A methodology to assess the maturity level of brewery business processes

Master Thesis

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Abstract

The purpose of this project is to develop a procedure to assess the maturity level of the brewery business processes to be able to determine the required level of process automation & IT for a brewery. This procedure is made up by several tailored questionnaires that have been based on the Process and Enterprise Maturity Model management assessment tool. This tool is described in the article called The Process Audit written by Michael Hammer and published by Harvard Business Review in 2007.

The prepared questionnaires focus on the beer production activities that belong to production operations management, also called MES layer. This framework is originated by ANSI/ISA and the activities are Detailed Production Scheduling, Production Resource Management, Product Definition Management, Production Execution, Production data Collection, Production Performance Analysis, Production Tracking and Production Dispatching.
Preface

This project comes up due to the fact that Joost Roldaan, Manager of the section Process Control & Utilities from the Heineken Supply Chain Group, wanted to have a system, a procedure to be able to determine the required level of process automation & IT for a brewery. And he needed a person, a student in this case, to perform this project. Therefore, as I was looking for a company to carry out the Master’s Thesis work for the MSc in Production Engineering and Management (at Royal Institute of Technology), we decided that I could move from Sweden to Holland, join Heineken and carry out this task.

It has been my first experience in a company and as far as I am concerned, I think it has been a great opportunity for me to realize how a big and vast company like Heineken International works day by day. Personally, it has been a very positive experience, I have learnt a lot and honestly, I hope my stay has helped contributing to the development of this project. There have been designed the foundations for the project as well as important steps have been taken. But still, the development must continue.

There are several ways to learn and understand how the work is done in a company. One solution is to read reports, read books, papers and even find information in the net. That is necessary and fine. However, there is something else that should be done. In this case, for this research the most direct and effective way to understand how things are done at Heineken is by meeting people that work in different areas and different departments.

Therefore, I want to thank the following people that helped me proceeding this study.

I would like to thank Joost Roldaan (Manager Process Control & Utilities, Supply Chain Group). Joost has been my supervisor, the sponsor of this project and the person that made my stay at Heineken possible. Thanks for the support, coach, confusing feedback and wise advices.

Ingrid Kokkelink (Reporting Analyst from the Group Supply Chain Control), Ingrid explained to me Heineken’s business drivers and how Heineken International is organized worldwide. In addition, how different sites report to OpCo’s, OpCo’s to Regions and Regions to the World corporate. She showed how a big company like Heineken is strategically controlled and guided by the Manufacturing Star.

Chris Versteegh (Engineer Policy & Eng. Quality Manager from the Group Supply Chain Policies). Joost and I met several times Chris and we had some discussions regarding the objective of the project and how to approach to it. Chris Versteegh played an advisory role for this study.

Martijn van Gorkum (Expert in planning and logistics operations management from the Group Logistics, Supply Chain Group). Martijn brought me into contact with André Ruigrok
and Jan Teeuwen. He also helped me analyzing the impact of the activity models on Heineken’s Supply Chain Star.

André Ruigrok (Senior Shop Floor Planner at Heineken Zoeterwoude). André explained to me how the scheduling process works at Heineken Zoeterwoude and he helped me answering the first questionnaire about Detailed Production Scheduling. I met him several times to discuss the questionnaire and he gave me feedback on it.

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Julio Martinez-Mejías (Production Planner, Heineken Spain) and Pedro Garcia (Planning manager, Heineken Spain). Julio and Pedro answered the questionnaire regarding the Detailed Production Scheduling process. They provided me as well, with information regarding Heineken Spain.

Jan Teeuwen (Expert in planning, IT solutions and site logistics from the Group Logistics, Supply Chain Group). Thanks to Jan, I could get in touch with Joerg Kremser and Anna Kyriakopoulou.

Joerg Kremser (Demand & Production Engineering dept.) at Brau Union Österreich AG (Heineken Austria). Joerg answered the questionnaires regarding the Detailed Production Scheduling process and the Production Resource Management process and his feedback helped me improving them. He provided me as well, with information regarding Heineken Austria.

Anna Kyriakopoulou (Production planning dept.) at Heineken Greece, Athens. Anna answered the questionnaires regarding the Detailed Production Scheduling process and the Production Resource Management process and her feedback helped me improving them. He provided me as well, with information regarding Heineken Greece.

Marry van Kuijk (Secretary Supply Chain Services). Marry scheduled many meetings on my behalf and she helped me out with all the administrative issues.

And last but not least, I would like to thank the colleagues from the Process Control & Utilities department with whom I have been having the lunch every day for six months.

Mikel Armendáriz Pérez

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Chapter 1: Introduction

This chapter gives an overview of Heineken International. First of all a general description of the company, showing Heineken’s position in the global market. And straight afterwards, a simple depiction of Heineken’s supply chain.

Finally, the assignment is explained in terms of its purpose, its phases, the areas to be covered by the study, the methodology, the expected contributions and the planning.

1.1 General description of the company: Heineken

Heineken International is a Dutch brewing company. It is one of the world’s leading brewers in terms of sales, volume and profitability. Heineken’s core business is brewing beer and it achieved by the correct combination of these four basic natural ingredients: Barley, water, hops and yeast.

The principal international brands are Heineken® and Amstel®, but the group brews and sells more than 170 international premium, regional, local and specialty beers and ciders, including Cruzcampo®, Birra Moretti®, Foster’s®, Maes®, Murphy’s®, Newcastle Brown Ale®, Ochota®, Tiger®, Sagres®, Star®, Strongbow® and Zywiec®. This facilitates the production of 125.8 million hectoliters.

