The integration of the MPMS and the formal meeting system

Meetings can only be effective if the appropriate and accurate information is discussed. Gathering information would make no sense if it is not clearly established what will be done with it. The MPMS supports these meetings by showing the information that must be checked (result indicators) and allowing the possibility of going into detail (process indicators). The meeting system applied in DDS Sant Cugat differentiate between daily meetings called “Daily stand-up meetings”, weekly and monthly meetings called “operating review meetings” and quarterly meetings called “top5 focus meetings”.

#### Daily stand-up meetings

The objective of this meeting is to define the abnormalities of the day before and the risks for the current day based on the information provided by the result indicators compared to the planned performance in terms of security, quality, volume and cost. In case of abnormalities, the associated process indicator is checked in order to quickly understand and react to the problems. For example, OEE measure is only checked in case that the volume was lower than the customer needs. This meeting is performed every morning in the shop floor by the APU staff (APU manager, quality manager and manufacturing engineering manager). After the meeting the DDS Sant Cugat directors do a plant tour through the five APUs in order to quickly review the major abnormalities and risks. The manufacturing teams that work in shifts also perform the daily stand-up meetings but with a lower scope.

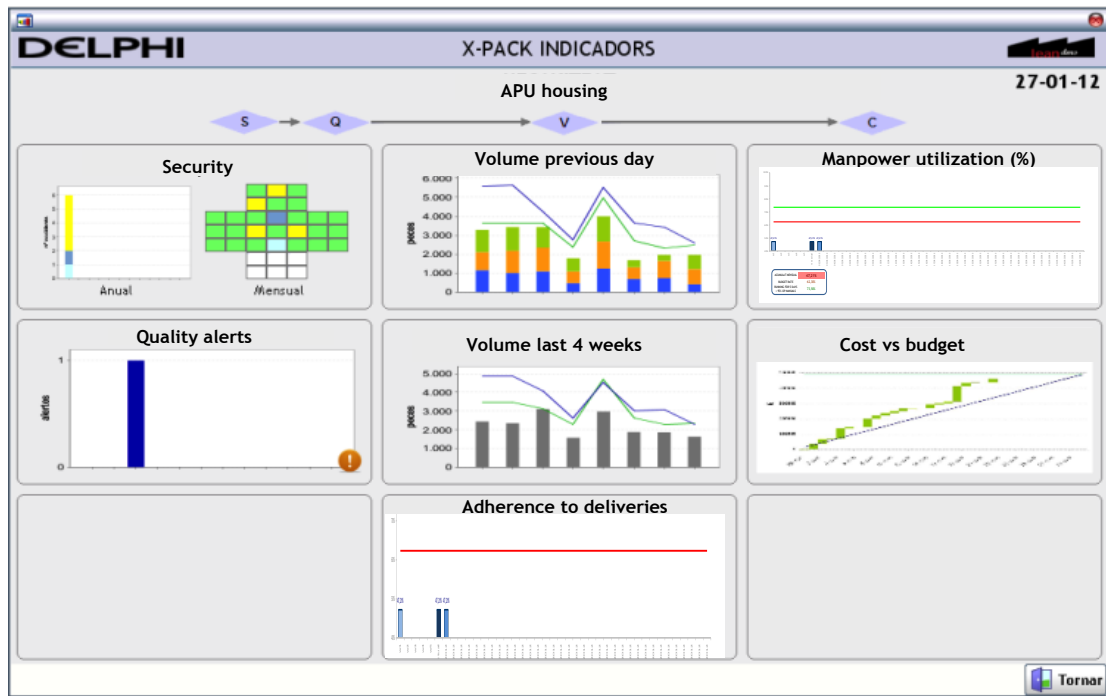


Figure 6- The manufacturing performance system that supports the daily stand-up meetings. Source: Delphi Diesel Systems S.L.



Figure 7- Example of a meeting area where the daily stand-meetings are done. There are 22 in all the plant (one per setter and operators team). Source: Photo done on a visit to Delphi Diesel Systems S.L.

### Operating review meetings and TOP5 focus meeting

The operating review meetings have the objectives of planning, result indicators performance review and continuous improvement. These meetings are performed on a weekly basis by the APU staff. On a monthly basis the team presents their performance results and the action plan to the plant directors.

