Faculty of Engineering of University of Porto

FEUP

Performance Measurement on Automotive Assembly Line

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Abstract

The subject of performance measurement was always alongside with automobile industry, since its beginnings by Henry Ford with the first automobile assembly line for the Ford T model to the current state of the art assembly lines, improving throughout time.

Nowadays, with the current automobile sector crisis, it is even more mandatory to achieve the best performance possible the lower resources. This overwhelming challenge leads to the needs of faster and more accurate ways to determine the performance in order to lead industry to right path.

The following document describes the processes used by Volkswagen-Autoeuropa to measure their performance on their assembly lines, also the design of an information system capable of measuring performance. A brief description on theories is presented as well as a functional prototype.

Acknowledgements

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Above all, to my family, for the love shown and the belief in my capabilities.

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Abbreviations and Symbols

KPI	Key Performance Indicators
VFF	Virtual Factory Framework
VW	Volkswagen
VW-AE	Volkswagen Autoeuropa
SOP	Start of Product
FIFO	First In First Out
MPV	Multi-Purpose Vehicle
Sci	Scirocco
SME	Small and Medium Enterprises
CSF	Critical Success Factor
ROI	Return of Investment
Sqm	Square Meters

Chapter 1

Introduction

The following thesis is part of requirements to achieve the Master's Degree in Electrical and Computer Engineering, Automation and Management Specialization in the Faculty of Engineering of University of Porto.

This makes thesis make an approach to the development of a system capable of measuring performance on an automobile assembly line, in a Volkswagen Plant.

On this chapter, the author introduces the objectives and overall framing of developed work as well as used methodologies and document organization.

1.1 Framing and Objective

On the actual scope of automobile industry, the performance measurement is a subject of greatest importance, this due to the financial crisis world is currently facing and especially to the oil crisis. Life is more expensive, potential buyers have less capacity to face investments. These factors are pushing plants to their productive limits in order to reduce costs to the minimum and make strategic decisions based on the most accurate data as possible and the fastest as possible for quicker reactions.

With the development of this work it is intended to learn the processes used by VW AE to measure the performance on the assembly lines and develop a system capable of effectively measure their performance. On a next phase of project it is meant to develop a new approach on how to determine the main Key Performance Indicators currently in use.

For the Volkswagen Plant, the outcome of this work would be an improvement to its current performance measurement process and also to comply with the role taken part on a larger European project, Virtual Factory Framework. For this project the Volkswagen Plant should contribute with it's know how for the achievement of VFF Objective, to foster and strengthen the primacy of Future European Factory Manufacturing.

Due to company security issues all values presented on this document were tampered as well as field names, focus was given to the overall process itself and its improvement capabilities.

1.2 Methodology

Due to the high level of complexity of current system, the author conducted a thorough investigation of the process in order to be able to fully understand it on all its extension and capability.

After the retrieval of all relevant data, based on workflow methodology, the author developed the requirements specifications according to systems engineering methodology.

As first step the concepts underlying the process, which could take high influence on project, were identified. Afterwards Stakeholders and system requirements were pointed out; this allowed a sketch of functional interfaces to be developed.

The interface follows an approach on workflow to make it easier to final user to follow the steps required.

1.3 Document Organization

This document is divided in the following chapters:

- Chapter 1 – Introduction and methodologies used.

  On this chapter an introduction to the subject is made and a brief explanation of used methodologies.
- Chapter 2 – Automotive Assembly Line

  Description of the assembly line present at the plant where the author was placed for final project.
- Chapter 3 – The VFF Project.

  Brief description of the Virtual Factory Framework is given in order to understand the wider range in which this thesis is inserted.
- Chapter 4 – Performance Measurement

  Brief introduction to performance measurement and current KPI processes description at Volkswagen Autoeuropa.
- Chapter 5 – Requirements analysis and Specification

  Requirements analysis and development of an early functional prototype.
- Chapter 6 – Performance Measurement Support System

  On this chapter a System Requirements Specification is presented.

  It's also presented a functional prototype.
- Chapter 7 – Conclusions

  Final conclusions on work developed are presented.

Chapter 2

The Automotive Assembly Line

Volkswagen Autoeuropa factory in Palmela is the largest foreign investment project ever done in Portugal, and its initial goal was to produce three MPVs from three different brands: Volkswagen Sharan, SEAT Alhambra and Ford Galaxy. Volkswagen Autoeuropa had a highly positive impact on the Portuguese economy, especially in what exports is concerned.

The overall initial investment in the project, including the development of the 3 models, amounted to 1.970 million EUR. When in 1991 Volkswagen and Ford signed the Autoeuropa Automóveis, Lda. "joint-venture", the responsibilities in the project were split: VW led the work on vehicle development, while Ford planned the factory facilities and purchasing.

It took four years since the signing of the shareholder agreement between VW and FORD in July 1991 until the start of production. During these 4 years one of Europe's most modern automotive production facilities was built in Palmela, with a total area of around 2 million sqm, including the Industrial Park where some of the main suppliers have settled.

On January 1st, 1999, Volkswagen Group assumed 100% of Volkswagen Autoeuropa's ownership. This change in the shareholding provided the potential for an increased use of the capacity of the Palmela plant. Moreover, it had no negative effect on the plant activity, which continued producing the Volkswagen Sharan, the Seat Alhambra and the Ford Galaxy. Four years later, in May of 2003, the production of 1.000.000 units is celebrated.

In February of 2006, Volkswagen Autoeuropa ends the production of the Ford Galaxy and initiates the production for the market of Volkswagen Eos, the first luxury car of the brand to be produced in Portugal. Due to the characteristics of the new model, a cabriolet with a unique convertible roof, Volkswagen Autoeuropa factory starts to work with 2 production lines, one dedicated to the production of the MPVs Volkswagen Sharan and Seat Alhambra and another dedicated to the cabriolet VW Eos.

Characterized for being a competitive factory in the automobile sector, Volkswagen Autoeuropa presents itself as a flexible company capable of facing the future challenges following the latest quality and environmental standards.

Yet in 2006 is done the announcement of a new product to Palmela's factory that intends to revive the former model Volkswagen Scirocco. Its production is started in 2008. In the same year, the 1.500.000th vehicle is produced in the factory.

Since its inauguration, Volkswagen Autoeuropa has been the target of several investment agreements aiming the settlement of new production infrastructures, equipment modernization and the training of the employees in order to turn the production lines and methods each time more efficient and increase the competences of its employees.

Volkswagen Autoeuropa's philosophy of continuous improvement has been placing it as one of the companies of the Volkswagen group in the leading edge in several productivity indicators.

2.1 Business

Volkswagen Autoeuropa, Lda is an automotive industrial unit of the Volkswagen Group located in Palmela, Portugal dedicated to vehicle manufacturing.

The car models produced nowadays are Volkswagen Sharan, Seat Alhambra, Volkswagen Eos and Volkswagen Scirocco.

The four main processes are divided in four distinct areas which are Press Shop (where most of the car panels for all products are cut and stamped from steel reels), Body Area (body welding and construction) Paint Shop (painting) and Final Assembly Area (where each car is assembled according to the final client specifications).

2.2 Objectives

The mission of Volkswagen Autoeuropa is to be the leader in providing the best products and services to the world-wide automotive market with the highest standards of environmental protection.

To complete our Mission, we will accomplish the following strategic objectives:

Achieve the highest customer satisfaction ratings for our products and services.

Become the lowest total cost producer providing the best product value to our customers.

Provide a work place that enables and encourages people to maximize their involvement and participation in order to achieve personal and Company goals.

Recognize the Environment in all aspects of our business and ensure continuous improvement in environmental performance within our Plant and towards the Community.

Favour a dynamic spirit in the work place that allows everybody to: rethink the processes, constantly search for the best practices, strive for state-of-the-art technology, exceed environmental protection requirements and always set new and more demanding standards.

Achievement of these strategies will ensure profitable growth and maximize the long-term value to our parent company and us.

2.3 Products

The Volkswagen Autoeuropa Plant has an installed capacity of 180thousand vehicles per year, on a 3 shift operation.

Currently it's using 2 shifts and is producing 3 models:

Fig. 2-1 – Volkswagen Sharan

The Volkswagen Sharan Fig. 2-1 is a family car with 7 seats.

Fig. 2-2 – Volkswagen Eos

The Volkswagen EOS, Fig. 2-2, the first luxury sports car from Volkswagen, its production started in 2005.

Fig. 2-3 – Volkswagen Scirocco

The Volkswagen Scirocco, Fig. 2-3, the "low cost" sports car that derived from the mythical Scirocco from the 70's.

2.4 Plant layout and Production Areas

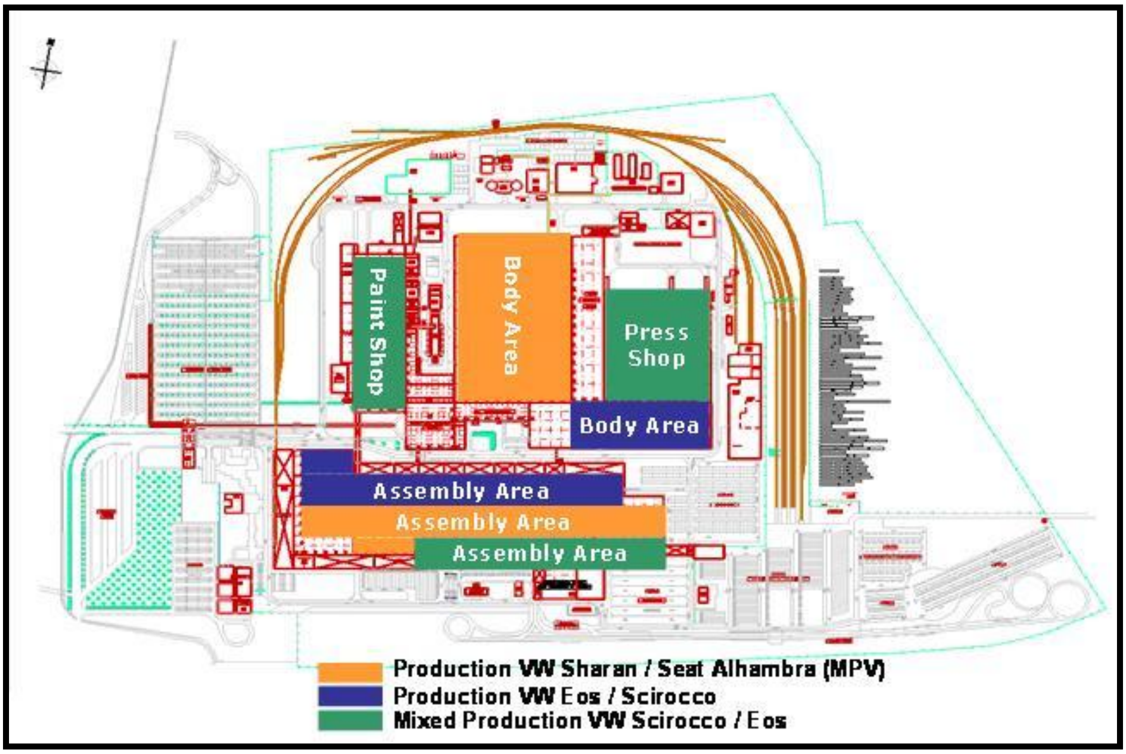


Fig. 2-4 – Plant layout

On Fig. 2-4 it is shown the plant map and its divisions, according to manufacturing area.

The production follows the movement against the clock pointers. Starting in Press shop then it shifts to Body shop, Paint shop and finally Assembly shop.

2.5 Production Areas

2.5.1 The Press Shop

This area has 23000m^2 and is responsible for producing metal parts from reels of steel.

It is currently producing:

- 138 parts for the MPV's Sharan and Alhambra,
- 78 parts for EOS,
- 70 parts for Scirocco.

It is working in a 2 shifts pattern. It's equipped with 5 tri-axial presses (2 of 3200ton, 2 of 2500ton and 1 of 1500ton (Fig. 2-5)) and also one "tandem" line with 6 presses (1700ton/1250ton) supported by cutting machinery.

Parts are built by specialized technician and the pressing cycles are reduced to 2-12 days in order to improve the storing and stocking costs.

Fig. 2-6 - Press Shop - overview of Press shop area, were 2 of the 5 tri-axial press are visible as well as several molds.

2.5.2 The Body Shop

The body is constructed according to the state of the art technology. With the aim of optimizing the material handling the building is located right next to the stamping shop area.

Fig. 2-7 – The Body Shop – Overview of body shop. Deck assembly where several robots perform automated tasks.

This area is divided in two, the first area, dedicated to MPV and Scirocco, Fig. 2-8, has 35000m^2 and the second, dedicated to Volkswagen EOS has 12530m2.

For the manufacturing process of Volkswagen Sharan and SEAT Alhambra 292 robots are automatically apply 94% of the 5745 soldering points.

For the Volkswagen EOS, 116 robots apply the 4825 soldering points. Robots from both these lines are from German origin, from KUKA brand. The remaining robots on this area are dedicated to the Volkswagen Scirocco, with an innovative automated structure; they apply 4373 soldering points, from Japanese origin, FANUC.

On this area the MPV teams work on single shift pattern and EOS/Scirocco teams work on double shift pattern.

The body shop has 6 more teams for supporting purposes that include 69 highly specialized technicians. During the night shift 16 workers remain for maintenance purposes.

2.5.3 The Paint Shop

The Paint Shop area, 22545m^2, works on 2 shift pattern and uses aqueous based inks. The process takes approximately 6.5 hours. On the process, innovative and environmental friendly techniques are used, like residual oils are separated from washing waters, anti-corrosive protection exempts of lead and chromium, primary and base enamels from aqueous base and washing waters re-used thanks to cascade cleaning systems.

This area has 10 robots for PVC applying and 5 more automated machines for primary and enamels appliance. This machinery is responsible for the transfer of 80% of ink; the other 20% are made in a manual process that has a recovery system capable of reducing the waste to almost zero.

Fig. 2-9 – The Paint Shop

The concept underlying the material supply is “single sourcing” that implies the only one supplier is responsible for management and control of entire process on the used material till its application on the final product. This area applies the “lean production” concept so there are no buffers which imply a rapid problem solving and continuous improvement.

2.5.4 The Trim & Assembly Shop

The $52542m^2$ represent the biggest area on Plant and it houses around 1000 workers organized in teams distributed over two shifts.

In order to improve the available resources the logistic concept “Just In Time” was implemented resulting on a reduction of stocks to just enough to complete on-going process.

This reduces the investment on warehouses and managing manpower, freeing it to other projects, but it implies a closers and special relation with suppliers.

Fig. 2-10 – The Trim & Assembly shop

On this area the system is based on FIFO (First In, First Out) this allows for a sequencing system for parts in witch when the body arrives to the station, the respective parts, chosen by the costumer, also arrive at station, to be assembled by the operator.

2.5.5 Workers

On plant there are the following worker divisions:

- Direct Workers, workers that have value adding operations to the final Product, usually all workers on the assembly are considered direct workers.
- Indirect Workers, workers that contribute for the evolvement of process, usually workers assigned to office locations.
- External services, these are workers contracted for their services and are not accounted for payroll
- External Temporary Agency, are short contract workers hired on specific conditions to fulfil a certain task and as soon as the task, they were hired for finishes, workers are dismissed.

On Fig. 2-11 is show the percentage of workers assigned to each area. It is also possible to infer that the Trim and Assembly shop is the area that takes the highest contribution to the KPI under analysis ahead on the document.

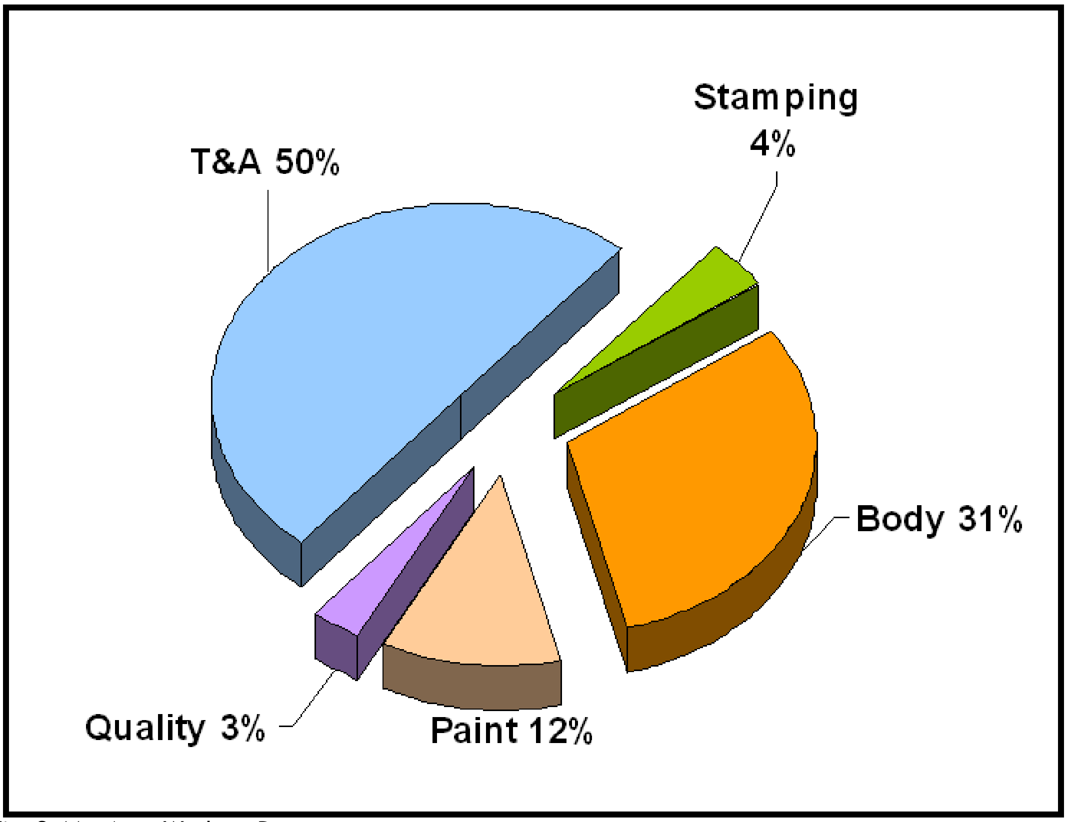


Fig. 2-11 – Area Workers Percentage

2.5.6 Working Schedule

In order to fulfil this production process, Fig. 2-14, the Plant is currently working on a two shift pattern with the configuration in Fig. 2-12, this represents an effective working time of 7.667hours. The value of E.W.T. is achieved by the calculation presented in Fig. 2-12, from the 8h and 30min shift all breaks are extracted, 30mim break for lunch time, two small breaks of 7min for smoking and/or eating and an additional 6min considered for weekly meetings.