The Figure 2 shows the top companies for the brewing industry in terms of volume. The company that holds the first position is the Belgium AB-InBev, then the London based SABMiller and in the third position the Dutch Heineken. Since 2010, the Mexican company FEMSA is part of Heineken. As figures show, there is a gap between the three “big” companies and the rest. In fact, the beer industry trend shows that this gap will continue increasing and in the future, the 3-4 producers that are able to keep their position will rule the market.
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Figure 2: The brewing industry: top 10 (Heineken company presentation, March 2010).

Figure 3 shows the international leading brands based on sales volume. Heineken, Amstel and (the European share of) Forster’s appear in the top 11.

Figure 3: The international leading brands (Heineken company presentation, March 2010).
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Heineken is the most sold beer and it is available in almost every country on the planet. It is therefore essential to put much effort in communicating the brand and sponsoring it. Heineken focuses on three main platforms: Sports, Film and Music.

In the sports field, Heineken sponsors the UEFA Champions League, the Rugby World Cup, the Heineken Cup (Rugby) and the USA Tennis Open.

Film industry offers an effective platform to reach a global audience, and Heineken appears in blockbusters like The Matrix, The Bourne Ultimatum and James Bond.

Heineken also takes part sponsoring music, over 100 live music events worldwide. Such as FIB in Spain, Oxegen in Ireland and Coachella in the USA.

The company is organized into five territories, which are then divided into regional operations. These regions are Western Europe, Central and Eastern Europe, The Americas, Africa and the Middle East, and Asia Pacific. The headquarters are divided between Amsterdam and Zoeterwoude, both in Holland, and employees around 55000 people all around the globe. The revenue in 2009 was €14.70 billion, the operating income €1.757 billion and the final profit €1.018 billion. Further information regarding Heineken International is available in the company’s website\(^1\) and in the annual report.\(^2\).

\(^1\) [www.heinekeninternational.com](http://www.heinekeninternational.com)

\(^2\) [www.annualreport.heineken.com](http://www.annualreport.heineken.com)
1.2 Description of the Heineken supply chain

Heineken’s supply chain is based on the SCOR model\(^3\). This model is a management tool for analyzing supply chains, spanning from the supplier’s supplier to the customer’s customer. It is based on five business processes:

- Source, processes that procure goods and services.
- Make, processes that transform product to a finished state.
- Deliver, processes that provide finished goods, order management, transportation management and distribution management.
- Return, processes associated with receiving and returning products.
- Plan, processes that control sourcing, making delivering and returning.

The Figure 4 shows a simplification of the Heineken supply chain.\(^4\)

\(^3\) The SCOR model is described in the Appendix D.
\(^4\) Heineken calls S2P (Source to Pay) to Source processes, D2W (Demand to Warehouse) to Make processes and M2C (Market to Cash) to Deliver processes.
In some breweries, like Zoeterwoude (Holland) and Sevilla (Spain), some suppliers do the raw material inventory control. It is their task to keep the inventory between the limits. Therefore, depending on the production demand they pull the raw materials, both raw materials and packaging materials: crown cork, bottles, kegs, labels, etc.

The Make business process describes the brewing and packaging processes. These two processes form the core business of the company. Brewing pulls raw materials and produces beer, and then packaging pulls beer from the brewing process and packaging material from the inventory.

Once the beer is bottled, the next step is to deliver it to the customers. Depending on the customer, it can be pushed or pulled by them. It depends on the customer’s weight. However, not all the beer is bottled or filled in kegs. Depending on the brewery, for instance Heineken Zoeterwoude (Holland) controls the warehousing for the US market. Therefore, depending on the US stock levels they ship more or less beer to America.

There is another important process called returnable’s management. This process manages the returnable bottles and kegs. These containers are collected from the customers and introduced back to the packaging process.

The Figure 5 shows the physical and process model for beer production. The process can be seen as a black box with inputs and outputs. This process receives as an input raw material lots and gives as an output bright beer for packaging.
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Figure 5: Physical and process model for beer production.

The blue dash line encloses the process “beer production”. The red dotted line encloses the process cells and the green squares represent the process stages. The black arrows are the transfers and the two dotted arrows are the dosing.

As commented before, not the entire amount of beer goes to packaging lines. A portion is filled in tanks and transported to customers.

The Figure 6 gives an overview of the planning process for a brewery.
Figure 6: Overview of the planning process.

The first phase is to determine the demand. For that, different techniques are applied for instance statistical forecasting techniques, promotions and events management, etc. Then the sales plan is decided and finally the production is planned. Here the steps are the MPS ⁵(Master Production Scheduling) design, improved by the RCCP ⁶(Rough Cut Capacity Planning) and next the MRP ⁷(Material Requirement Planning) creation, optimized by the CRP ⁸(Capacity Requirement Planning).

As a result of the planning process, fabrication orders and action lists are obtained.

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5 MPS is the process to determine the brewery plans to produce finished products (where independent demand is defined), quantities and dates.
6 RCCP is the process of converting the master production schedule into requirements for key resources, often including labor, machinery, warehouse space, suppliers, capabilities, and in some cases, money. This comparison assists the master scheduler in establishing a feasible master production schedule.
7 MRP is the process to calculate the brewery requirements for all materials (semi-finished products, raw materials, packaging materials, returnable packaging materials, etc.) that are specified in the bill of Material.
8 CRP is the process to establish, measure and adjust limits or levels of capacity of work centre.
1.3 Definition and description of the assignment

1.3.1 Overview

Any organization that produces products and/or delivers services should be viewed as a system requiring continuous process improvement and innovation. When appropriate events and conditions initiate the process, customer requirements and organizational resources such as raw materials, money, information are transformed into goods, services, and business outcomes for the customers' benefit. The result of that can be a physical component, such as a tangible product and also an informational or knowledge-based one, such as a report, book, or expertise provided. In the case of Heineken, the results are clear: beer and packaging material like kegs bottles, cans etc.