The TOP 5 focus meeting is performed every quarter with the purpose of selecting the most important improvement projects. The APU staff define their performance dimension focus called “business problem” between security, quality, volume and cost (in order of importance). The definition of the “business problem” is based on result indicators with targets linked to internal and external customer needs. It is decided which the five most important projects are, that the team will focus on. These are called the “TOP5 priority projects” and they are focused on the performance dimension that will have more impact on APU’s internal and external performance as suggested by Skinner (1974). In figure 9, there is an example of the TOP5 priority projects from the fourth quarter of 2011 (Q4 2011) listed in order of importance.

	QVC	Title (including target)	owner	achieved	saving (k€)	Status	
<b>Q4</b> <b>2011</b> <small>Security Cl</small>	1	V	OEE IMAS DFP1 (55% → 61%)	JR	55%	V	Repeat
	2	V	OEE IMAS AI DFP1 (60% → 68%)	PR	67%	V	100%
	3	V	OEE HO DFP3 hard stage (70% → 80%)	JR	80% (no FM)	V	100%
	4	V	ROF Heat Treatment founds	PR	100%	V 40k€/y	100%
	5	Q - C	Material reduction in jail by 15% (124keur current)	PR	99k eur	25k eur	100%

Figure 8- Example of APU TOP 5 focus meeting conclusions from the fourth quarter of 2011 (Q4 2011). Source: Delphi Diesel Systems S.L.