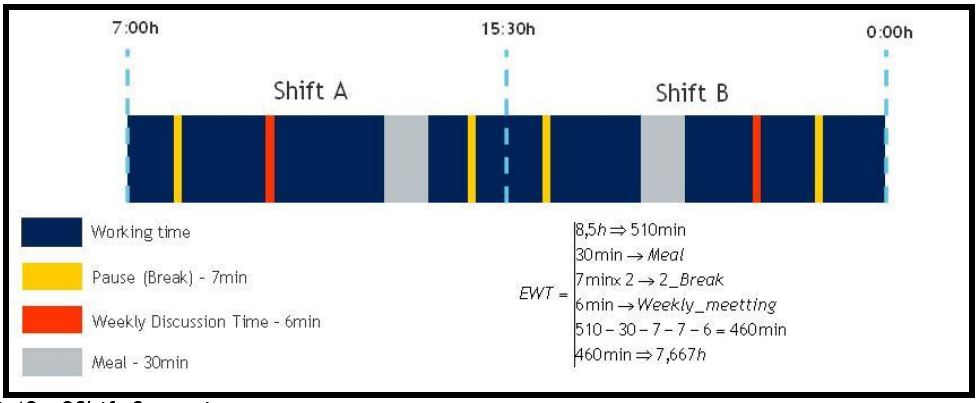


Fig. 2-12 – 2Shift Scenario

The current 2 shift production scenario, in case of market demand, can be extended to a third production shift, Fig. 2-13, making the plant reach its maximum installed capacity. Although shifts are not the same length, this is proven to achieve the best results.

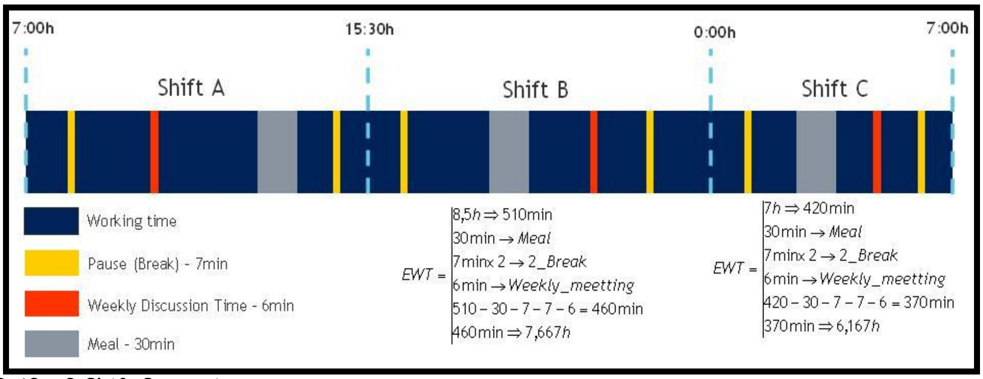


Fig. 2-13 - 3 Shift Scenario

2.6 Assembly Line Characterization

The production process is characterized by four different areas, the Press shop, the Body shop, the Paint shop and the Trim and Assembly shop; they are organized as shown in Fig. 2-14.

Since only bought cars are made, after the information arrives the process to build the car starts and follows the steps.

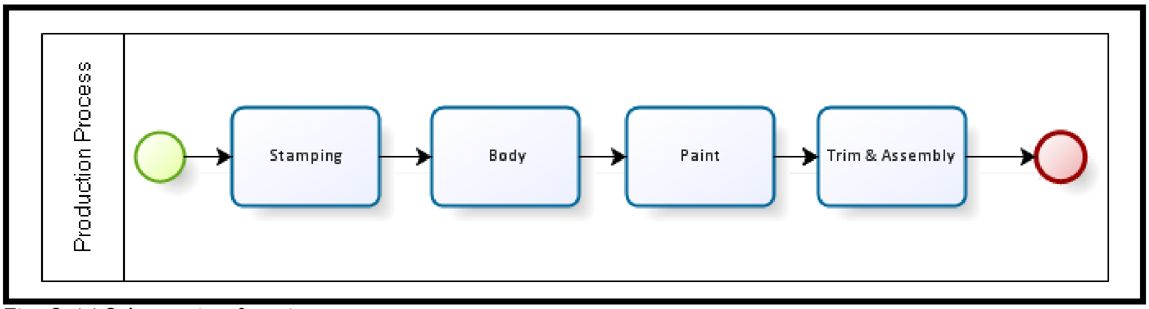


Fig. 2-14 Schematic of entire process

For characterizing the line, the Stamping shop must set aside due to its specific process.

In Fig. 2-15, it's pointed that the real car assembly process only starts in Body shop, here parts from Stamping shop are gathered and assembled into a car body.

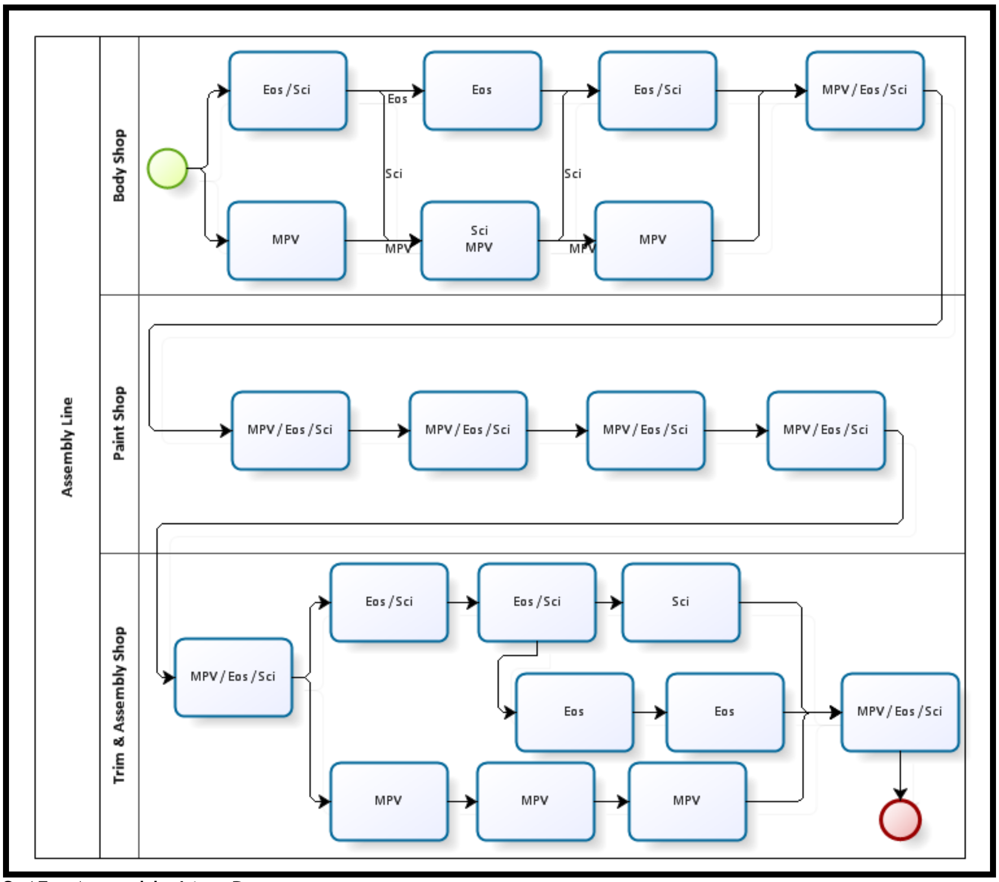


Fig. 2-15 - Assembly Line Process

Several steps are merged since they are similar from model to model, this is particularly true in case of Eos / Sci, and these two models are very alike and for that reason, share the assembly line in various stages.

On this point dwells the major difficulty of data processing. This is how to assign each worker to each car. This is currently done by a percentage based on built cars.

After the last stage in Body shop, all three models follow through Paint shop in serial progress, there is no difference between processes, some variation due to shape of body, but essentially materials are the same and applied the same way.

When painted Bodies arrive to Trim & Assembly shop, the first step is to remove the doors to make it more accessible and easy to work with. The real assembly process starts after this point. It follows several stages, like dashboard assembly, decking, name given to the stage where body meets preassembled chassis, with engine and gearbox, suspension, fuel tank…, seats and glasses are assembled and doors re-assembled.

A small set of tests are conducted and car is released for costumer

The Stamping shop works differently, it has production cycles. Since there can't be a line to stamp every piece, as in an assembly line, the area has to make short production series and store for small amount of time.

The stocks are in a small warehouse between the Stamping shop and Body shop, this works as a buffer to allow Stamping shop production cycles of 2 to 12 days.

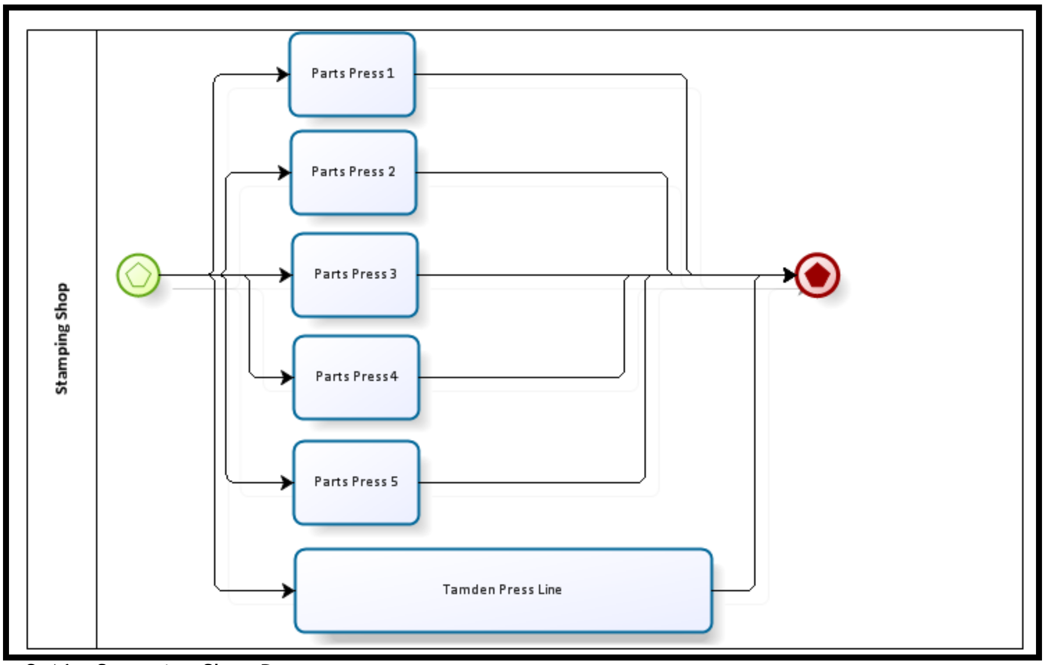


Fig. 2-16 - Stamping Shop Process

Chapter 3

The VFF Project

3.1 The VFF Concept

The VFF project is an international project under the "*Seventh Framework Programme*" from European Commission.

The VFF project main objective is to foster and strengthen the primacy of future European Manufacturing, by defining the Next Generation of Virtual Factory Framework. It will promote the increase of performance in design, management, evaluation and reconfiguration of new or existing plants while upholding major time and cost savings.

It will support the capability to simulate the dynamic and complex behaviour of total plant approached as a complex long living product.

The VFF will research and implement the underlying models and ideas for a new conceptual design to implement the next generation of virtual factories and also to lay down the basis for future applications in research areas.

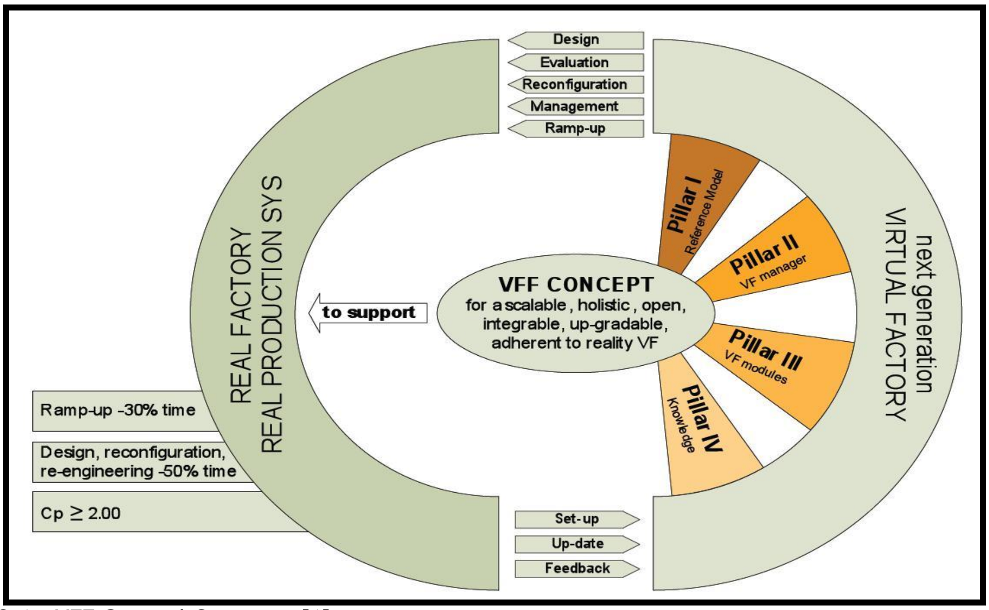


Fig. 3-1 - VFF General Overview [1]

Currently the Project includes 4 key pillars.

I Reference Model for factory planning. Based on new industrial key paradigm “Factory as a Product” and considering new planning methodologies like “non-linear, nondeterministic planning”. The concrete outcome is a Reference Model on Factory Planning having as background element a Factory Data Model, capable of taking into account the needs of a holistic and scalable modelling of real time management of manufacturing data and of collaborative engineering networks [1].

II VF Manager Core. It’s the tool responsible for handling the common space of objects that represent the factory. This representation is based on the factory data model defined in Pillar I. The VF manager enables a centralized coordination of the external decoupled modules (defined in Pillar III), in a way that allows the framework to be extensible and scalable, thanks to the internal transition system of the core, fostering unparalleled performances, openness, and increased quality in the environment representation [1].

III Functional Modules. The decoupled Functional Modules implement the various tools and services for the factory design, reconfiguration, management… these modules operate independently on the same Common Space of Factory Objects, defined in Pillar II [1].

IV Integration of Knowledge at different layers as engine for the modules aiming at giving reality to the envisioned Learning Factory. The primary objective is to use contextual knowledge to model a wider range of complex systems and support greater comprehension of the modelled phenomenon. Moreover, the integration of knowledge throughout the VF has the potential to deliver fundamental advisory capabilities as a companion to factories development in all its scales and complexity dimension [1].

The collaboration of the four pillars leads to the realization of the Virtual Factory concepts. The Factory Data Model element utilizes information generating an overall picture of the factory together with its characteristics, allowing the modelling and handling of data real-time. The data utilized for the development of the Data Model is stored in the Knowledge Repository, where it can be further exploited. The VF Manager Core supervises the common space of the framework, ensuring that all pillars, together with their respective components and actors, interact smoothly, while also managing the flow of data and knowledge to and from the Knowledge Repository. Pillar III hosts the Functional Modules that utilize the available knowledge and the insight acquired via the data model to implement tools and services.

3.2 The VFF expectations

The Virtual Factory, deployed according to the VFF concept, has to be permanently synchronized with the Real Factory aiming to achieve time and cost savings in the design, ramp-up, management, evaluation and reconfiguration of the Real Production itself. The Real

Factory, interacting in terms of feedbacks and of data needed to set-up and up-date the simulation system, closes the loop.

The proposed pillars foster the implementation of a holistic, modular, open and scalable Virtual Factory meant to achieve clear, well-identified and measurable goals for the real production system according to quantitative indicators/measures:

- Time for factory design, re-configuration, re-engineering: -50%. The implementation of the new reference model for factory planning (see point 1 of the S&T objectives), integrated with formalized multi-competence knowledge deriving from past and current planning processes, allows to shorten the time required for new processes design and existing processes reconfiguration and re-engineering, thanks to a quick retrieval of actual pertaining know-how, an intelligent selection of coherent functional modules.

- Ramp-up time -30%: quick, efficient and adherent to reality modelling speeds up analysis, synthesis and diagnosis, allowing an accurate but rapid prediction and optimization of production processes during the pre-production stage though preserving the reliability of information gathered during production ramp-up and its value-adding usability in the later stages.