At the same time that businesses are serving customers and their evolving needs, they should be measuring their performance using appropriate key performance indicators (KPI’s) evaluated against the requirements of customers. Therefore, organizations should view their resources as a set of assets that can change and adapt to the needs of their customers and use their resources to manage their customers’ expectations.

1.3.2 Purpose of the assignment

Heineken owns over 119 breweries in more than 65 countries, which makes the necessities and technological requirements of each brewery remarkably different. For instance, a brewery in Rwanda or in Cambodia does not produce the same amount of Hl as a brewery in Singapore or in Netherlands does. That is why the purpose of this assignment is to develop a continuous process improvement (CPI) to determine the required level of process automation & IT for a Heineken brewery regardless neither its location nor the production capacity. Therefore, it turns out to be essential to assess the maturity level of the different processes that take place in a brewery, so a good understanding of the site’s current state can be achieved.

To perform this task, the CPI is set by the phases that can be seen in the Figure 7.

Figure 7: Continuous process improvement (CPI).

The description of the phases that form the CPI is detailed next.
1.3.3 Phase 1: Define Business Drivers

The purpose of this phase is to identify the business drivers. It is necessary to identify well the Key Performance Indicators (KPI’s), because these will monitor the performance of the process improvement. In this case, if the organization moves to a higher maturity level, this should be visible by an improvement of the corresponding KPI’s.

1.3.4 Phase 2: Current State Understanding

The purpose of this phase is to identify and collect the Heineken’s brewery business processes and design a methodology to assess the maturity level of each process. So a comprehensive understanding of the existing processes can be achieved before proceeding with the Future State Design. It is the core task of this assignment and it will provide a deep understanding of operational issues as well as an identification of immature processes.

1.3.4.1 Obtain an updated overview of processes that take place in a brewery.

To evaluate the maturity of the business processes that take part in any organization, and in this case, processes of a brewery, it is essential to have a deep understanding and description of the processes that occur within a brewery. This means that first; it is interesting to collect an updated overview of those processes.

1.3.4.2 Develop a checklist/questionnaire to assess the maturity level of each business process.

The business processes that are going to be audited belong to different areas and departments within the site. Therefore, it results essential to have a common tool that can be applied to assess the maturity of these processes.

It is the aim of this part of the assignment to develop a tailored document, in the form of checklist/questionnaire, which provides the sufficient information and understanding of the brewery in terms of maturity. Thus, this document can be used as an additional audition tool to establish the maturity level of specific key processes within a brewery.

1.3.5 Areas to be covered by the assessment

The Functional Hierarchy Model , Figure 8, originated from ISA-95, describes the different level of activities that can be found in an organization. Level 0, 1 and 2 are the levels of process control. Level 3 is usually called the MES level. It consists of the activities that must be executed to perform the production process that is executed in the levels below. This level 3 corresponds to Manufacturing Operations & Control activities and is formed by Production Operations Management, Maintenance Operations Management, Quality Test Operations Management and Inventory Operations Management. Finally, the highest level (level 4) is the ERP level. Here financial and logistic activities are executed.
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Level 3 activities that belong to Production Operations Management have the highest priority in this assignment. Then Maintenance and Quality Operations Management.

On the other hand, the equipment hierarchy model originated from the ISA-88 describes the physical brewery setup. As it can be seen in Figure 9, a brewery site is physically split into the following areas:

- Utilities: Continuous production
- Beer Production: Batch production
- Packaging: Discrete production
- Distribution & Logistics (Low priority)

In the maturity assessment, only business processes that belong to Utilities, Beer Production and Packaging are going to be covered. Distribution & Logistics form another area of the brewery; however, this area is out of scope in this assignment.
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So, within Beer Production, Packaging and utilities, activities that belong to Production Maintenance and Quality Operations Management are going to be analyzed.

ISA-95 part 3 standard models each of these fields, which consist of 8 different activities or processes, Figure 10.

![Generic activity model of manufacturing operations management, ISA95.](image1)

As it can be seen in Figure 10, this is the generic activity model. And depending on the type of activities: Production, Maintenance or Quality, the model will change. In the next example (Figure 11) the activities that are being analyzed belong to Production Operations Management.

![Activity model of Production Operations Management.](image2)

The Figure 12 gives a general view of the context. This assignment belongs to the D2W (Demand to warehouse) business process. This process is located between its supplier, which is S2P (Source to pay) and its customer, which is M2C (Market to cash).
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Figure 12: General picture
1.3.6 Methodology

The maturity level assessment is going to be fulfilled by the help of the framework called The Process and Enterprise Maturity Model (PEMM), which is described in the article called The Process Audit (by Michael Hammer) published by Harvard Business Review in 2007.

In this paper, some features that apply to individual processes are identified and described. These features are called process enablers and determine how well a process is able to function over time. These process enablers are Design, Performers, Owner, Infrastructure and Metrics.

There are also described in this article another four characteristics called enterprise capabilities that are necessary for a company to determine whether it is ready to proceed with the process-based transformation or not. These four enterprise capabilities are Leadership, Culture, Expertise and Governance.

Different engineers from several areas (Beer Production, Packaging, IT, Quality etc.) will support the development of the questionnaire, as it is necessary to adapt each statement of the PEMM framework to fit the appropriate area and activity.