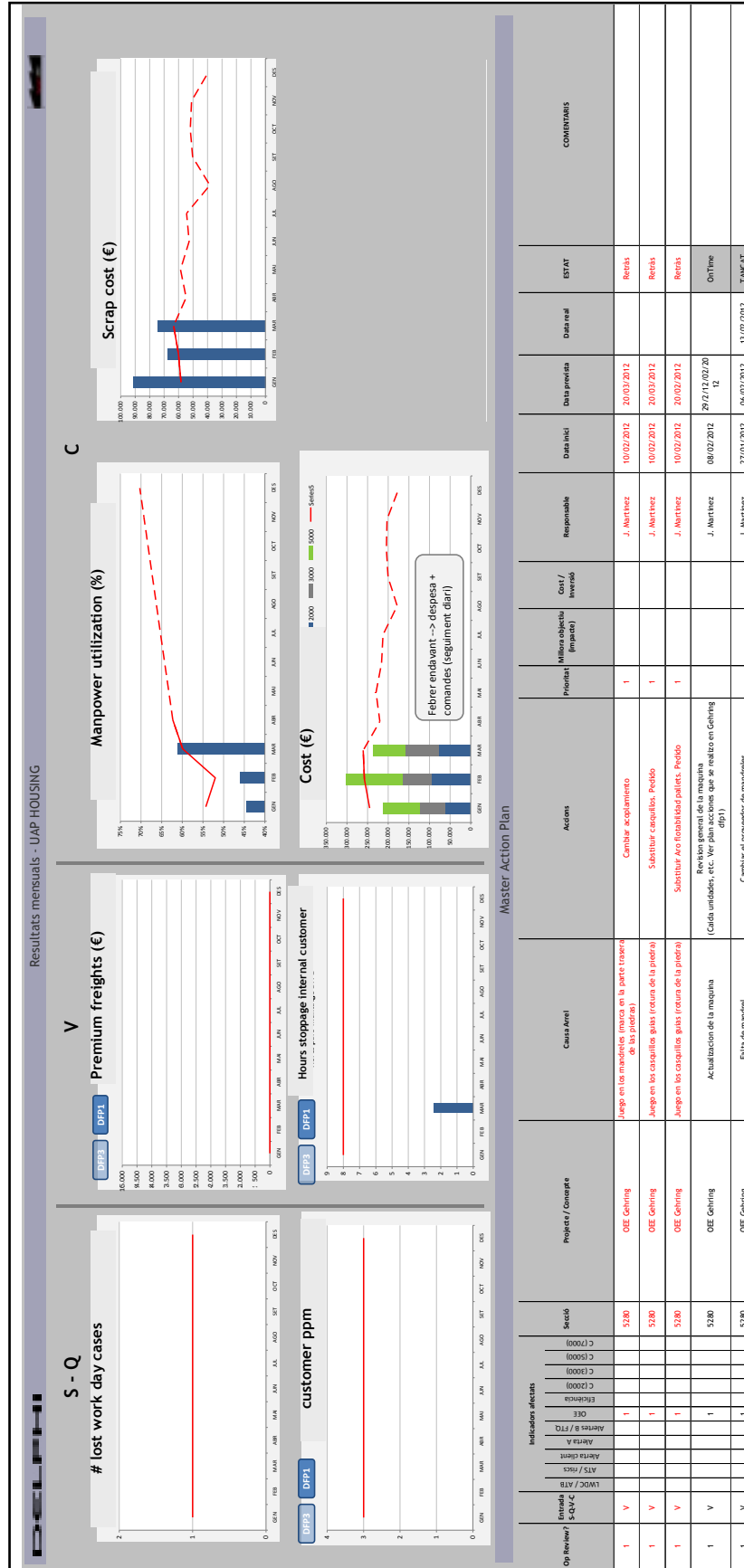


Figure 9- The manufacturing performance measurement system that supports the operating review meeting. Source: Delphi Diesel Systems S.L.

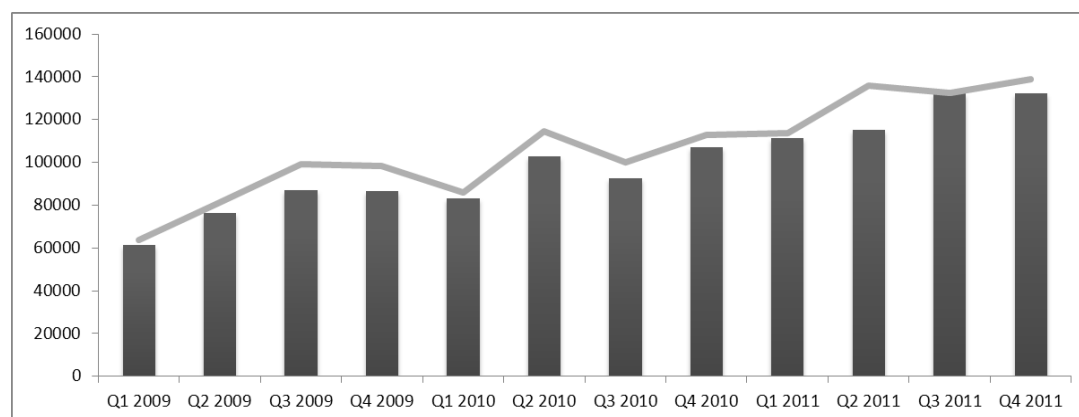
## 5. Results

The solution presented in this paper resulted in being highly successful, with an increase of OEE levels from 5% to 10% from January 2009 to January 2012. The following table shows how the current OEE values are very close to the design OEE. The design OEE is the OEE that the machine can perform based on the manufacturing process. Higher values than design OEE can only be achieved through a redesign of the machine.

<i>Manufacturing process</i>	<i>Number of machines</i>	<i>OEE average January 2012</i>	<i>Design OEE</i>
Drilling	10	65%	65%
Drilling	2	68%	70%
Heat treatment and surface hardening	1	97%	95%
Electrochemical machining	4	75%	80%
Grinding	7	85%	85%
Cleaning	3	95%	95%
Assembly	20	95%	95%
Test	10	80%	80%
Painting	1	90%	90%

*Table 2-OEE results vs design OEE values. Source: Delphi Diesel Systems S.L.*

The result indicators also show radical improvements. The use of an integrated near real-time performance measurement and formal meeting system made it possible for the APU teams to focus on the volume performance dimension and the aspects that would have a critical impact in the volume increase. From the first quarter of 2009 to the fourth quarter of 2012 there was an increase of volume of 120%, with no capital expenditure in new equipment, through bringing OEE values close to the design OEEs and several cycle time improvements. It must be noted that the new MPMS and the formal meeting system described in this paper had an important contribution to this achievement but they are not the only factors that had influence in this achievement.