- Capability Index Cp >=2.0: the effective virtual representations of the entire production systems, fostering multi-loop evaluation procedures, multi-dimensional target systems, knowledge-driven decision support, quickened problem-solving sub-processes, allows a cost and time saving evaluation of existing and designed processes, resulting in radically enhanced production quality. The effectual virtual representation of all the production phases and of their mutual interrelation enables the intelligent selection of parameters affecting critical product characteristics and the improvement of production parameters, resulting in a reduction of process normal variation and of the overall amount of defective products answering to increasingly stringent design specification requirements.

Moreover, a strong qualitative factor has to be considered:

- Democratization: the project will provide a ground-breaking framework for a new VF but also democratize its usage thanks to new open technologies, thus providing basis for decision making to all levels and functions, allowing for quick yet substantiated decisions to be made where they unfold full potential. The VFF will open access to Virtual Representation technologies to larger group of enterprises, including SMEs.

The Figure 13 integrates the VFF concept schema, further detailing the identified pillars

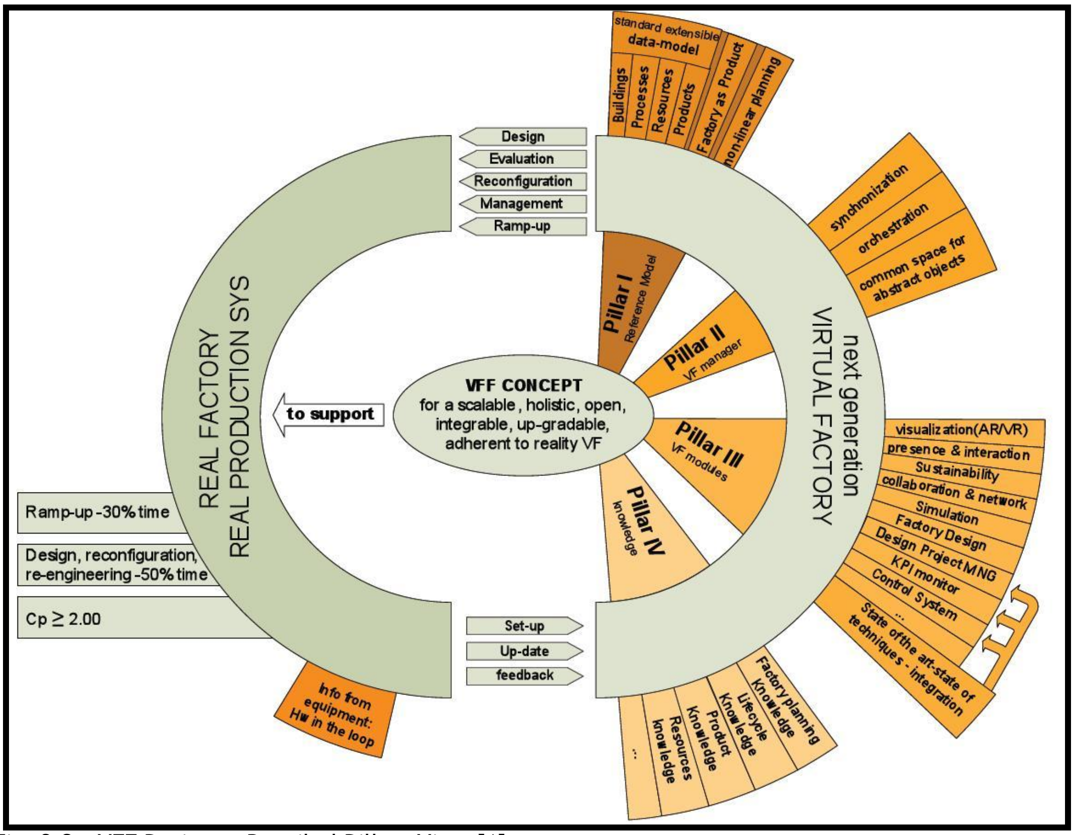


Fig. 3-2 - VFF Project - Detailed Pillars View [1]

The VFF Project is meant to represent an enormous advancement to current factory framework. Such advancements are detailed in the next table.

	State of the Art	VFF Advancement
1	Focus on single elements	Holistic view for the **Factory as a Product** - All scales - Entire life-cycles
2	Many interfaces to be taken into account for different tools and technologies	**Reference framework** including all enterprise process
3	Standard planning process	New planning methods and tools based on a new **Reference Model** - Factory as Product paradigm - Non Linear, Non Deterministic process concept
4	Different data models	**Common extensible data model** for: - products - processes - resources and - building
5	Snapshot of the factory	Real-time image of the factory over life cycle
6	Current supporting tools set - Expensive - Proprietary - Large suite	**Democratization** of the Virtual Factory - Open - Standard - Decoupled Functional Modules
	Europe as provider of factory with non integrated digital representation, failing to holistically approach the factory and thus not helping to shorten the planning as well the rump-up phase	**Virtual Factory Framework for MADE in EUROPE FACTORIES**

Table 3-1 – The VFF Advancements referring to current State of the Art [1]

Chapter 4

Performance Measurement

Performance measurement is a simple concept without a simple definition.

Essentially, performance measurement analyses the success of a work group, program, or organization's efforts by comparing data on what actually happened to what was planned or intended [2]. Performance measurement asks "Is progress being made toward desired goals? Are appropriate activities being undertaken to promote achieving those goals? Are there problem areas that need attention? Successful efforts that can serve as a model for others?" [3]

There are countless angles which to look at performance measurement, but the underlying concept will be the same. One possible definition:

Performance measurement is the selection and use of quantitative measures of capacities, processes, and outcomes to develop information about critical aspects of activities, including their effect on the public. [3]

For understanding the definition, terms like capacity, process, and outcome must be clarified.

Capacity means the ability of a work group, program, or organization to carry out the overall job, and in particular, to provide specific tasks. Capacity means, for example, that you have sufficient staff, training, facilities, and finances, among other things.

Process means the things that are done by defined individuals or groups – or to, for, or with individuals or groups. Process means all the tasks and jobs.

Outcome means a change, or lack of change, such as the tests, investigations, or educational services you offered as part of your process, above.

There is no exact definition when it comes to usage of the term "performance measure." Different people have different definitions for what constitutes the "measure" part.

Although there are many different ideas about what a "measure" is, there is one commonality among them:

A performance measure measures something, usually progress towards an objective or goal. So it doesn't matter if it’s called a performance measure or a performance indicator or, in some cases, a performance standard. The important idea to retrieve is the concept that a performance measure measures something.

A good definition of a performance measure:

A Performance Measure is the specific quantitative representation of a capacity, process, or outcome deemed relevant to the assessment of performance. [3]

Key Attributes of a Performance Measure

- Validity: a valid measure is one that captures the essence of what it professes to measure.
- Reliability: a reliable measure has a high likelihood of yielding the same results in repeated trials, so there are low levels of random error in measurement.
- Responsiveness: a responsive measure should be able to detect change.
- Functionality: a functional measure is directly related to objectives.
- Credibility: a credible measure is supported by stakeholders.
- Understand ability: an understandable measure is easily understood by all, with minimal explanation.
- Availability: an available measure is readily available through the means on hand.
- Abuse-Proof: an abuse-proof measure is unlikely to be used against that which is, or those who are, measured.

A Performance Standard is a generally accepted, objective standard of measurement such as a rule or guideline against which an organization's level of performance can be compared [4].

A performance standard establishes the level of performance expected. Standards can be descriptive or numerical. A descriptive standard characterizes certain infrastructure components or certain activities – that is, certain capacities or processes – that are expected to be in place.

A numerical standard establishes a quantifiable level of achievement. Numerical standards are often used as minimum standards. These standards look very much like goals or objectives, except that you are evaluated on whether or not you have achieved them, not on your progress toward achieving them. For this reason, numerical minimum standards can be controversial.

Both kinds of performance standard can be considered a measure of performance, in that each helps you evaluate the success of your efforts by comparing what actually happened against the standard. The numerical standard is easiest to consider a measure because it is quantifiable – you can compare the level you achieved against the standard. The descriptive standard is harder to consider a "measure" by itself, but you can find ways to measure your level of achievement with such a standard.

To summarize, a performance measure... measures something. A performance measure can measure your capacity to undertake services, the specific things you do to provide the services, and the consequences of having provided the services. A performance measure is a quantitative representation of system. Hence, if something called a performance “indicator” or a performance “standard” measure something – such as capacity, process, or outcomes – it is a performance "measure."

How do other performance assessment activities relate to performance measurement? Performance measurement is an aspect of performance management Performance management is what you do with the information you've developed from measuring performance.

Performance managing means using performance measurement information to manage your public health capacity and processes: for example, to review services and programs; assess and revise goals and objectives; assess progress against targets; conduct employee evaluations; and formulate and justify budgets.

Performance measurement is needed as a management tool to clarify goals, document the contribution toward achieving those goals, and document the benefits received from the investment in each program. – U.S. Department of Health and Human Services [5]

The problem with measurement is that it can be a loaded gun – dangerous if misused and at least threatening if pointed in the wrong direction. – Dennis S. O'Leary

4.1 Key Performance Indicators

A Key Performance Indicators is a tool to assess performance.

Some companies have formal, enterprise-wide performance measurement systems in place (such as Six Sigma, the Plan-Do-Check-Act methodology, or the Balanced Scorecard). Such systems enable executives to look across the organization's business activities to gain a holistic view of the company's performance. Other companies use a simpler approach, measuring the performance of one or more discrete aspects of the business.

Regardless of the system a company uses, all organizations use key performance indicators (KPIs) to assess their performance.

What is a KPI?

Understanding KPI’s can help you measure your and your group's progress toward corporate and unit goals.

Key Idea

A key performance indicator (KPI) is a measure reflecting how an organization is doing in a specific aspect of its performance. A KPI is one representation of a critical success factor (CSF)—a key activity needed to achieve a given strategic objective. Organizations that measure performance identify the handful of critical success factors that comprise every strategic objective.

For example, depending on a company's strategy, the organization might have a KPI for the percentage of income the organization derives from international markets. Another KPI might be the number of customer complaints about orders filled incorrectly. Some organizations use many KPIs, for all their different areas of operation. Other enterprises' KPIs may focus on a specific area. For instance, a social service non-profit may focus all its KPIs on the amount of aid that is granted to different entities.

Typically, each unit within a company also has a set of KPIs that support the company's goals. Performance data for a unit's KPIs can be rolled up into the company's KPIs to reflect total organizational performance in any given area being measured.

You probably won't participate in developing KPIs at the corporate level. However, you may be involved in creating KPIs at your unit's level—especially if your unit was recently acquired or has been associated with a new product, process, department, or line of reporting. Regardless of your situation, you should be aware of the KPIs that are in place in your organization. With this awareness, you can measure your and your group's progress towards corporate and unit goals.

Three types of KPIs

Key performance indicators come in three types:

- Process KPIs measure the efficiency or productivity of a business process. Examples include "Product-repair cycle time," "Days to deliver an order," "Number of rings before a customer phone call is answered," "Number of employees graduating from training programs," and "Weeks required to fill vacant positions."
- Input KPIs measure assets and resources invested in or used to generate business results. Examples include "Dollars spent on research and development," "Funding for employee training," "New hires' knowledge and skills," and "Quality of raw materials."
- Output KPIs measure the financial and nonfinancial results of business activities. Examples include "Revenues," "Number of new customers acquired," and "Percentage increase in full-time employees." Three particularly common output KPIs that are used by managers include:
    - Return on investment (ROI): Return on investment represents the benefits generated from the use of assets in a company, unit, or group—or on a project. ROI is helpful to top executives, finance managers, board members, and shareholders. A possible way to express return on investment is to divide

net income (revenues less expenses less any liabilities, such as taxes) by total assets. ROI measures how effectively managers have used resources, and can be figured as follows:

ROI = Net Income/Total Assets

- Economic value added (EVA)™: EVA, popularized in the 1990s by U.S. management consultancy Stern Stewart & Co., is defined as the value of a business activity that is left over after you subtract from it the cost of executing that activity and the cost of the physical and financial capital deployed to generate the profits. In the field of corporate finance, EVA is a way to determine the value created, above the required return, for a company's shareholders. It's therefore useful to senior management, boards, and shareholders and other investors. EVA is calculated as follows:
- EVA = Net operating profit after taxes minus (net operating assets multiplied by the weighted average cost of capital)
- Shareholders of a company receive a positive EVA when the return from the equity employed in the business's operations is greater than the (risk-adjusted) cost of that capital.
- Market share: The percentage of sales in a given industry segment or sub-segment captured by your company.

All three types of KPIs—process, input, and output—generate valuable performance information. A mix of the three types ensures a comprehensive picture of your unit's or organization's performance.

4.2 Volkswagen Autoeuropa Process Description

Volkswagen Autoeuropa joined the VFF project under the scope of Performance Measurement, to provide the project its knowledge and vision on Man Power KPI calculation.

This participation was inserted on scenario 2 of the VFF, “Ramp Up and Monitoring”, as the name states it is divided in two stages, the Ramp Up and the Monitoring phases.

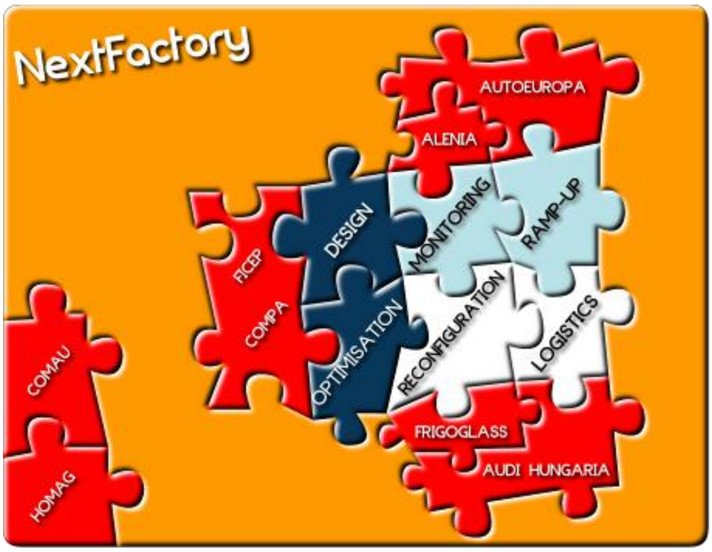


Fig. 4-1 - Participation Scenarios

The Ramp Up phase is described as:

"The VFF tool will demonstrate in Ramp Up phase, an efficient setting up, verification and commissioning of software and procedures"

The Monitoring phase is described as:

"The capability to monitor the real factory will be demonstrated as well the connection between the real and the digital factory."

The current process to determine KPIs in Volkswagen Autoeuropa is described in Fig. 4-2 - Performance Monitoring in Volkswagen Autoeuropa. The entire factory process is taken into account and from it the overall inputs and outputs are retrieved.

The inputs are: Manpower and Material and the Outputs are final Products

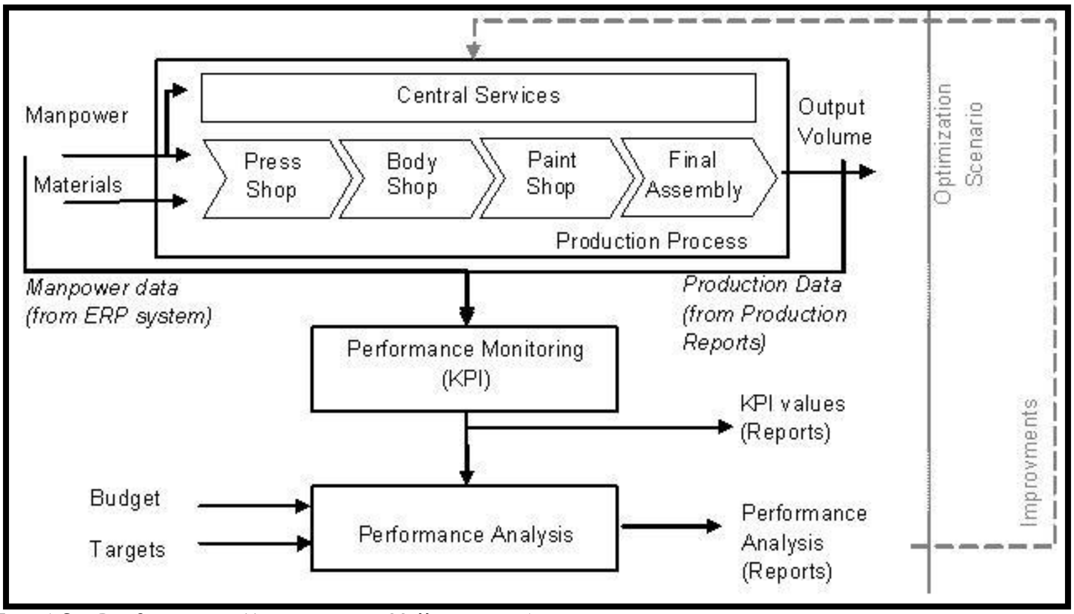


Fig. 4-2 - Performance Monitoring in Volkswagen Autoeuropa

The pattern for production of new car model follows the stages presented in Fig. 4-3, there are 4 early stages, not presented in picture, that are responsible for project viability tests, prototype building and studies on future assembly lines for that model.