1.3.7 Expected contributions of the assignment

- The maturity checklist/questionnaire would provide the possibility to determine the required level of process automation & IT for a particular brewery.
- It is possible to improve the performance of the business processes by redesigning them. This redesign must be done in such a way that the elimination of the waste (the non-value adding activities that creates higher cost, errors, deviations, delays, uncertainties, etc.) is achieved.

The benefits that can be obtained by applying a MES\textsuperscript{9} system are the following:

- Reduction of errors (and thus a reduction of waste and rework)
- Easier location of the causes of problems
- Reduction of manual entry time
- Reduced cycle-time and efficient use of equipment (and thus increased yield)
- Improved planning and schedules
- Reduced order-to-ship times, etc.

\textsuperscript{9} MES centres wholly on the manufacturing aspect of a business, and as a result its functionality does not extend to cover areas such as finance or customer relationship management. An MES system will, for example, tell when an item is ready to be shipped but would not automatically handle any invoicing or update a customer’s record. In order to link plant floor events in real-time with business events, Enterprise Resource Planning (ERP) might be a better option.
1.3.8 Planning

The first step is to prepare a tailored questionnaire for each of those processes described in Figure 10. The first area to be analyzed is Beer Production, and here Detailed Production Scheduling.

This first process (Detailed Production Scheduling) is analyzed as a prototype. Afterwards, depending on the complexity, following processes (Resource Management, Production Dispatching, etc.) have been developed in parallel.

The objective is not to analyze every process lightly and finish everything in six months, but to go gradually doing things right. Since this tool is planned to be implemented among the Heineken breweries.
Chapter 2: Business Drivers definition

2.1 Heineken’s Balanced Score Card: Heineken performance star

This chapter gives a concise explanation/overview that shows how the corporation is conducted. Therefore this phase deals with the identification of the business drivers. It is necessary to identify well the Key Performance Indicators (KPI’s), because these will monitor the performance of the process improvement. In this case, if the organization moves to a higher maturity level, this should be visible by an improvement of the corresponding KPI’s.

The balanced scorecard is a strategic planning and a management system. This system is extensively used in business and industry environment and it provides a method to align the business activities to the vision and strategy of the organization, improving internal and external communications, and monitoring organization performance against the strategic goals (Kaplan & Norton, 1996).

The balanced scorecard suggests viewing the organization from four perspectives. And to develop metrics, collect data and analyze it relative to each of these perspectives: The Learning & Growth Perspective, The Business Process Perspective, The Customer Perspective and The Financial Perspective. (Figure 13).

The Financial Perspective tries to identify a few relevant high-level financial measures. This perspective helps to answer to the question: How do we look to shareholders?

The Customer Perspective tries to answer the question: How do customers see us?

The Internal Business Perspective tries to answer the question: What must we excel at?

Figure 13: The Balanced Scorecard perspectives (Kaplan & Norton, 1996).
And finally, the *Innovation and Learning Perspective* tries to answer the question: Can we continue to improve and create value?

The literature regarding the *Balanced Scorecard*, points out that Kaplan & Norton were thinking about a medium sized commercial organization in the USA when choosing these topic areas. And it is due to this reason why probably, they are not very helpful to other kinds of organizations. Some, for instance Heineken, has focused on alternative headings and questions.

Heineken uses a similar approach to strategically control and guide the company, and its *Balanced Scorecard* is called “Heineken Supply Chain Star”. In this case, as it is a star it has five points, which are the five perspectives: The Quality Perspective, The Cost Leadership Perspective, The Customer satisfaction Perspective, The Social Responsibility Perspective and The Organization & People Development Perspective. The Figure 14 shows the Heineken Supply Chain Star.

![Figure 14: Heineken Supply Chain Star.](image)

Figure 14 shows Heineken Supply Chain Star’s perspectives. Each point is composed by several KPIs, 30 in total.

Cost leadership deals with productivity and financial measures. Customer Satisfaction deals with indicators that embrace the customer. Social Responsibility measures the company’s impact over the nature and environment: water, electricity, thermal energy, etc. Organization & People Development deals with everything regarding people that form the company. Finally, Quality deals with the aspects regarding the quality of the brewed beer.
These KPIs are deployed in the following way:

- **Cost Leadership**
  - 1 OPI NONA Bottle
  - 2 OPI NONA Can
  - 3 OPI NONA Keg
  - 4 Production Productivity
  - 5 Productivity Warehousing
  - 6 Total cost outbound Transportation
  - 7 Total FTE in HQ SC and L&D HQ, incl. planning
  - 8 Extract losses
  - 9 One Way Packaging Material Losses
  - 10 Supply chain stock level (days)
  - 11 Fixed Production Cost
  - 12 Cost from Palletiser to 1st Customer

- **Customer Satisfaction**
  - 1 Packaging Conformance to Schedule
  - 2 Short Term Demand Forecast Accuracy
  - 3 Perfect Customer Order

- **Social Responsibility**
  - 1 Water Consumption
  - 2 Electricity Consumption
  - 3 Thermal Energy Consumption
  - 4 Non-recycled Industrial Waste

- **Organization & People Development**
  - 1 Absence Rate
  - 2 Accident Frequency
  - 3 Corporate TPM Audit

- **Quality**
  - 1 Taste Score Fresh
  - 2 Taste test 3 month
  - 3 FTR Batch Packaging
  - 4 FTR Batch Finished Product
  - 5 Just. Complaints Bottle/Can
  - 6 Just. Complaints Keg
  - 7 Freshness (in the market)
  - 8 Total Packaging quality in the market

*Heineken Supply Chain Star* is the result of reporting, merging and compiling the information provided by the breweries around the globe. Each brewery has its own *Balanced Scorecard*, called *Manufacturing Star*. This *Star* is similar to the later. The Figure 15 shows the Heineken SC Star reporting structure.
Monthly, every brewery reports the associated M Star to the corresponding OpCo\textsuperscript{10}. In the same way, monthly every OpCo reports to the associated Region and finally, quarterly the Regions report to the World Corporate. (Figure 16).