*Figure 10-Volume evolution vs. target volume from 2009 to 2011. Source: Delphi Diesel Systems S.L.*

## **6. Conclusions**

This paper exposes a novel practice that consists in an integrated manufacturing performance measurement system and formal meeting system, designed and used as a single system. The paper is based on a case study carried out at Delphi Diesel Systems plant in Sant Cugat (Spain). The described system started the development in 2009, when DDS Sant Cugat faced a new and demanding challenge. Due to the high demand the strategy of Delphi consists in taking as much advantage as possible of the capacity of the plant. To serve these objectives an integrated manufacturing performance measurement and meeting system has been developed that gives great importance to the overall equipment effectiveness measure. The MPMS supports a formal meeting system by showing the information that must be checked (result indicators) and allowing the possibility of going into detail (process indicators). The goal of the system is to strengthen the focalization of the activity on the value stream's volume increase. The system is IT supported and allows having near-real time information with a reasonable cost. The application was highly successful and made the plant capable to cope with the increasing customer demand through an increased focus of the organization on the volume performance dimension.

This research provides an exploratory contribution in the fields of performance measurement systems and the transition to lean enterprise. Leading authors highlight the importance of value stream focus from a conceptual point of view (e.g. Womack and Jones, 1994; Hines et al., 1998; Liker, 2004). Focus on value stream implies to appropriately adapt the measures of performance. Works dealing on the topics of value performance measurement or meeting systems are present in the literature. Several methods for developing a manufacturing performance measurement system (MPMS) are presented (e.g. Bourne *et. al.*, 2000). Some case studies describing an MPMS development are found in the literature (e.g. Lohman, 2003). Maskell and Kennedy (2007) suggest that the establishment of a formal meeting system complements the setting up of the performance measurement system, by coordinating the monitoring of the value stream metrics which measure the performance of the teams at a group level. The original contribution of the present work consists in describing a case in which measurement performance and meetings system are considered as a whole. Here the development and implementation of the MPMS and the formal meeting system come from a single decision and form an integrated tool. Meetings can only be effective if the appropriate and accurate information is discussed. Gathering information would make no sense if it is not clearly established what will be done with it. The presented system can be useful to strengthen the focus of the activity on value streams performance. The practice exposed has not been presented previously in the literature. The results obtained in the analyzed case suggest that it is promising approach that deserves more application and research.

For the management community, this paper provides a new way of designing and using manufacturing performance measurement systems that may be used in other real practical cases. The described system can give place to major performance improvements with minimum investment. It shows a detailed example of how to collect data and measure OEE by using information more detailed than other procedures previously described by the literature, such as the classification into the six big losses proposed by Nakajima (1988). This case suggests that the application of information technology and lean can be interdependent and complementary as suggested by Cottyn et al. (2011). It is thought that the presented methodology is a good complement to manufacturing organizations using Just in Time principles where, according to Schonberger (1986), all operations within a value stream are turned into bottlenecks so they continuously need to receive problem-solving attention. In addition, the case provides a potentially inspiring example of how use meetings to control and improve the production activities. Meetings are often considered as a time consuming and few productive activities. To link formalize the meetings celebration and link them to production

performance indicators is a try to increase their utility and their own performance. That is what has been successfully done in the analysed case and can be used as a reference for other possible implementations.

This research has one main limitation; this study is applied in a single manufacturing plant and provides in consequence tentative and provisional insights. Considering the limited amount of research on the subject this kind of exploratory research is considered to be appropriate. Further research should be conducted using multiple industries in order to verify our findings. The research presented in this paper suggest that the performance measurement system and meeting system can be useful to strengthen the focus the activity on the value stream. However, there is still a need to dig deeper into the some non obvious relationships of the presented system with contextual variables. Further research is needed in this area in order to grasp how lean enterprises use organizational elements to focus on value streams.

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Acrylic on canvas 600x300mm  
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The purpose of this thesis is to investigate which practices lean enterprises adopt to focus on value streams. A case study of four plants is developed. The four plants have successfully performed a lean transformation with significant performance improvements, and belong respectively to Delphi Diesel Systems, Sogefi Filtration, a company within the furniture industry and Renault. The organizational practices under analysis are: (1) the establishment of organizational units based on value streams; (2) the use of a performance measurement system based on value streams, and (3) the adoption of a formal meeting system. These organizational practices were found in all four of the studied companies. The adoption of these practices was standard and consistent across the different organizational units within the studied plants. However, the application of the concepts strongly depended on the specific circumstances of the plants such as size, complexity and lean transformation maturity. This research provides a contribution in the fields of organizational practices and the transition to lean enterprise. Managerial implications consist of the possible application of the described practices to other cases and situations.

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