After these initial first steps, the Ramp Up scenario occurs. It is the time considered between the SOP till the SOP+1year

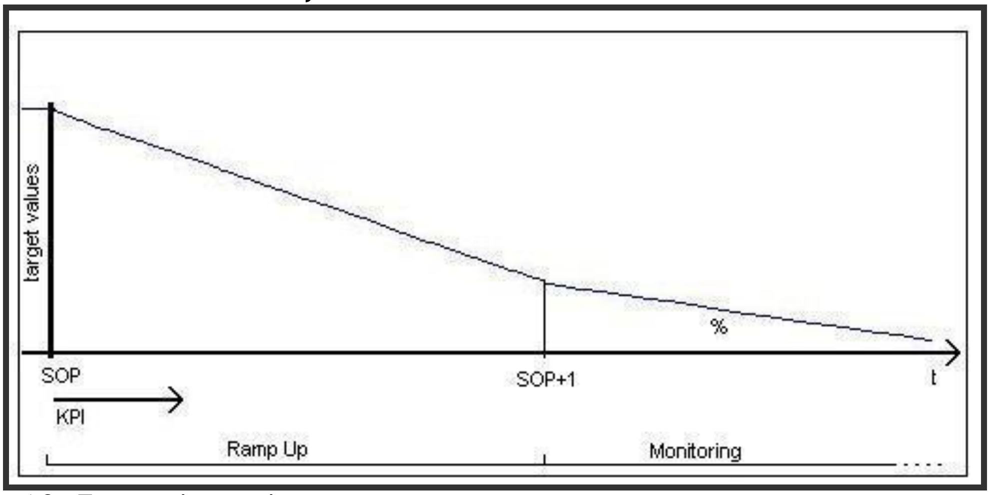


Fig. 4-3 – Target values evolution

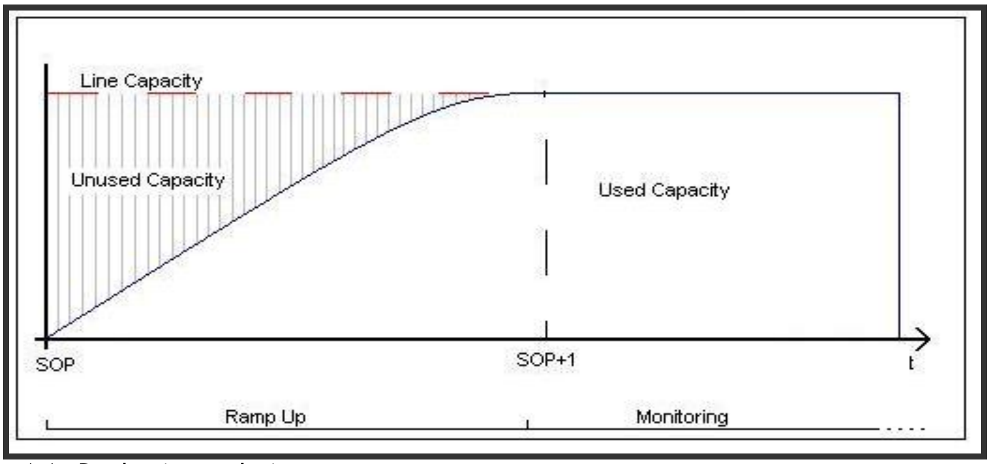


Fig. 4-4 - Production evolution

During the Ramp Up scenario, the KPI used are obtained using the same premises as during the monitoring stage, although are compared to special target values.

These special target values are predetermined by the analysis of process by the Planning Department on plant and by the central planning in VW – WOB. By these studies, the values for target are derived empirically using the know-how and comparing the complexity of new project with previews models.

During the Ramp Up the most common negative impacts on KPI are:

- Not using the entire installed capacity;
- Unstable building process;
- Considerable amount of workers under training condition;

- Quality issues:
- Suppliers;
- Process;
- Logistics;

All these issues lead to only one outcome: the need of Rework hours.

During the Ramp Up process, the objective is to achieve the target values defined for the SOP +1, these target are defined using two main items, the Project Profitability and the Automation level of the construction process. This leads to a constant target value decrease that makes the overall process increase its performance.

After the SOP +1, the Monitoring phase begins, although a negative slope remains on the target values evolution, it lowers smoothly along the time. This will make the process to increase its performance leading to a continuous improvement.

4.3 Volkswagen Autoeuropa Key Performance Indicators

On the VW-AE, in the department where the author was placed there are currently 3 Man Power KPI in use, they are: the OHPU, the HPU and the Productivity. On the fowling pages a brief description of each is given.

After a detailed analysis of calculations process for the HPU indicator is presented, this indicator was chosen by the author due his familiarization level with this indicator.

4.3.1OHPU – Organizational Hours per Unit

OHPU is a KPI for labour performance used for benchmarking between different factories of the industrial sector. It is calculated monthly. It is defined by the formula:

Equation 1

$$\text{OHPU} = \frac{\text{Total Working Hours}}{\text{Production Volume}} \quad \text{(hours/u nit)}$$

OHPU values are calculated not only for the factory as a whole but also in detail for each Product and each Organizational Divisions, like organization structure, core business areas, major assembly areas and labour types.

Total Working Hours are obtained from the Payroll, for internal employees and also from other sources for third party workers currently on plant, temporary workers, external maintenance services...

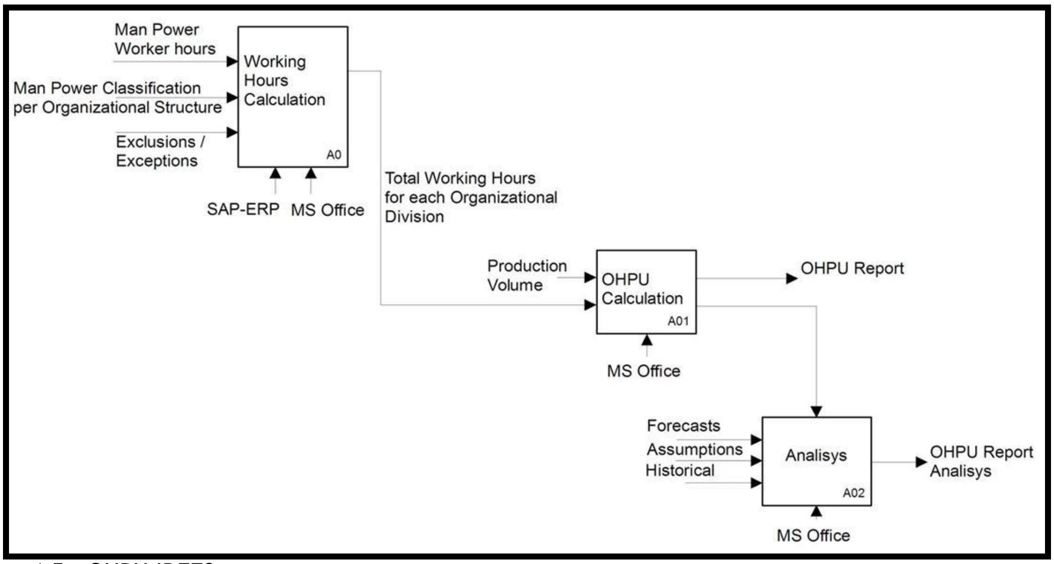


Fig. 4-5 - OHPU IDEF0

Each subtotal, per product, production area and other splits, are calculated with the sum of employees accounted hours according to its “Cost Centre/Organizational Unit” classification, excluding hours related to training and others kind of absence leaves.

Production Volumes for each product during each time period are collected from the Production Reports.

After the completeness of the data mining process, the calculation is made and a report generated. It is broadcasted for management analysis and decision support.

This report is periodical with the cadence of 1 month. The reports always include the previews values and the annual cumulative.

4.3.2Productivity (units/employee)

It is a KPI that measures the total number of units, with no distinction between different products, produced by the number of employees, for the factory total and for each considered organizational divisions, splits.

Equation 2

$$\text{Productivity} = \frac{\text{Production Volume}}{\text{Manpower}} \times \frac{229\ \text{Days}}{\text{Working Days}} \quad (\text{units/employee})$$

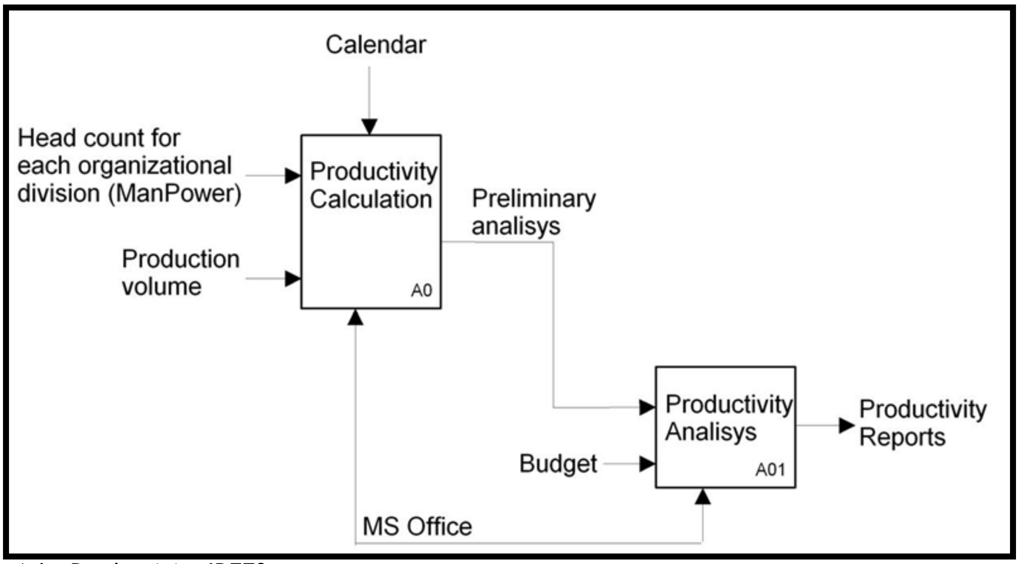


Fig. 4-6 - Productivity IDEF0

Actual Volume is the total number of units produced on the chosen time period.

Actual Manpower is calculated as the average between the current and previous month total number of employees, including temporary agency employees; by definition, is considered the number of active employees in the last day of each month. Employees with no cost for factory are not accounted;

Actual Working Days is the average value of the number of effective working days officially scheduled for each product;

“229 Days” is as predefined factor based on year calendar.

The Productivity reports are monthly and include the “actual” values side-by-side with “budget” values and include an historical with values from each month of the current year. The report includes detail for each organizational division.

Budget Volume, Manpower and Working Days are previously defined and fixed for all months in the beginning of each year in the official Budget. With this values will be calculated the “Budget” Productivity values which will be used as a reference in Productivity analysis.

4.3.3Hours per Unit (HPU)

The H.P.U. is the first KPI the author worked in Plant and is the one he dedicated more time, therefore it’s logical to be the one he is more comfortable with.

The Hours Per Unit (HPU) is a KPI that translates the number of hours required to build a car. It is determined for a specific given time and for a specific model. It is also used for benchmarking purposes between VW Plants all around the world.

It is obtained applying the following formula:

Equation 3

$$HPU = \frac{M.A. \times E.W.T.}{Production\ \ Volume} \quad (hours/unit)$$

In the previews formula, there are three factors, they are:

- M.A. – This represents the manpower attending on factory on the period referred for determining the KPI.
- E. W. T. this is the Effective Working Time, as previously stated, it represents the working hour in which workers are actually working on their positions on the assembly line. This value can be changed in case of line stoppage due to errors or workers council meeting.
- Production Volume is the constructed volume for the given time for the given model.

The HPU is determined only for Core Business areas for each model; this means that only workers with value adding operations, to the final product are accounted for, these workers are nominated as direct workers.

To achieve the number of direct workers (M.A.) currently attending, information must be gathered from three sources, the Payroll Direct, the Absenteeism and Adjustments.

- The Payroll Direct is the number of direct workers currently in working in plant. The Absenteeism gives the workers considered as absent in the day.

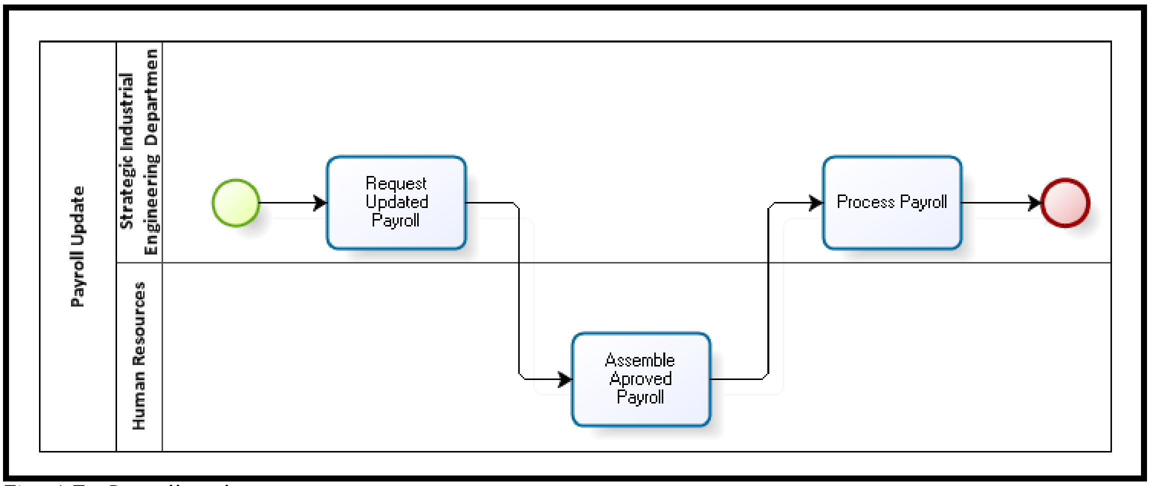


Fig. 4-7 – Payroll update sequence

- The absenteeism is the number of workers in absence on the production line, workers that are attending formation are also considered as absent.

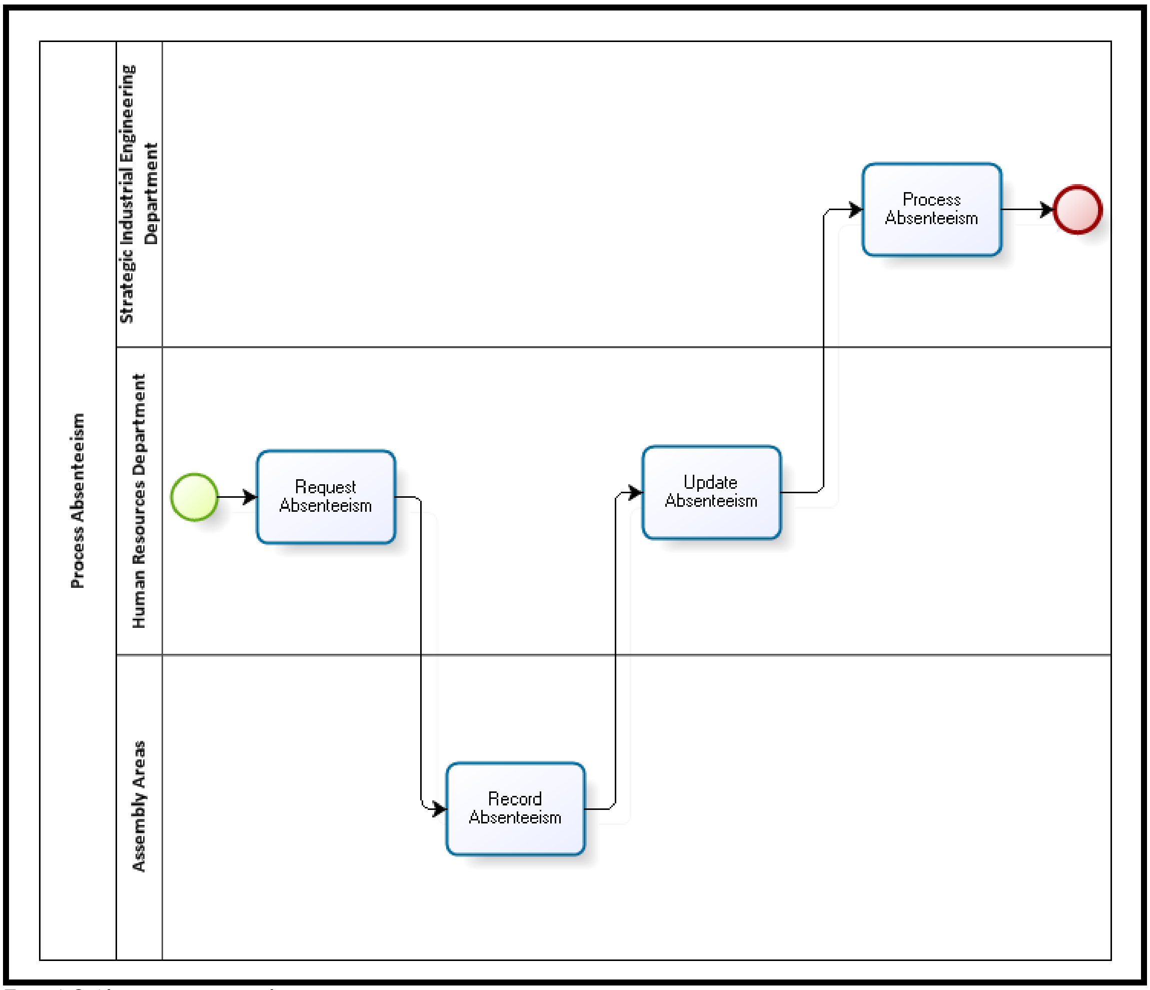


Fig. 4-8 Absenteeism gather sequence

- The Adjustments are changes of workers status inside plant, borrows and loans between the several different departments.