This is interesting to know, because if a brewery moves to a higher maturity level, this should be visible by an improvement of the corresponding KPI’s. Either and improvement regarding cost, customer satisfaction, social responsibility, people development or quality. Or even and improvement in more than one perspectives.

\textsuperscript{10}OpCo: Operating Company.
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This chapter identifies and collects brewery business processes and presents a methodology to audit the maturity level of each process.

Firstly, an updated overview of the Production Operations Management’s processes is carried out. The Figure 11 shows the activity model and the interconnections among the processes.

Then, it is explained the direct and indirect impact of the Production operation management’s activities on the performance of the different perspectives of the Heineken Supply Chain Star (see Figure 14).

Afterwards, there is a brief but explanatory description of the breweries that have contributed to the development of this project by answering the questionnaires for scheduling and resource management processes. Stressing the tridimensional perspective of each brewery: volume, labor and no. of variants.

And finally, it is shown the development of the corresponding tailored questionnaire. In connection to this, the Appendix B shows the description and explanation for the Maturity Level Assessment Questionnaire (MLA Questionnaire).

3.1 **Detailed Production Scheduling**

3.1.1 Updated overview of the process

The first analyzed process is Detailed Production Scheduling.

According to the ISA95 Detailed Production Scheduling shall be defined as: “the collection of activities that take the production schedule and determine the optimal use of local resources to meet the production schedule requirements. This may include ordering the requests for minimal equipment setup or cleaning, merging requests for optimal use of equipment, and splitting requests when required because of batch sizes or limited production rates. Detailed production scheduling takes into account local situations and resource availability.”

The Figure 17 depicts the Detailed Production Scheduling activity model interfaces.
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Figure 17: Detailed Production Scheduling activity model interfaces (ISA95).

The *Sales & Operation Planning* department sets the number of brews to brew and packaging lots to produce for a week. Then the scheduling department receives that information and converts the global planning into a detailed schedule, always taking into account the resource availability. The production schedules can be split or merged in order to reduce the setup time, changeover and optimize the production. This detailed schedule contains process orders for the brew house and for the packaging.

Here different production policies are applied. On the one hand, the brew house, packaging, bright beer and filtration are triggered by a push procedure. On the contrary, as the tank room is highly variable a pull technique is applied. So when a batch is started a new process order is created, and when a batch ends, the process order will end.

It is interesting to point out that although the automation level is high, before the production can take place, every *Process Order* has to be approved manually.

The scheduling department at Heineken Zoeterwoude, according to the SCOR model considers two different policies for the three different big customers. Firstly, “make-to-stock” (push) for the Dutch and American markets. And secondly, “make-to-order” (pull policy). The “make-to-stock” is primarily executed to control the US inventory (*Supply chain integration*) as well as the internal market. These products are pushed because beer market tends to be seasonal with several predictable peaks within the year. On the other hand, “make-to-order” policy is executed for customized products and for low volumes. However, the forward (push) and backward (pull) scheduling strategies may sometimes vary. This is because the production plant is “alive” and there are always specific constraints for the plant, time buffer allocation on bottleneck resource and priority assignments for each work order.

At Heineken Zoeterwoude the scheduling process is carried out one week in advance to the real production and the business plan from *Sales & Operation* is revised quarterly.
3.1.2 The impact of the scheduling process on Heineken’s Supply Chain Star

Detailed production scheduling may influence the Cost Leadership point of the Supply Chain Star because there are KPI’s within Cost Leadership that are related to the scheduling process. For instance, the KPI called Supply chain stock levels, is influenced by the scheduling in the sense that doing a good scheduling the stock levels, the buffers can grow. Or in the opposite way, if a wrong scheduling is done, the stock levels can go down and we can run out of products.

Scheduling process also has influence on the Social Responsibility. This is because a more suitable scheduling can improve the water, electricity and in general utility levels. It also affects the Quality point of the Supply Chain Star. For example, an efficient scheduling can improve the First Time Right KPI for the products, improving its quality.

However, it is not so clear the influence of the production scheduling over the Organization & People Development. It could increase or decrease the Absence rate of people. In the sense that for example, if there is an alteration of the scheduling in the end of the day and this happens repeatedly, probably this would affect this KPI.
3.1.3 Development of a questionnaire to assess the maturity level of the process

3.1.3.1 Heineken Zoeterwoude

Heineken Zoeterwoude is part of Heineken Nederland, together with Den Bosh. They produce and package the following beer brands:
Amstel, Heineken, Lingen's Blond, Murphy's Irish Red, Vos and Wieckse.
At Heineken Zoeterwoude they produce beer for the Dutch market as well as for the US market.

At Heineken Zouterwoude the scheduling department covers this functionality. Mr. André Ruigrok, Senior Shop Floor Planner and manager of this department supported this assessment. Martijn van Gorkum, consultant from the Corporate Distribution & Logistics from the Logistics group gave advice and provided good documentation.
The Questionnaire 1 shows the questions and the answers provided by Mr. André Ruigrok.