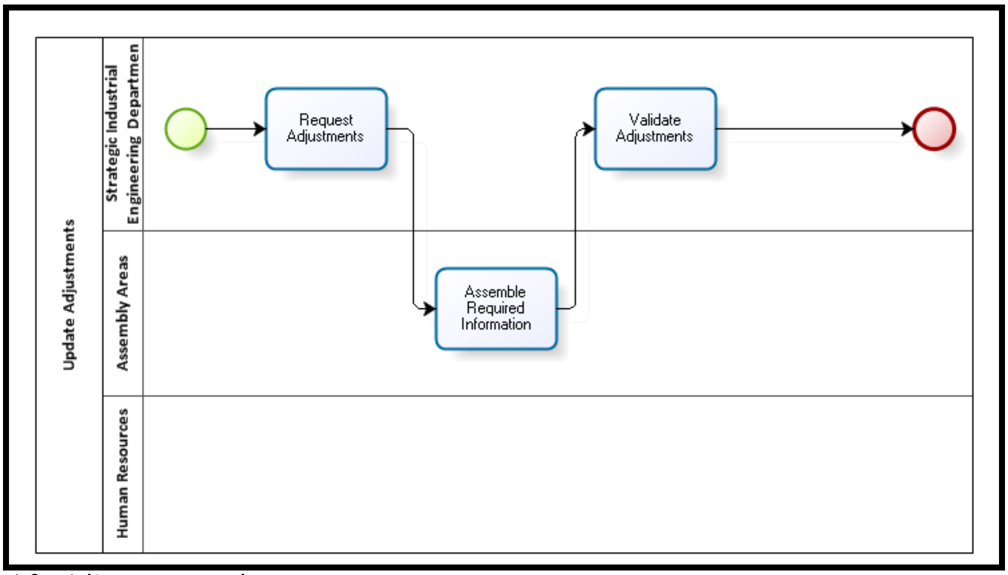


Fig. 4-9 – Adjustments gather sequence

The Effective Working Time (E.W.T.) is considered 7.667h.

The production volume is obtained from an internal system, responsibility of Logistics Department, which stores all factory operations and production.

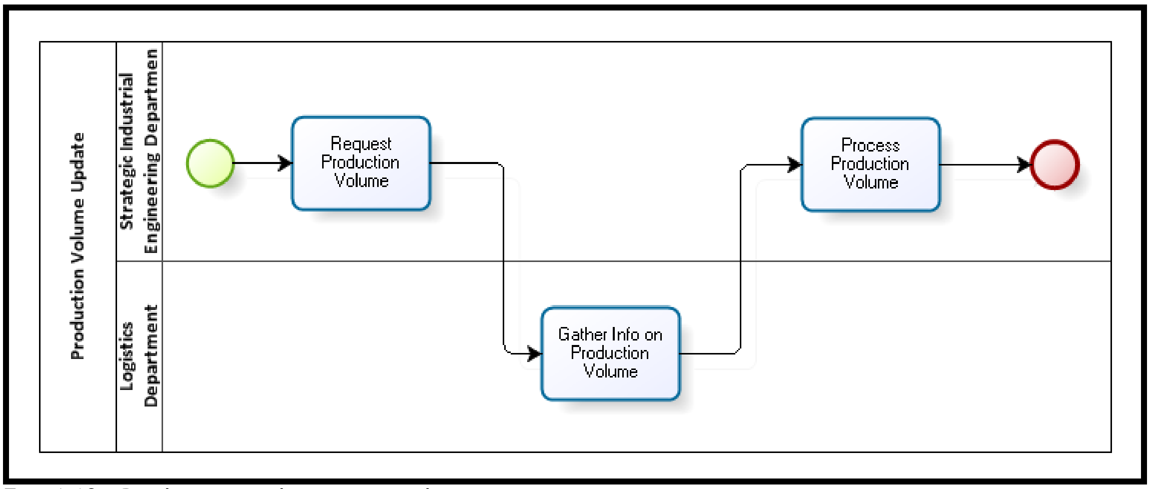


Fig. 4-10 – Productions volume retrieval

The HPU is currently a daily report, but it’s time frame can be changed to the desired period.

4.4 HPU Calculation Process Analysis

The calculation process is easy, as it can be seen from the formula itself, the hard step is the data gathering and processing steps, the countless number of details makes it almost impossible to automate. The description of the process is presented on Fig. 4-11

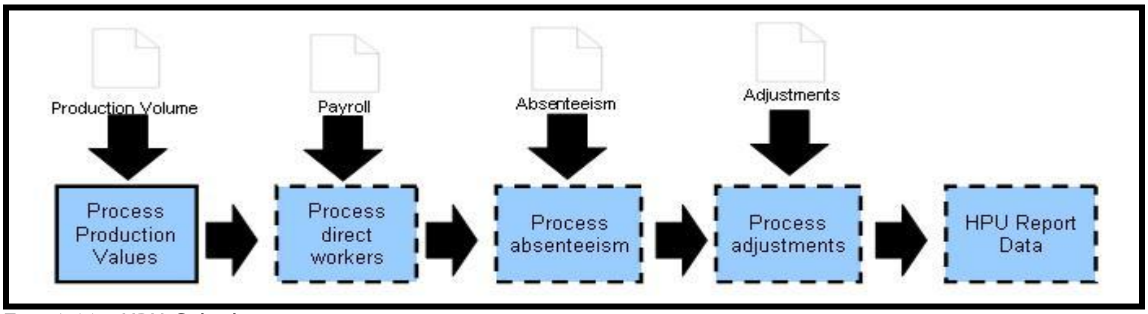


Fig. 4-11 – HPU Calculation steps

From Fig. 4-11 a set of 4 main steps are identified, these steps are: the Production Values, the Retrieval of Direct Workers, the Absenteeism Processing and the Adjustments Processing.

Process Production Volume

In order to retrieve the production volumes a system, maintained by the logistics department, is accessed and the values regarding the production volumes are retrieved from an automatically generated pdf file organized as a table with 3 columns representing each column the car model

Vol_{i} - Volume of produced car on referred time period [i]

Process Direct Workers (Payroll)

From the Human Resources Department an Excel file arrives, through e-mail, with the last payroll status, it is then placed on a local database for sorting the workers according to their status. For the HPU only direct workers are considered.

$Payroll_{i\ j}$ - Current number of direct workers on Plant Payroll

Process Absenteeism

In order to retrieve the absenteeism, the SAP-HR system implemented on Plant, is accessed and two lists are retrieved, one containing all the workers considered as absent on Plant, on the time period referred for the report, and another list that contains workers that are not yet considered as absent by the system but are absent on Plant.

These two lists are combined and verified for duplicate entries and then placed on a local database that counts absent workers by area and status.

$Absenteeism_{i\ j}$

Process Adjustments

The adjustments can be considered as changes in the workers status, these changes can due to internal transfers, temporary changes, borrows, loans, etc…

$Adjustments_{i\ j}$

Effective Working time

The EWT is the effective working time, as already referred; it assumes the values of 7,667hours that can change due to line stoppage time.

EWT_{i} Number of Effective Working Hours on the time period [i] referred

The final value of HPU comes directly from the appliance of following formula

$$\mathrm{HPU}_{i\ k} = \frac{MA_{i} \times EWT_{i}}{Vol_{i}}$$

The [i] represents the time period to which report is referred to and [k] the car model to which the report is referred to

To get the value of M.A. the following step has to be made combining the 3 data gathering processes.

$$MA_{i\ j} = Payroll_{i\ j} - Absenteeism_{i\ j} - Exceptions_{i\ j}$$

The M.A. is divided by the following categories of workers [j]

$$j \begin{cases} \mathit{Body} \\ \mathit{Body}\ \text{EOS} \\ \text{Body Mix} \\ \text{Body Scirocco} \\ \text{Paint Mix} \\ \text{Quality} \\ \text{Stamping} \\ \text{T\&A} \\ \text{T\&A EOS} \\ \text{T\&A Sci} \end{cases}$$

4.5 Information Flow

As stated previously, the methods for data gathering are add-hoc and are based on simple tasks, like collecting data from SAP System, store it as an excel file and process the file for accounted situations, but these tasks are of highly difficulty to implement as an automated system. There are no data transfer standards or templates, also reports might be as accurate and as fast as possible and desired due to human errors and time delays on deploying information.

On the next chapter an analysis to the requirements of a system capable of measuring the performance on the assembly line at Volkswagen Autoeuropa is made.

Chapter 5

Requirements Analysis and Specification

Although several KPI indicators are used in Volkswagen Autoeuropa this requirements analysis and specification will be focused on the HPU indicator. This indicator is currently used to measure performance on the several Plants from VW group.

5.1 Stakeholders

On an early stage of requirements analysis and specification the main elements involved in process were identified and their expectations over future system exploited. When actors were identified a set of iterative meetings took place for the definition of more detailed expectations.

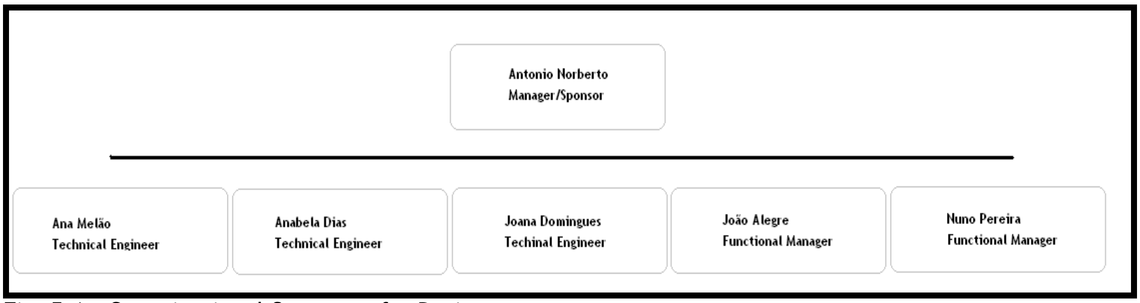


Fig. 5-1 – Organizational Structure for Project

The Sponsor provides the financial resources and seeks the involvement of all organization. He is involved in controlling and monitoring the goals of the project at a higher level, and is the centrepiece in terms of decision changes.

The Project Manager Role is her played by the Manager/Sponsor, he is responsible for defining the plan of the Project and components associated with it, keep the project within the stipulated time and budget and identify, monitor and respond to risks associated with the implementation of the Project.

The Functional Manager is responsible to provide information to the Project Manager and guaranty the execution of project.

5.2 General System Requirements

The system is meant to be implemented on the Strategic Industrial Department in VW-AE. According to the informatics knowledge level of users the system must function intuitively and simple in order to save time to users. The users should have access to their specific functions by introducing a login username and a password.

- The system must allow several user levels with different permissions,
- The system has to be configurable to send notifications on some operations via e-mail,
- System must facilitate communication between the involved departments for data request reminders,
- System must be reliable and trustworthy,
- Easily installed and maintained,
- The system must fulfil the company security standards.

Regarding the calculus functions the system is idealized for KPI calculation.

- The system is intended to calculate KPI automatically,
- Data sources, algorithms and methods must be easily editable,
- Input of data can be made by different ways:
    - Importing files with specific format (by users),
    - Automatically importing from other systems (to de defined),
    - Directly adding/editing via interface.

The Reporting Functions should comply with:

- Produce reports with the KPIs values and other data values,
- Reports can be graphics and/or tables and must be editable,
- Data must be stored for future revision or for other purposes re-use,
- Export reports in different file formats,
- Capability of forecasting the behaviour of KPI over short period of time.

The users allowed in the system must fit on the categories presented on Table 5-1.

Table 5-1 - Users Levels

User Level	User Description	Functions allowed
Admin	SIE Dept. Members	Insert/Delete/Edit all data All advanced Configurations
User	Responsible from each Area/Dept.	Insert/Edit specific data
Viewer	Persons allowed viewing the reports.	View reports only.

5.3 Functional Requirements

After the initial requirements recovery, the information gathered allowed a better picture of the system to be developed. In a way to support the requirements specification, the UML language was used, specifically the usage diagrams.

A set of 3 use case package was defined with 10 use cases.

The use case diagrams define dependencies and relation between the use case and actors.

For a better understanding the Actor is an entity that requests and demands actions and receives reactions. Each can actor can participate in more than one use case. The use case represents de dependencies and events performed by an actor on the system.

Use Cases Packages

The use cases will be divided into 3 major packages as shown in Fig. 5-2:

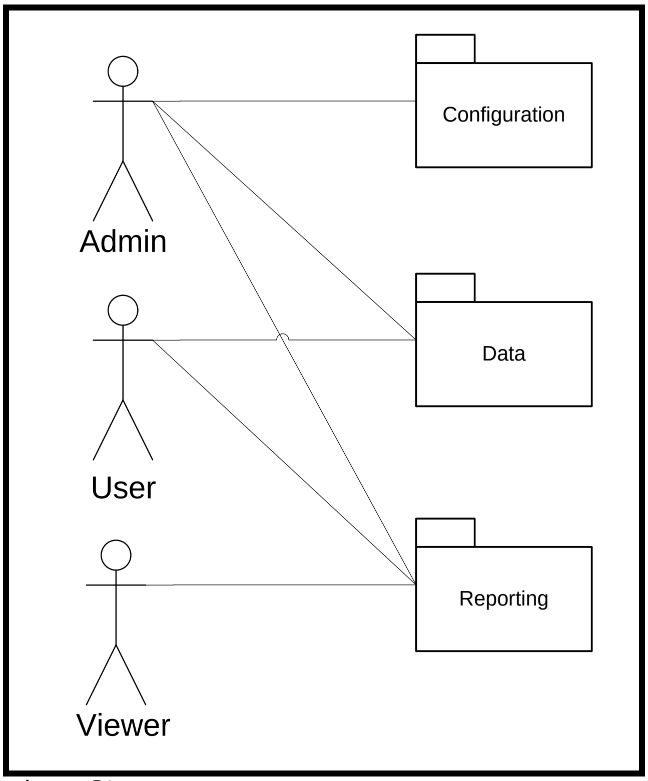


Fig. 5-2 – Use Case Packages Diagrams

On the following pages these use case packages will be detailed and specified.

- Configuration package include all use cases related to workflow and other general configurations.
- Data package approaches all use cases to support data importing, editing, validations, etc.
- Reporting package is related to all use cases that allow report viewing: selecting information, time period ranges, etc.

Package Configuration

For the Configuration package, 4 use cases were defined. They are presented on the Fig. 5-3.

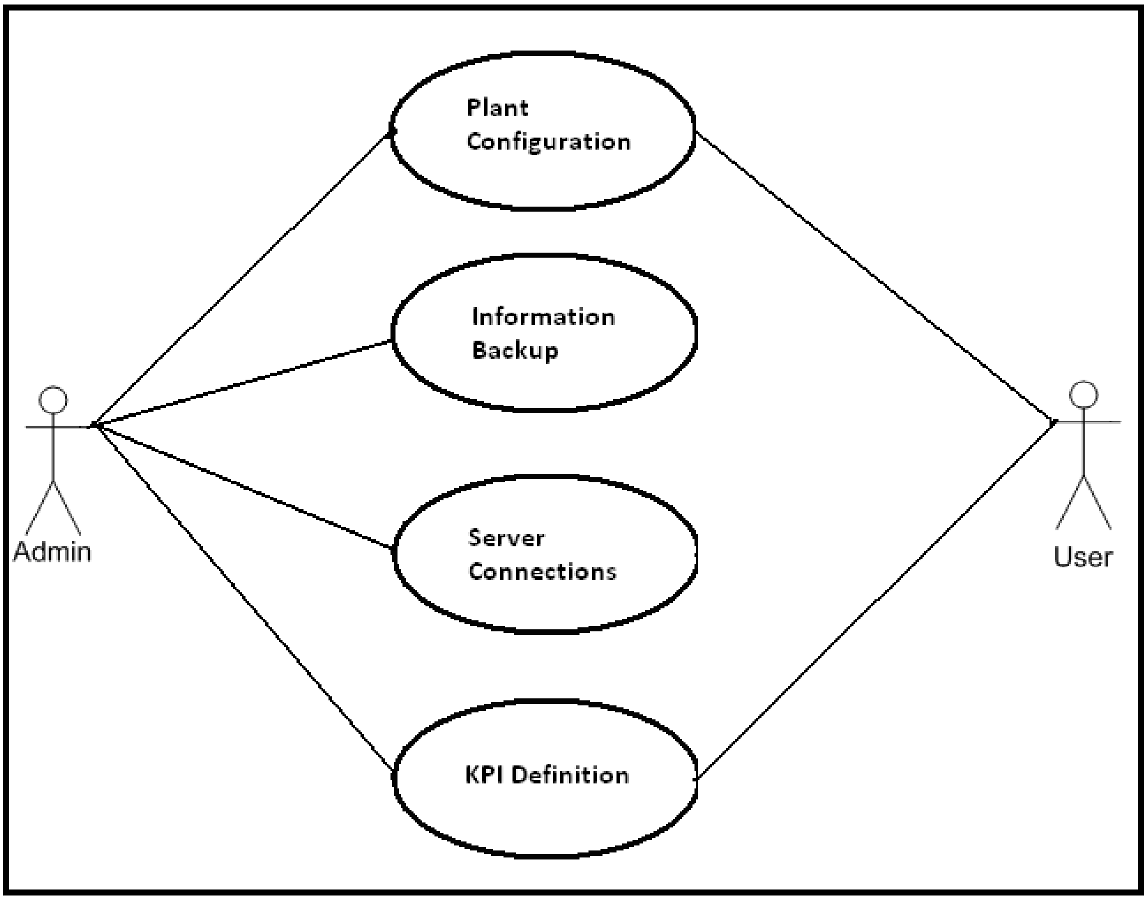


Fig. 5-3 – Configuration use case package

“Configuration” Use Cases

Case Use ID
Plant Configuration

Description
User inputs or edits organization structure in the system.
Actors
Admin. Or User levels
Requirements
The user must be logged in and have Admin access level.

Case Use ID
Information backup
Description
User manages the backup information on reports (validation)
Actors
Admin. level
Requirements
The user must be logged in and have Admin access level.

Case Use ID
Server Connections
Description
User establishes and manages the connection with database servers
Actors
Admin. level
Requirements
The user must be logged in and have Admin access level.

Case Use ID
KPI Definition
Description
User defines new KPI
Actors
Admin. Or User levels

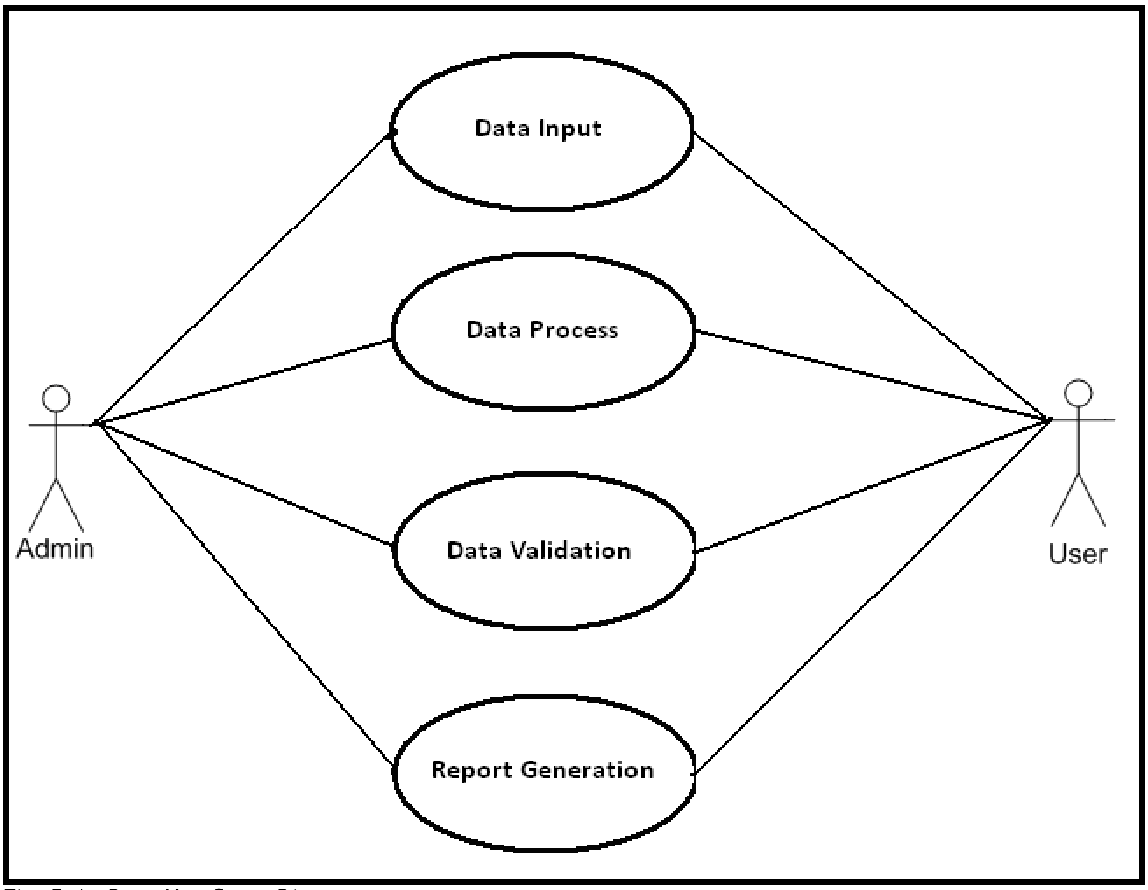


Fig. 5-4 - Data Use Cases Diagram

"Data" Use Cases

Case Use ID
Data Input
Description
User loads required data for report generation
Actors
Admin. Or User levels

Case Use ID
Data Process
Description
User follows the data processing for uncommon values
Actors
Admin or User level users.

Case Use ID
Data Validation
Description
User makes the validation of all data inputs prior to report generation
Actors
Admin. or User levels

Case Use ID
Report Generation
Description
User generates final report and broadcast its availability
Actors
Admin. or User levels

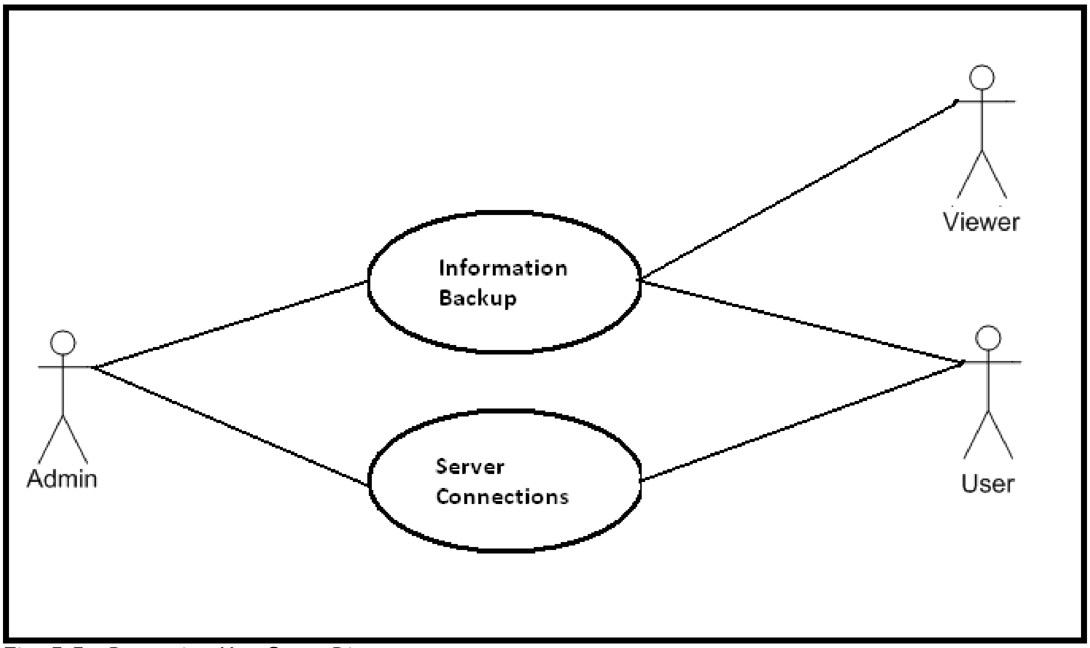


Fig. 5-5 - Reporting Use Cases Diagram

“Reporting” Use Cases

Case Use ID
Consult Report
Description
User consults existing reports
Actors
Admin, User or Viewer level users.

Case Use ID
Generate Report
Description
User builds new report based on pre - approved data on backup
Actors
Admin or User level users.

5.4 Early Prototype

As a small aide to prove the validity of project, the author committed to build an early functional prototype with the mere intention of demonstrating the possibilities on the improvement of calculation process with a simple automation of the data processing stage.

It was built using the available tools in company, Microsoft Excel and its internal functionalities, Visual Basic for Applications.

Due to company security reasons and lack of access to its systems it was not possible to extend the prototype further into the data gathering stage of process. Therefore, its only function is to process all previously gathered raw data and determine the values of KPI.

For the prototype the KPI chosen was the H.P.U. due to author familiarization.

Detailed Specification of Indicator

H.P.U. – Hours Per Unit is a Key Performance Indicator.

It is built by the number of production hours over the number of built cars on the same period. Although it defies the academic theory around KPI by inverting the calculation process, inputs over outputs, that makes it more easily readable for its analysis, as the output comes in hours, not as a percentage of produced car, which is always harder to understand than the amount of time itself. This could lead to a misdirected attention to decipher its value instead of its meaning.

Presentation

As referred previously the KPI should be presented against historical data and target values. The way chosen by company to present this indicator on Volkswagen Autoeuropa is presented on Fig. 5-6.

HPU Soll	HPU Ist	HPU Δ	Area	HPU Soll	HPU Ist	HPU Δ	MA Soll	MA Ist	MA Δ	Overtime (Std./Fzg.)
1,38	1,57	0,19	Press	1,38	1,70	0,32	21	26	5	0,00
9,40	6,72	-2,68	Body	9,40	5,77	-3,63	145	88	-57	0,00
3,42	3,64	0,22	Paint	3,42	3,60	0,18	53	55	2	0,00
16,12	14,75	-1,37	Assembly	16,12	15,33	-0,79	248	234	-14	0,00
1,70	1,73	0,03	Quality	1,70	1,83	0,13	26	28	2	0,00
32,02	28,41	-3,61	Total	32,02	28,23	-3,79	493	431	-62	0,00

Fig. 5-6 - HPU Report Presentation

On this report, the decision-maker agent is presented with report on Fig. 5-6 there he can see how each area on Plant is performing on current time period as well as an overall comparison with historical values from the same period of time over the previews days and previews week.

On top is also possible to see the production volumes as well as target production volume.

Calculation process

The calculation process is easy, as it can be seen from the formula itself, the hard step is the data gathering and processing steps, the countless number of details makes it almost impossible to automate. The description of entire process is presented on

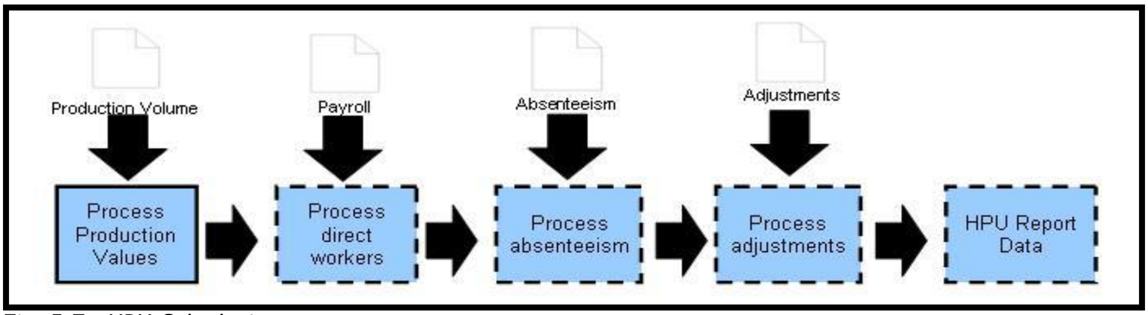


Fig. 5-7 – HPU Calculation steps

Interface

The prototype interface is based on Microsoft Excel VBA script.

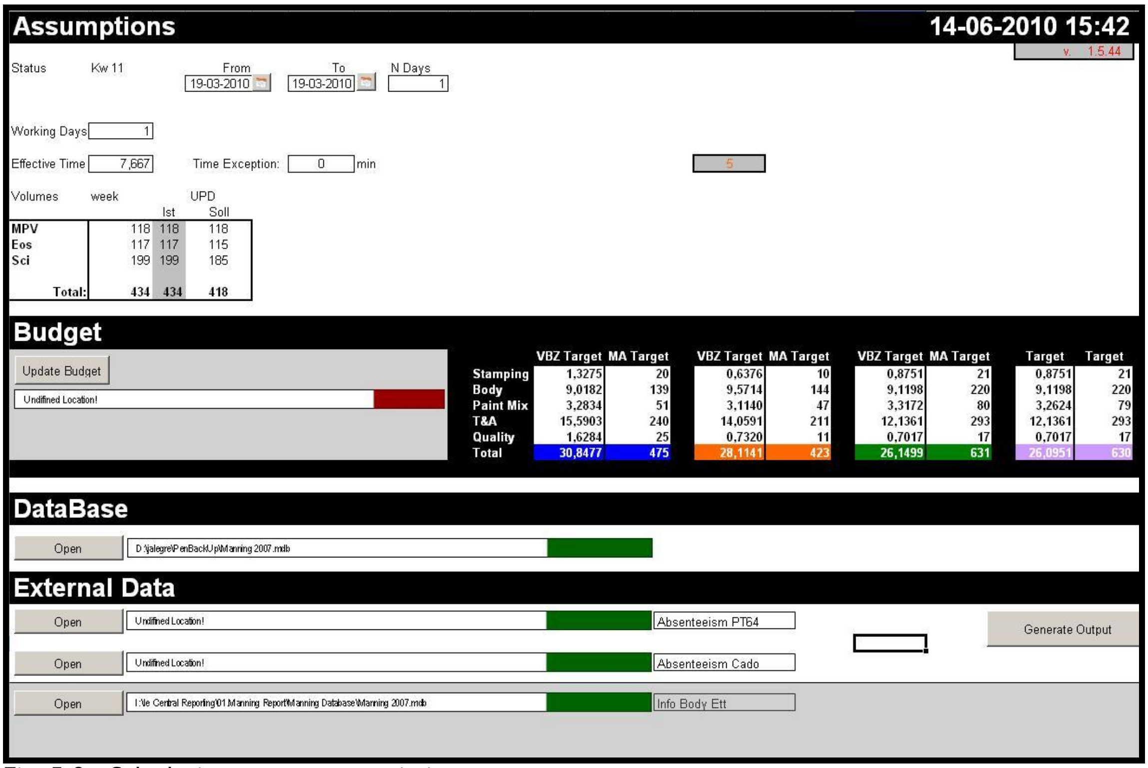


Fig. 5-8 – Calculation prototype – main input screen

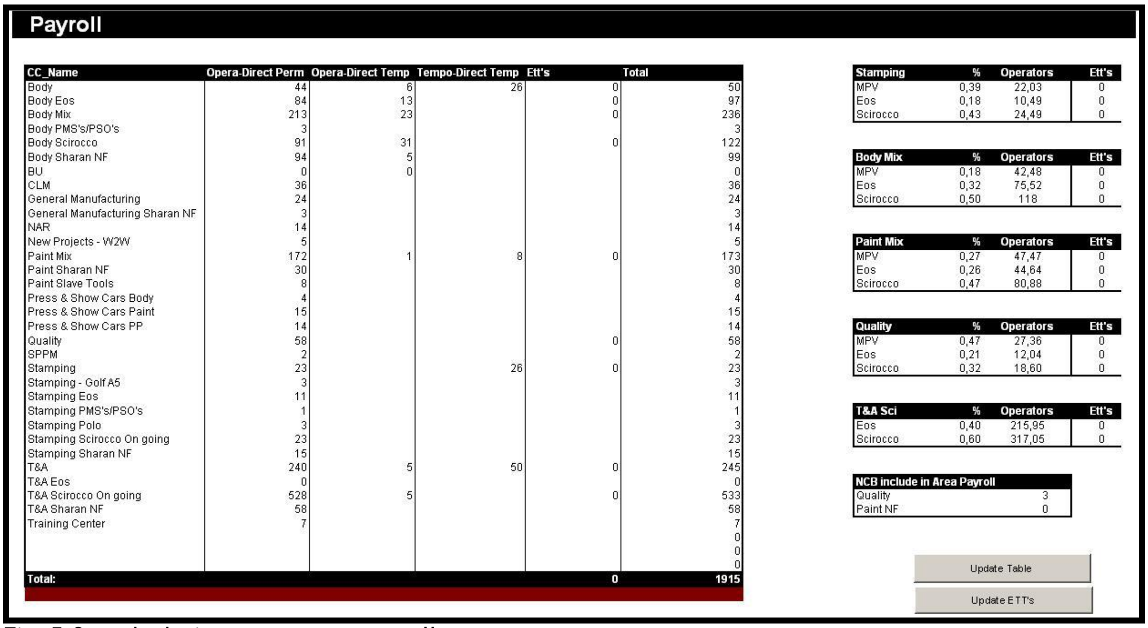
On Fig. 5-8 the main input screen is presented.

On this screen the first input is the date the report is referred to. After this, user is capable of defining the time discounts that took place on the referred time period, discounts can be due to workers council meetings or malfunctions on the assembly line, the Effective Working Time is determined automatically, production volume is also inserted on this screen, it is inserted by model and must be referred to the time period considered before.

On this screen, user is prompted for the location of database and location of retrieved Absenteeism excel files, then by pressing the “Generate Output” button an automated sorting algorithm is executed making the Absenteeism sheets with “Imputed” and “Absent” to be merged counting all workers that are already counted as absent and all workers that are absent from plant but not yet considered as absent on system.

Here are also presented the target values to witch final value is compared to.

On this screen, many steps were possible to improve and automate but due to internal company security issues, the access to databases and other logging systems was limited to the author.