Production schedulers (Prod. Scheduling dept. at Heineken Zoeterwoude) receive process inputs (no. brews to brew and packaging lots to produce) and then they plan the schedule according to the optimal use of local resources. They can take into account past experiences to avoid failures and achieve successes.
The product definitions, available resources, reports on WIP and completed work reports (inputs/outputs in general) are identified. Furthermore, the needs of production dispatching are known while doing the scheduling. In addition, there are some mutual performance expectations among scheduling and dispatching, tracking, material, filtration, container etc. The documentation regarding the scheduling process identifies some interconnections among scheduling and resource management, dispatching, tracking etc. It is functional and it can be seen as end-to-end documentation that defines the needs of the process customers and suppliers like filtration, material, container etc. this documentation is somehow connected to the enterprise’s data system.
Instead of focusing on KPI’s (Key Performance Indicators) that might be high level indicators, people in charge of the production scheduling identify process performance indicators like changeovers, delayed tasks and so on.
Performers are skilled, trained and versatile enough so they can replace each other if someone is missing. Actually, recently in the scheduling department at Zoeterwude some people left and now they have to share among the rest of the team the remaining tasks. In addition, they do not need a ferrous guidance from the top people since they are skilled in self-management. However, they still need external help to take some business decisions regarding the production scheduling when they face something new.
People at the scheduling department are not only involved to their particular function; but they are also involved to the process of scheduling. They follow the process design so they help each other and facilitate the work to people who execute the process. In addition, they strive for doing a good schedule since they know that the process is aligned to the
enterprise’s goals. And whenever they see that something can be performed in a better way, they propose and execute improvements.

The scheduling department at Heineken Zoeterwoude is the owner of the production scheduling process, and there is a senior shop floor planner that coordinates this team. This manager, as well as the team in general, is involved in the process in terms of time allocation and commitment. However, there is no senior executive in charge of this process.

The scheduling team and the senior shop floor planner document the process and design and implement improvement projects taking into account that those changes should be aligned with the process design and goals.

The scheduling department has the capacity to force changes and improvement projects like redesigning projects. In addition, they have the control over the technology budget.

The scheduling department uses different software for different purposes: SAP for the ERP, AS (Advance Scheduling) for performing the scheduling, Excel for doing calculations, Pluto database, etc. Although some programs may not be the latest ones in the market, they are good enough to support the process. In addition, the IT is somehow integrated and adhered to enterprise standards. Generally speaking, this scheduling department is very mature as far as information systems and tools is concerned.

There are role definitions, job descriptions and job training based on the process documentation. The hiring, development, reward and recognition are balanced against the process and enterprise’s needs. However, in certain moments may happen that some problems are solved due to “heroes”. The positive part is that when a new problem (a deviation) occurs and these “heroes” solve it, straight afterwards the rest try to understand and learn how it is done. Therefore, no more “heroes” are required next time.

At Heineken Zoeterwoude the scheduling department does not pay much attention to the KPI’s. There is one KPI that measures the no. of changeovers. But apparently, this indicator does not provide clear information since sometimes it may be better to schedule many changeovers while other times less. However, the look at the process performance indicators (PPI’s) and have some feedback from there.

Apparently, there is a need of basic metrics to check the process’ status and performance. So therefore, this part is compulsory required for achieving an improvement based maturity level.
### Questionnaire 1: Questionnaire to assess the maturity of the Production Scheduling Process (Zoeterwoude)

**A methodology to assess the maturity level of brewery business processes**
3.1.3.2 Heineken Spain-Sevilla

The Questionnaire 2 shows the questions and the answers given by Mr. Julio Martínez-Mejías and Mr. Pedro García, Production Planner and Planning manager from the brewery in Sevilla (Heineken Spain).

Heineken Spain is constituted by four breweries sited in: Sevilla, Madrid, Valencia and Jaen. The annual beer production is around 11 million hectoliters and is packed in cans, bottles and kegs.

In the case of Sevilla, which is one of the newest and most technologically advanced breweries in Europe, there are 8 packaging lines and the production capacity is around 4.5 million hectoliters per year. Being the annual beer production estimation for 2010 of 4.2 million hectoliters.

At Heineken Spain, they produce more than 33 different brands, being Cruzcampo and Heineken the most famous brands. In total, there are 21 packaging lines and around 2800 people work at Heineken Spain.

Heineken Spain represents the 25% of the total beer production volume within Heineken Europe and the 9% of the global production volume within Heineken International.

![Graph showing Heineken Spain-Sevilla data]

According to the answers provided by Mr. Julio Martínez-Mejías and Mr. Pedro García, the design of the production scheduling process at Sevilla is very mature. This is because the customer and supplier processes S2P (Source to Pay) and M2C (Market to Cash) are integrated with the D2W (Demand to Warehouse) process. This, must be connected the metrics.
### Questionnaire for assessing the maturity of the Production Scheduling Process (Sevilla)

**Questionnaire 2:** Questionnaire to assess the maturity of the Production Scheduling Process (Sevilla).

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### Chapter 3: Current state understanding

A methodology to assess the maturity level of brewery business processes
3.1.3.3 Brau Union Österreich AG (Heineken Austria)

The Questionnaire 3 shows the questionnaire and the answers provided by Mr. Joerg Kremser (Demand & Production Engineering dept.) at Brau Union Österreich AG (Heineken Austria).

Firstly, it is important to point out that although the questionnaire sent to Mr. Kremser is regarding the Production scheduling, the answers provided by him are regarding the beer packaging lines scheduling. This is because at Brau Union, there is no beer production; they only bottle and package the beer. Therefore, they only do the packaging planning and the material requirement planning.

Brau Union is made up by 8 breweries. Five big ones (each between 800.000 - 1.000.000 Hl) and three small ones (between 20.000 - 140.000 Hl). In total, there are 16 different lines and about 450 products. For example, there is a one-way bottling line with 100 different products, 22 different packaging types, 21 different beer types and 16 different bottle types. There are about 2.100 employees in Brau Union.