Payroll

CC_Name	Opera-Direct Perm	Opera-Direct Temp	Tempo-Direct Temp	Ett's	Total
Body	44	6	26	0	50
Body Eos	84	13		0	97
Body Mix	213	23		0	236
Body PMS's/PSO's	3				3
Body Scirocco	91	31		0	122
Body Sharan NF	94	5			99
BU	0	0			0
CLM	36				36
General Manufacturing	24				24
General Manufacturing Sharan NF	3				3
NAR	14				14
New Projects - W2W	5				5
Paint Mix	172	1	8	0	173
Paint Sharan NF	30				30
Paint Slave Tools	8				8
Press & Show Cars Body	4				4
Press & Show Cars Paint	15				15
Press & Show Cars PP	14				14
Quality	58			0	58
SPPM	2				2
Stamping	23		26	0	23
Stamping - Golf A5	3				3
Stamping Eos	11				11
Stamping PMS's/PSO's	1				1
Stamping Polo	3				3
Stamping Scirocco On going	23				23
Stamping Sharan NF	15				15
T&A	240	5	50	0	245
T&A Eos	0				0
T&A Scirocco On going	528	5		0	533
T&A Sharan NF	58				58
Training Center	7				7
					0
					0
					0
Total:				0	1915

Stamping	%	Operators	Ett's
MPV	0,39	22,03	0
Eos	0,18	10,49	0
Scirocco	0,43	24,49	0

Body Mix	%	Operators	Ett's
MPV	0,18	42,48	0
Eos	0,32	75,52	0
Scirocco	0,50	118	0

Paint Mix	%	Operators	Ett's
MPV	0,27	47,47	0
Eos	0,26	44,64	0
Scirocco	0,47	80,88	0

Quality	%	Operators	Ett's
MPV	0,47	27,36	0
Eos	0,21	12,04	0
Scirocco	0,32	18,60	0

T&A Sci	%	Operators	Ett's
Eos	0,40	215,95	0
Scirocco	0,60	317,05	0

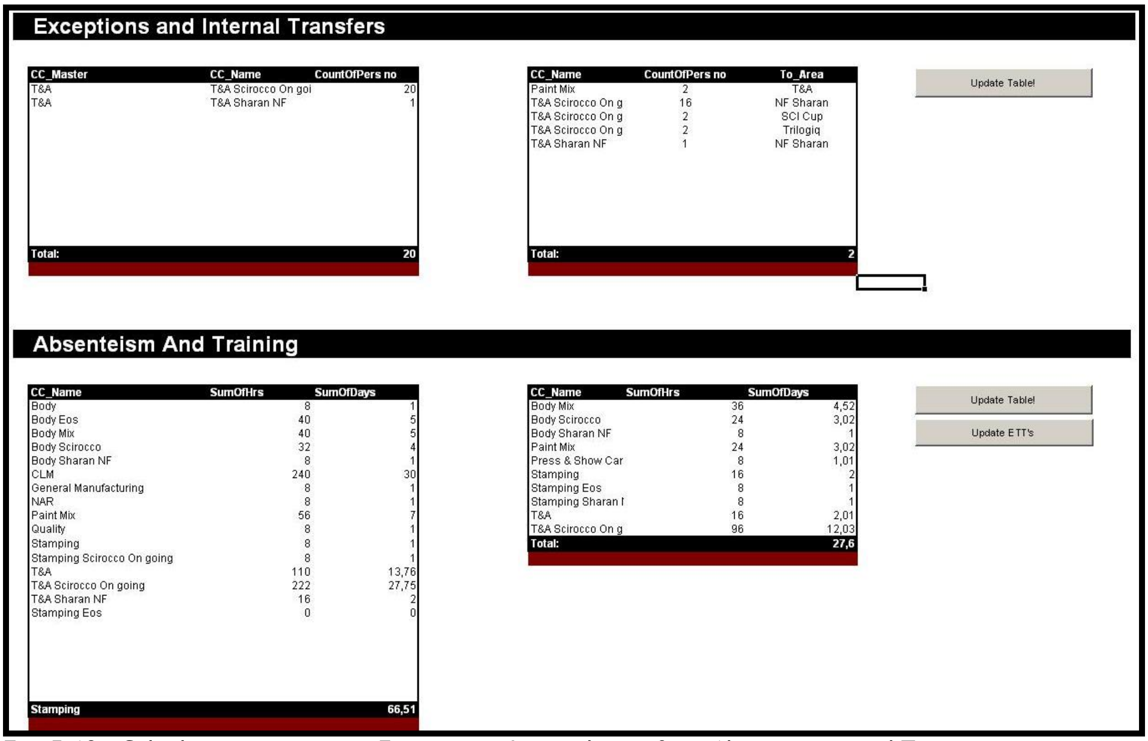
NCB include in Area Payroll	
Quality	3
Paint NF	0

Update Table

Update ETT's

Fig. 5-9 – calculation prototype – payroll screen

On the Payroll section is placed automatically the content of database with payroll regarding to the date referred on first screen. A manual input box, fig xx, is shown for manual temporary workers assign to each area.



Exceptions and Internal Transfers

CC_Master	CC_Name	CountOfPers no
T&A	T&A Scirocco On goi	20
T&A	T&A Sharan NF	1
Total:		20

CC_Name	CountOfPers no	To_Area
Paint Mix	2	T&A
T&A Scirocco On g	16	NF Sharan
T&A Scirocco On g	2	SCI Cup
T&A Scirocco On g	2	Trilogiq
T&A Sharan NF	1	NF Sharan
Total:		2

Update Table!

Absenteism And Training

CC_Name	SumOfHrs	SumOfDays
Body	8	1
Body Eos	40	5
Body Mix	40	5
Body Scirocco	32	4
Body Sharan NF	8	1
CLM	240	30
General Manufacturing	8	1
NAR	8	1
Paint Mix	56	7
Quality	8	1
Stamping	8	1
Stamping Scirocco On going	8	1
T&A	110	13,76
T&A Scirocco On going	222	27,75
T&A Sharan NF	16	2
Stamping Eos	0	0
Stamping		66,51

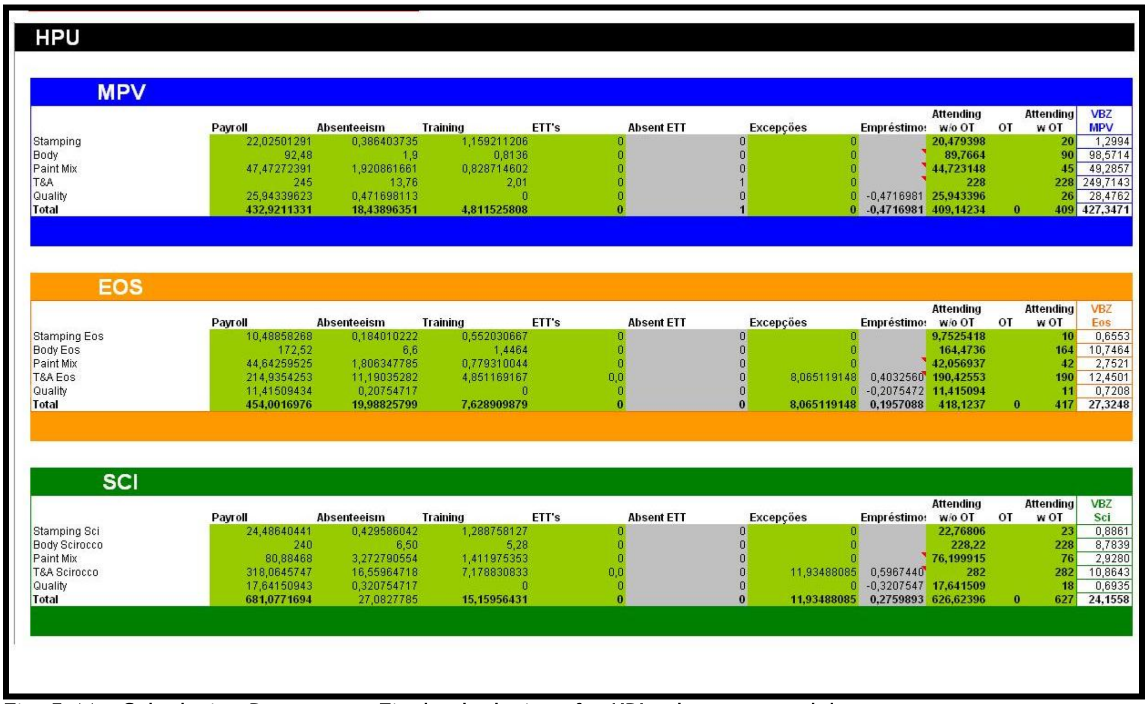
CC_Name	SumOfHrs	SumOfDays
Body Mix	36	4,52
Body Scirocco	24	3,02
Body Sharan NF	8	1
Paint Mix	24	3,02
Press & Show Car	8	1,01
Stamping	16	2
Stamping Eos	8	1
Stamping Sharan I	8	1
T&A	16	2,01
T&A Scirocco On g	96	12,03
Total:		27,6

Update Table!

Update ETT's

Fig. 5-10 – Calculation prototype – Exceptions, Internal transfers, Absenteeism and Training screen

As the previews screen, this is also populated automatically from database and user has to fulfil the temporary workers by hand.



HPU

MPV

	Payroll	Absenteeism	Training	ETT's	Absent ETT	Excepções	Empréstimos	Attending w/o OT	OT	Attending w OT	VBZ MPV
Stamping	22,02501291	0,386403735	1,159211206	0	0	0		20,479398		20	1,2994
Body	92,48	1,9	0,8136	0	0	0		89,7664		90	98,5714
Paint Mix	47,47272391	1,920861661	0,828714602	0	0	0		44,723148		45	49,2857
T&A	245	13,76	2,01	0	1	0		228		228	249,7143
Quality	25,94339623	0,471698113	0	0	0	0	-0,4716981	25,943396		26	28,4762
Total	432,9211331	18,43896351	4,811525808	0	1	0	-0,4716981	409,14234	0	409	427,3471

EOS

	Payroll	Absenteeism	Training	ETT's	Absent ETT	Excepções	Empréstimos	Attending w/o OT	OT	Attending w OT	VBZ Eos
Stamping Eos	10,48858268	0,184010222	0,552030667	0	0	0		9,7525418		10	0,6553
Body Eos	172,52	6,6	1,4464	0	0	0		164,4736		164	10,7464
Paint Mix	44,64259525	1,806347785	0,779310044	0	0	0		42,056937		42	2,7521
T&A Eos	214,9354253	11,19035282	4,851169167	0,0	0	8,065119148	0,4032560	190,42553		190	12,4501
Quality	11,41509434	0,20754717	0	0	0	0	-0,2075472	11,415094		11	0,7208
Total	454,0016976	19,98825799	7,628909879	0	0	8,065119148	0,1957088	418,1237	0	417	27,3248

SCI

	Payroll	Absenteeism	Training	ETT's	Absent ETT	Excepções	Empréstimos	Attending w/o OT	OT	Attending w OT	VBZ Sci
Stamping Sci	24,48640441	0,429586042	1,288758127	0	0	0		22,76806		23	0,8861
Body Scirocco	240	6,50	5,28	0	0	0		228,22		228	8,7839
Paint Mix	80,88468	3,272790554	1,411975353	0	0	0		76,199915		76	2,9280
T&A Scirocco	318,0645747	16,55964718	7,178830833	0,0	0	11,93488085	0,5967440	282		282	10,8643
Quality	17,64150943	0,320754717	0	0	0	0	-0,3207547	17,641509		18	0,6935
Total	681,0771694	27,0827785	15,15956431	0	0	11,93488085	0,2759893	626,62396	0	627	24,1558

Fig. 5-11 – Calculation Prototype – Final calculations for KPI values per model

On Fig. 5-11 all calculations are made, to achieve the final KPI value. From this screen the values are taken to build the final report.

Conclusion

By this simple calculation prototype is easily seen that the main problem remains, this is, the allocation of workers. Although some steps were greatly improved, like that absenteeism categorization, a step that manually done takes an average of 3 minutes is done on prototype in an average of 8 seconds; this represents an improvement on this part of process around 91%.

The problem of data validation remains. Because there is no standardized data transfers it is not possible to automate the data treatment on other process like temporary workers assign and the data gather remains manual due to company security restrictions.

Chapter 6

Performance Measure Support System

After the specification of requirements and the construction of the early prototype the author achieved a better understand on the process and its difficulties.

The next step was to develop prototype interfaces with users. This was done using an iterative process, with several meetings with stakeholders, with the objective of tuning to the best the acceptance level and an improvement on workflow. This specification was prepared focusing on the current KPIs used in Autoeuropa but system was idealized as scalable, this means it can be also used to define and determine new KPI's to be developed/adopted and used on Plant or even on other plant with different characteristics.

To the launch of application a splash screen is displayed with the company logo, as seen on Fig. 6-1.

Fig. 6-1 - Splash Screen

The program then prompts user for a login and password, Fig. 6-2.

Fig. 6-2 - Login Screen

After the Log in user is prompted with the main screen, depending from the user level, it can change the number of available options. Admitting for the demonstration of interfaces and Admin is logged in; the menu presented is the following:

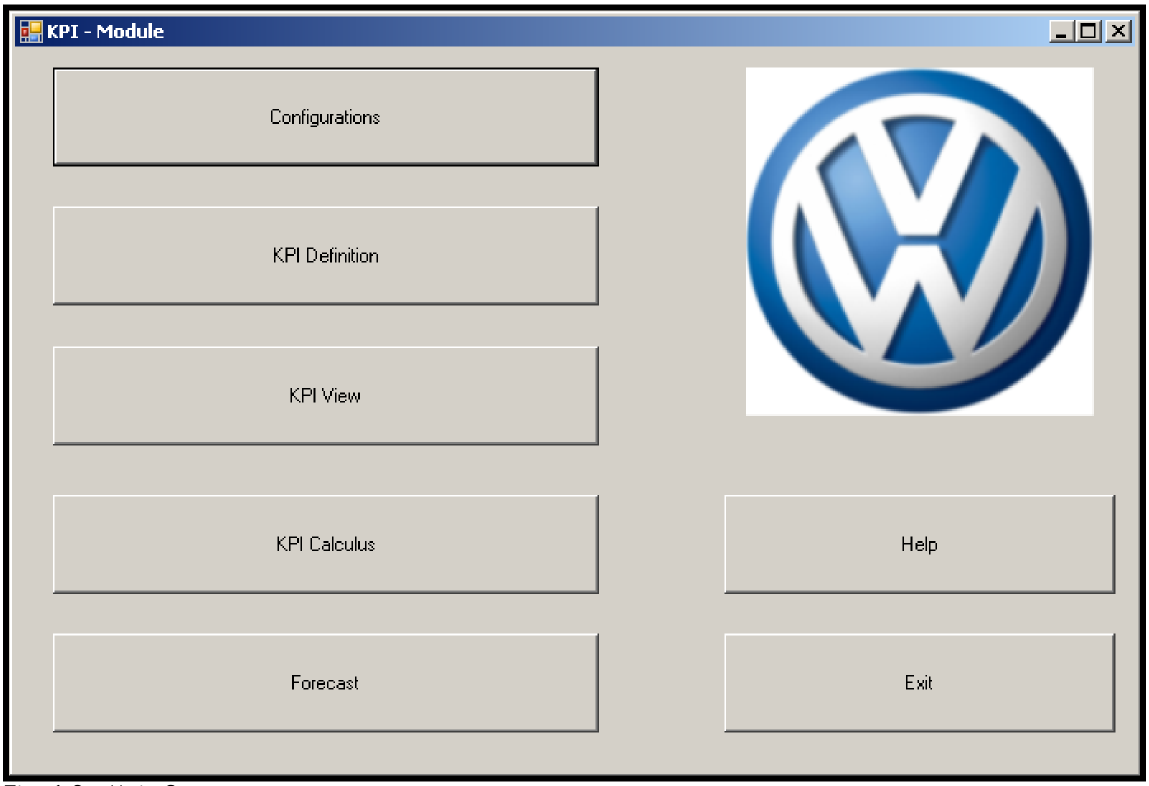


Fig. 6-3 - Main Screen

On this main screen, user can access the Configurations screen, that contains all the configurations for the Plant, allowing to configure internal organization of Plant, working schedule, historical database with previews validated data for report generation, how assembly lines are configured and the attribution of cost centres to each area and also the program configurations such as network connections, user accounts and logging operations. This can be seen on Fig. 6-4.

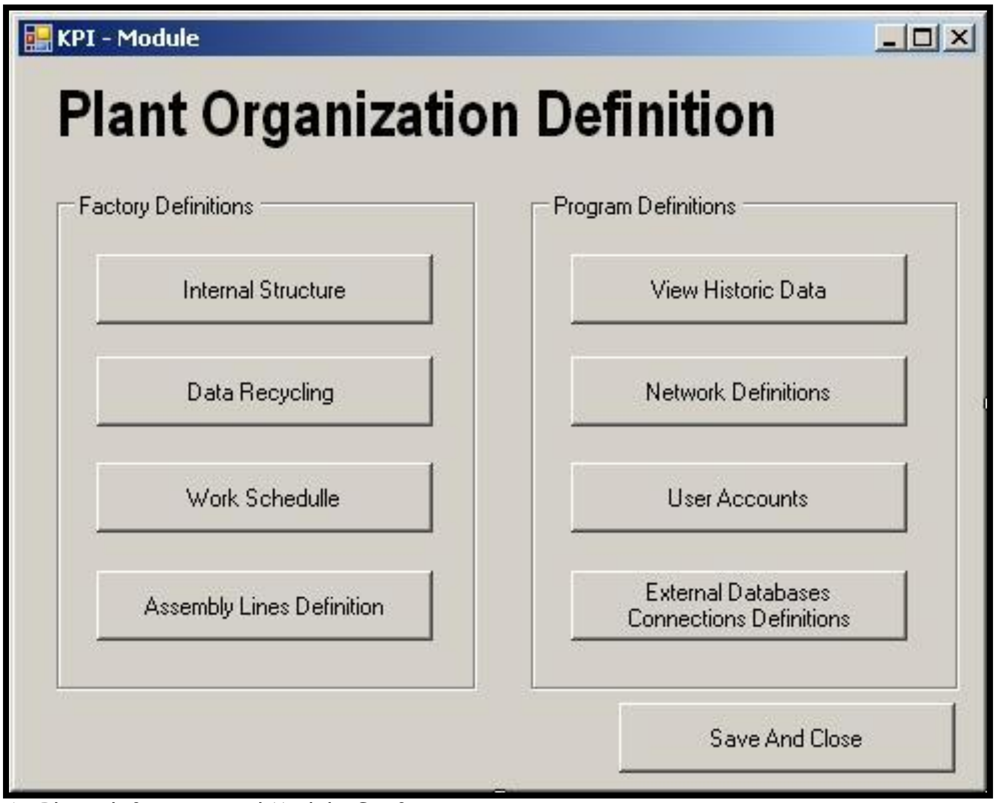


Fig. 6-4 – Plant definitions and Module Configurations

After all changes made to configuration user can return to main screen. The option **KPI Definition** allows user to access a screen to define or re-define KPIs. Here user can choose between available inputs and/or define new inputs, in that case he's taken to Fig. 6-6, when inputs are chosen, they automatically appear as blocks for formula definition, Fig. 6-5

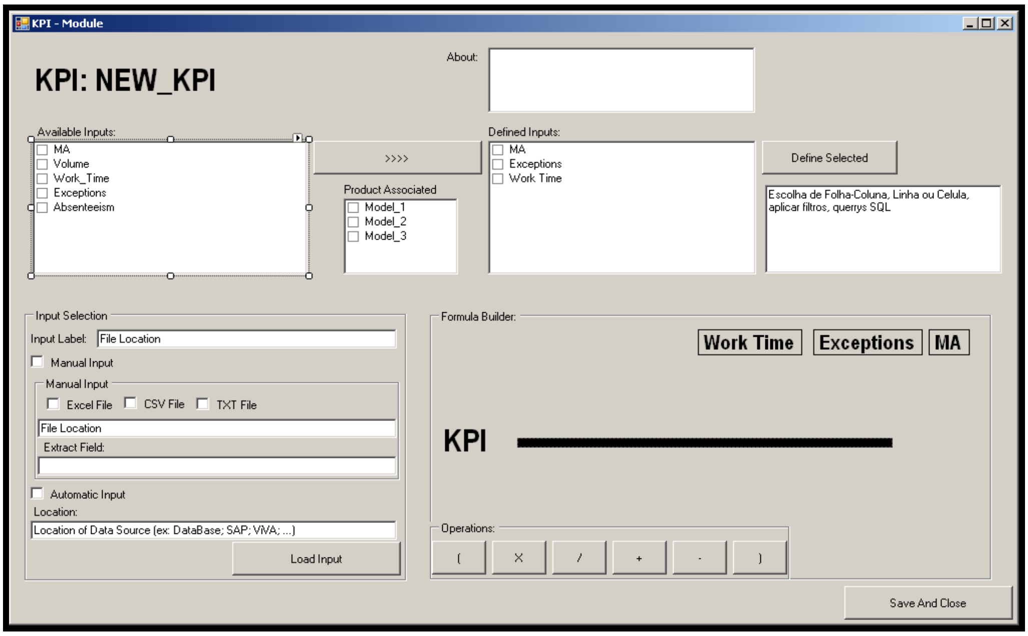


Fig. 6-5 – Interface for defining new KPI

As mentioned previously, if user decides he needs new input values, he is prompted with the screen on Fig. 6-6, here a list of all values is presented and some criteria for data sorting are available to help tuning the data, after defined here, these inputs appear automatically on the list of available inputs for KPI definition.