![Figure 18: Volume, labor and no. variants for Brau Union Österreich AG.](image)

According to the answers provided by Mr. Kremser, the purpose of the Packaging lines scheduling process is very mature. There is internal integration with other beer processes like production, utilities, etc. Furthermore, they try to improve the packaging process by integrating with their customer and suppliers: S2P (Source to Pay) and M2C (Market to Cash). The context of the process is mature too. They know the requirements of other processes and they share mutual performance expectations in the sense of KPIs. However, they only do that within the D2W business process (Demand to Warehouse) and they can still improve this area by sharing and discussing performance indicators with business processes like S2P and M2C.

However, there is an area where they should put more stress. They should give more importance to the documentation and description of the process, because apparently they do not document the process deeply enough. The responsible for this activity is the owner of the scheduling process, who is highly involved in the continuous improvement of the
scheduling process. But however, he does not give so much importance to the
documentation. The reason why the description/documentation of the process is so
important is that it helps tremendously to the well performance of the process, since it
describes the expectations for product definitions, available resources, WIP, etc.
Regarding the people that perform the packaging scheduling, they understand and control
the process successfully and they are very familiar with the fundamental business concepts,
furthermore, they provide the manager with solutions to several problems so the process
can be performed in a better way.
On the other hand, the information systems that they use are mainly Excel sheets, Futur
Master and SAP. Futur Master and Excel for the scheduling of the lines and SAP for the
communication with upper levels (Level4).
Finally, they have KPIs/PPIs to check and control the packaging lines. The targets on these
metrics are derived from the enterprise’s strategic goals; however, they do not use them as
a motivation tool for the employees and still they have to refresh and regularly review them.
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Questionnaire 3: Questionnaire to assess the maturity of the Packaging Scheduling Process (Austria).
3.1.3.4 Heineken Greece (Athens)

The Questionnaire 4 shows the questionnaire and the answers provided by Mrs. Anna Kyriakopoulou (Production planning dept.) at Heineken Greece, Athens. At Athens, Heineken produces beer and mineral water.

- For beer products:
  There are 8 packaging lines, 44 people are working on these lines per shift, and the families of products produced are:
  50cl returnable bottles, 50cl returnable bottles 6-packs, 33cl returnable bottles, 33cl returnable bottles 6-packs, 33cl bottles o/w, 50cl cans 4-packs, 50cl cans loose, 33cl cans 6-packs, 33cl cans 8-packs, 33cl cans 12-packs, 33cl cans loose, 50l kegs, 30l kegs, 20l kegs and all those products for Amstel, Heineken, Alfa, Fischer (4 different brands) and for Bock, Buckler and Exports only in some packages, 7 of the above the highest.
  Total amount of SKU’s locally produced about 146.

- For Mineral water:
  2 packaging lines, 8 people working per shift and about 20 SKU’s locally produced.

According to the answers given to this questionnaire (Questionnaire 4), the purpose of the production scheduling process is very mature; there is internal integration, which means that they fit to other processes like packaging, utilities, etc. In addition, they are trying to improve the process by integrating with their customer and suppliers: S2P (Source to Pay) and M2C (Market to Cash). However, they still can improve the context of the scheduling; they know the needs of their customers but they can improve the process by setting some internal mutual performance expectations, in the way of sharing KPIs, among scheduling and resource management and production tracking for example. This can be possible because the documentation/description of the process is very mature and can help, for instance by sharing and aligning the targets of each process.

Regarding the people that perform the production scheduling, the questionnaire shows that people at Heineken Greece are very familiar with fundamental brewing concepts and they understand and know perfectly how things work at their brewery. They are skilled in process standardization practices and they are willing to do a good scheduling to improve the way they brew beer.

The manager that is in charge of the scheduling is also highly involved in the process and tries to motivate and coach workers. This manager meets other managers quite often with the aim of sharing KPIs so they can improve the related processes.

As far as the information - systems are concerned, at Heineken Greece, for the production scheduling process they use structured Excel sheets to help the Future Master software. In addition, they have a complete planning and scheduling of the brewing processes. The schedule the brew house, they plan the filtration and they plan the cellar as well. As said, they use Future Master for doing that.
The maturity level regarding HHRR of this process is also high. The job profiles are aligned with the company and they are always trying to improve them, by enterprise collaboration, by personal leaning programs, etc. Finally, the metrics that they use to check whether the scheduling process is going well are quite mature too. At Greece, they have and they use the KPIs/PPIs to set feasible production targets. However, Mrs. Kyriakopoulou mentioned that they still have to improve this area by revising and improving the KPIs more often.
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**Questionnaire 4: Questionnaire to assess the maturity of the Production Scheduling Process (Athens).**
3.1.4 Required automation per maturity level

The Figure 19 shows the beer production processes and the automation required for the scheduling process.

![Figure 19: Required automation for Detailed Scheduling Process.](image)

According to the different processes and to the way these processes are planned, it can be said that there is a relationship between the maturity level and the type of planning. The basic planning that it is carried out is the brew house scheduling. If this scheduling is done at least the scheduling process should be at level P1. At this level, usually the brew house scheduling is done by paper. And the main business benefit that is achieved by scheduling this part is the labor reduction. This is mainly because an increase in the automation level allows doing the same work with less people.

It is considered that if there is a filtration planning then the scheduling level should be at P2. And usually the scheduling tool is the MS Excel. By planning the filtration part, the Just in Time (JIT) response is the main area that is improved.

Furthermore, if there is a cellar planning, then the scheduling process should be very mature, probably P3-P4. And here advanced and dedicated scheduling tools are utilized. Therefore, by doing a comprehensive cellar planning quality is the main factor that is usually improved.
3.2 Production Resource Management

3.2.1 Updated overview of the process

According to the ISA95 Production Resource Management shall be defined as: “the collection of activities that manage the information about resources required by production operations. The resources include machines, tools, labor (with specific skill sets), materials, and energy”.