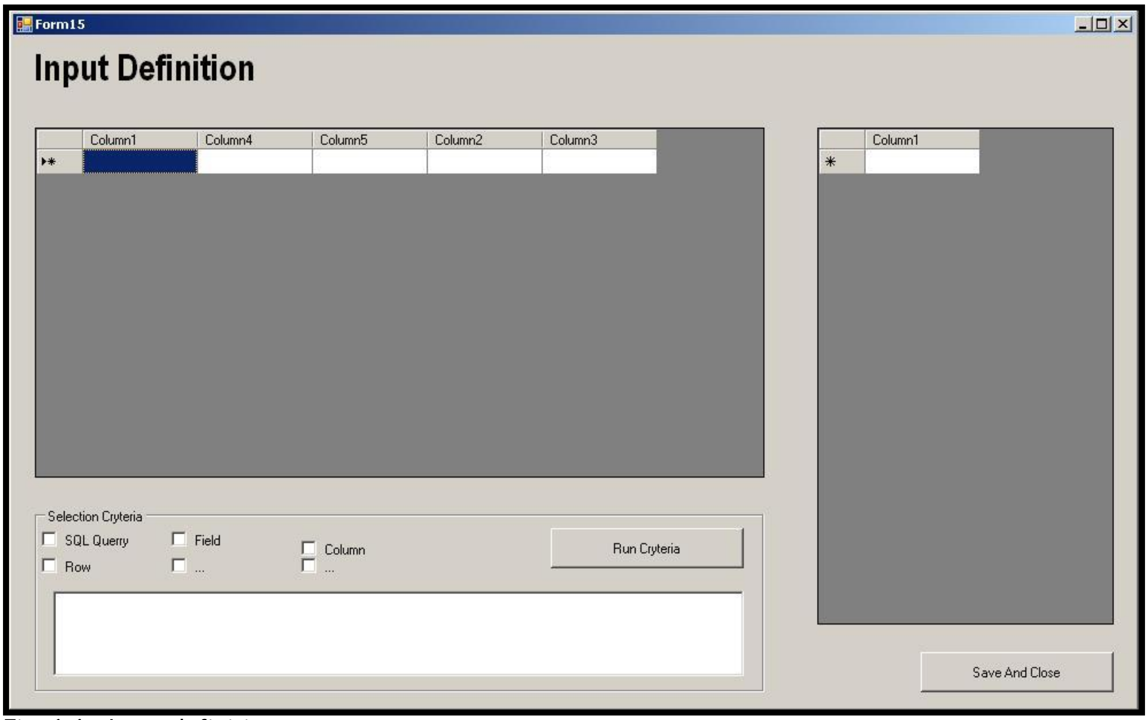


Fig. 6-6 – Input definition

Something similar is presented when new product is added, user has to define its name and assign the cost centres assigned to that same product. Fig. 6-7.

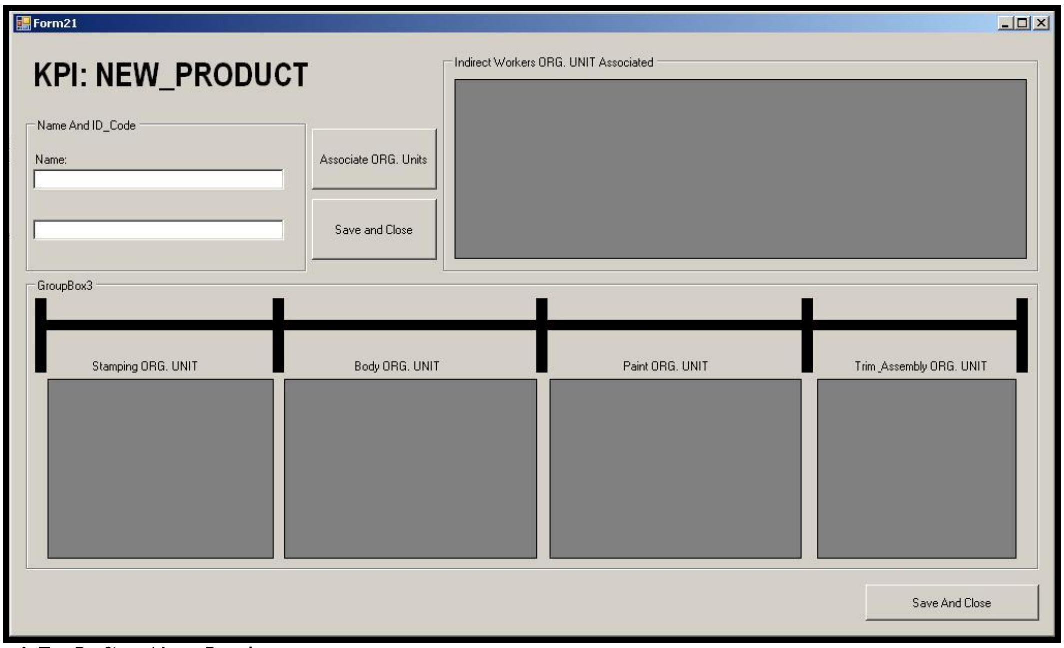


Fig. 6-7 – Define New Product

When user selects the option to start the calculation process, the following screen is presented; Fig. 6-9, here user can select the available options to generate a report

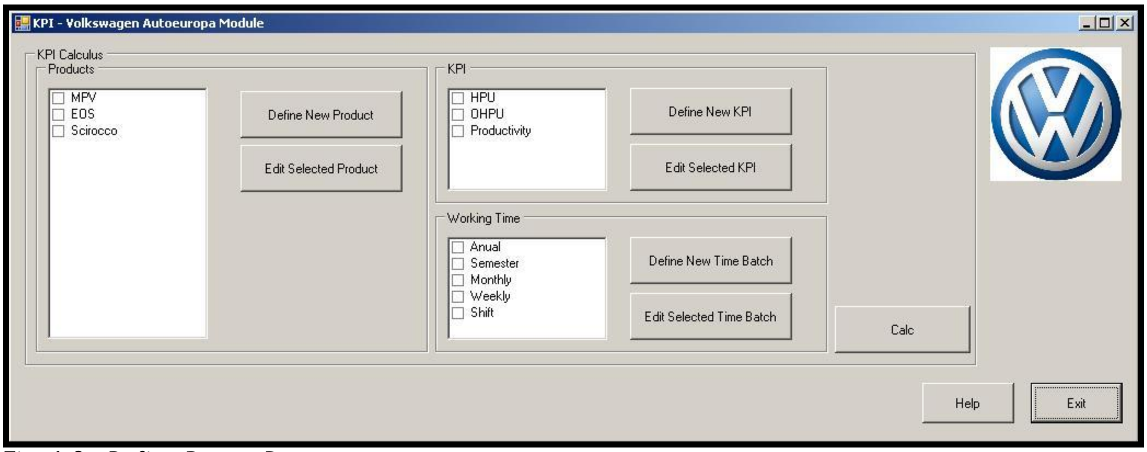


Fig. 6-8 - Define Report Prompt

After choosing the product, the KPI and the time period for the report, data is gathered and presented on screen like on Fig. 6-9, here is requested to user to review values for any un-noticed data error, discrepancies and uncommon values.

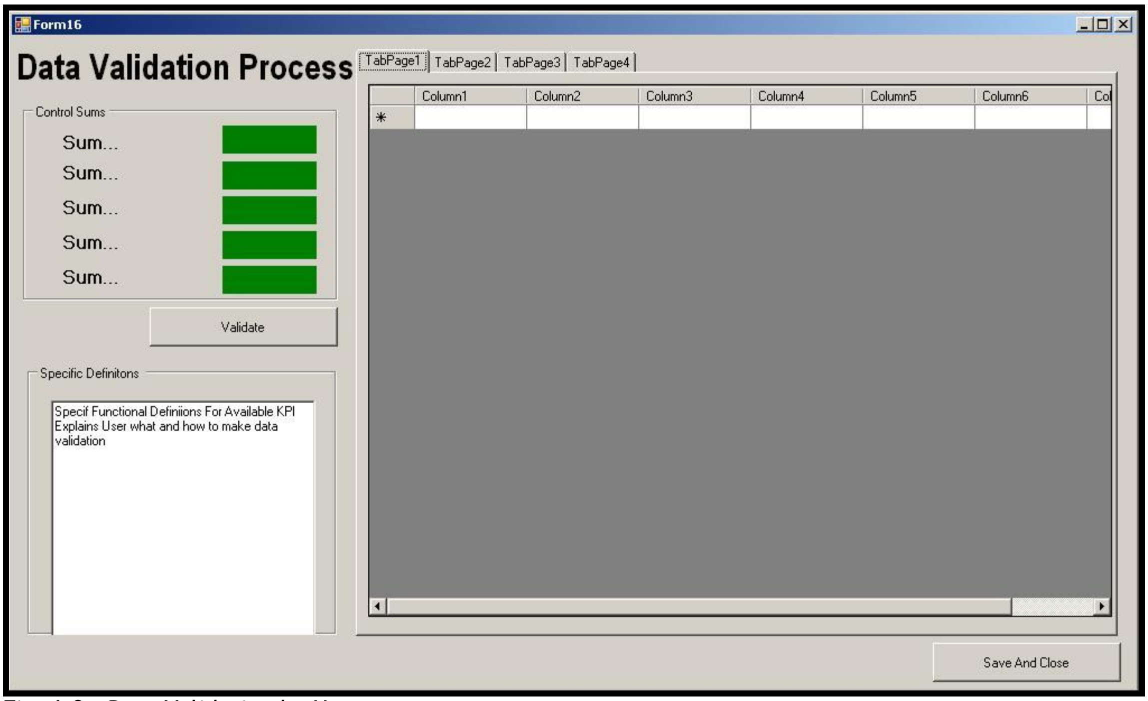


Fig. 6-9 – Data Validation by User

The final report is presented on a graphical form on screen, Fig. 6-10.

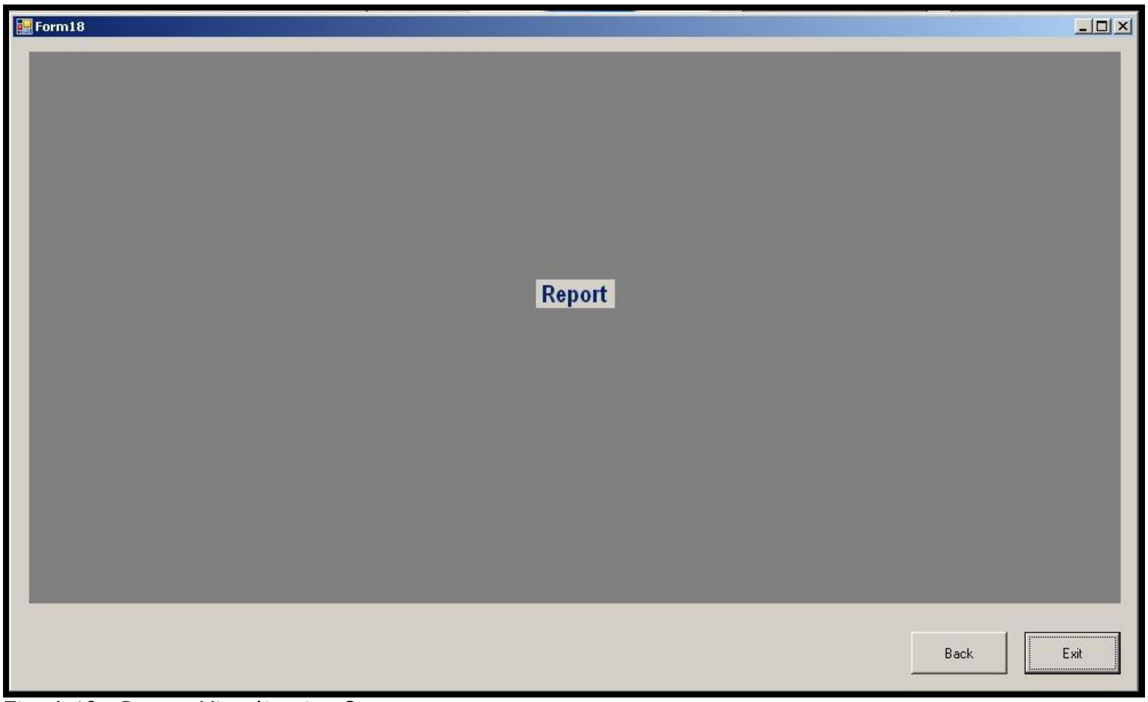


Fig. 6-10 - Report Visualization Screen

Chapter 7

Conclusions

7.1 Main Conclusions

The development of this thesis and its specification allowed a visual prediction on the future KPI calculation system. By doing this a better picture was formed, to all the stakeholders of the bottlenecks of process and its handicaps. These handicaps on KPI usages lead to several adjustments every day on the process and therefore the impossibility of improving and fully automate the entire process.

With the early prototype, based on Microsoft Excel, some steps where automated and a significant improvement on wasted time was made, but due to lack of template usage between the several departments, the automated steps are under risk of failing and therefore compromising the entire process of calculation.

The produced System Requirements Specification, based on IEEE 830 – 1993, allowed a better explanation of ideas and constraints, as well as a good specification on wanted functionalities.

This specification is also part of Virtual Factory Framework Project and it leads the VFF to a major advance on developing one of its modules

The usage of Process Engineering Methodology allowed broadness and ambitious specification identifying some additional and unpredicted functionality.

For the specification of user interfaces used an approach through workflows techniques and the concepts evolved to a commonly accepted model for all stakeholders.

The developed work fulfilled all the objectives proposed at its beginning, the current calculation methods were learned and analysed, an early functional prototype was made for the immediate help on partially solving the major problem, the time taken to build the reports and a software requirements specification was developed alongside with involved stakeholders in order to bring it as close as possible to the demanded.

7.2 Future work

The impact of this thesis is not yet measurable, but expectations are high.

During the next year the development and implementation of specified system will take place. After, its approval by the stakeholders, by conducting a series of validations scenarios on main phases, the “Monitoring” and the “Ramp-up” phases, it is planned to be incorporated on Volkswagen Autoeuropa systems and also on the VFF Project.

References

[1] VFF Documentation at www.vff-project.eu

[2] Oregon State University Family Study Centre (Clara C. Pratt, et al.). Building Results: From Wellness Goals to Positive Outcomes for Oregon's Children, Youth, and Families, 2nd ed. (Salem, OR: Oregon Commission on Children and Families, 1997).

[3] National Research Council. E. B. Perrin, J. S. Durch, and S. M. Skillman, eds., Health Performance Measurement in the Public Sector: Principles and Policies for Implementing an Information Network. (Washington D.C.: National Academy Press, 1999).

[4] Virginia Department of Planning and Budget, Planning and Evaluation Section. Virginia's Handbook on Planning & Performance (Richmond: VA Department of Planning and Budget, 1998).

[5] Dennis S. O'Leary, Joint Commission on Accreditation of Healthcare Organizations. "Measurement and Accountability: Taking Careful Aim," Journal of Quality Improvement 21(July 1995): 354-357.

[6] Based on: Joint Commission on Accreditation of Healthcare Organizations (JCAHO).

[7] Jorge Ferreira Pinheiro, Antonio, “BP2IT” Master Thesis, Faculty of Engineering – University of Porto