In the case of Heineken, resource management identifies only activities related to equipment and materials/products.

The direct control of these resources is performed in production dispatching and execution and it is not fully governed by computers, since it may be partly handled by manual processes.

The Figure 20 depicts the Detailed Production Scheduling activity model interfaces.

![Image of production resource management activity model interfaces](image)

Figure 20: Production resource management activity model interfaces (ISA95).

More information regarding this activity model can be look up in the ISA95.00.03 document and in the ISA95 Functionality for production by Heineken Supply Chain.

In the case of Heineken, most resource activities are activities for providing information to production personnel, routing activities and for planning and scheduling.

Examples of these activities (ISA95.00.03):

- Providing material, and equipment resource definitions. The information may be provided on demand or on a defined schedule, and may be provided to people, to applications, or to other activities.
- Providing information on resource (material or equipment) capability (committed, available, or unattainable). The information is based on the current status, future reservations, and future needs (as identified in the production plan and detailed production schedule) and is specific for resources, for defined time spans and process segments. It may include information on current balance and losses to product cost accounting and may be provided on demand or on a defined schedule, and may be provided to people, to applications, or to other activities.
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- Ensuring that requests for acquisition of resources to meet future operational capabilities are initiated. Example: Checking that an equipment sterilization status is correct (“Clean”) before it is assigned to a production operation.
- Providing information on the location of resources and assignment of resources to areas of production.
- Coordinating the management of resources with maintenance resource management and quality resource management. Example: Providing a location for a mobile inspection machine that can be used in multiple locations.
- Collecting information on the current state of equipment, and material resources and on the capacity and capability of the resources. Information may be collected based on events, on demand and/or on a defined schedule, and may be collected from equipment, people and/or applications.
- Collecting future needs such as from the production plan, current production, or maintenance schedules.
- Managing reservations for future use of resources.

Task examples:

**Resource availability:**
This task provides time definitions for doing the scheduling. It takes into account working hours, labor regulations, holiday calendar, brakes, plant shutdowns, shift schedules etc.

**Collecting future committed resource information**
This task aims at committing the resource availability based on the production scheduling and product requirements.

**Equipment resource information management**
This task aims at managing the information regarding the equipment resources and future equipment availability. Equipment states are used to indicate the occupation of units. They support the production personnel, planning and the batch control system in making operational decisions. The following states are used: Standby, Production/cleaning, used and maintenance.

**Material/products resource information management**
This task aims at managing the information regarding the required material and energy resources and future material and energy availability. It includes as well, managing information regarding material conditions and changes in energy sources.

MRP is done at level 4. However, Management of materials resources will be done at level 3 for materials, which are handled as batches (Materials which are processed). Therefore, this is done for all semi-finished products and also for some raw materials like Malt, which will be handled as batch. The batch information is registered, the transfers are registered and the information about consumption of material lots will be registered as well. And finally, with these registered values, the stock will be updated (level 4 stock).
3.2.2 The impact of the resource management process on Heineken’s Supply Chain Star

Production resource management influences the Cost Leadership point of the Supply Chain Star. Because for example, the simple selection of one production line or another varies the fixed production cost for the processes and products. It also affects the amount of FTE in production. Resource management influences the Customer Satisfaction point as well. This is because it affects on the Short Term Demand Forecast Accuracy KPI. It happens the same with Social Responsibility and Quality. Depending on which materials and products are used, the utilities (water, electricity, etc.) consumption, the Non-recycled Industrial Waste and Taste Score Fresh can vary.
3.2.3 Development of a questionnaire to assess the maturity level of the process

3.2.3.1 Brau Union Österreich AG (Heineken Austria)

The Questionnaire 5 shows the questionnaire and the answers given by Mr.Kremser (Demand & Production Engineering dept.) at Brau Union Österreich AG (Heineken Austria). As mentioned before, at Brau Union there is no beer production; there is only beer bottling and packaging. However, although the questionnaire sent to Mr. Kremser is regarding the Production scheduling, the answers provided by him are regarding packaging resource management.

According to the answers to this questionnaire, the purpose and the context of the process are very mature at BUO. However, it seems to be a lack of documentation that should describe the process.

In the case of the people that perform the resource management, the questionnaire shows that they understand and know what they have to improve from the system to perform the process in a better way. They do also propose changes and improvement initiatives to support the process. However, they are not so skilled at standardization practices and therefore, when new functionalities are applied they need external support.

The manager of this process is focused on continuously improving the process, the packaging resource management process. However, the questionnaire shows that he/she should put more stress on documenting the process as well as meeting other managers to align and integrate the processes that have interests in common.

Regarding the information systems, at BUO Futur Master, Excel sheets and SAP are utilized to support the process. Futur Master basically for the demand and the supply planning, Excel sheets for the communication among breweries and planning department and mainly SAP for the resource management, with some support of the Futur Master software.

Finally, as far as the metrics of the process are concerned, it is interesting to point out that although there are Key Performance Indicators (KPIs) and Process Performance Indicators (PPIs) related to the process, they do not used them so much. They could use them to control the process and to set process regarding targets. The process’s documentation, as well as the metrics (KPIs/PPIs), is a field that could help to increase the maturity of the packaging resource management.
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Questionnaire 5: Questionnaire to assess the maturity of the Packaging Resource Management Process (Austria).

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3.2.3.2 Heineken Greece (Athens)

The Questionnaire 6 shows the questionnaire and the answers provided by Mrs. Anna Kyriakopoulou (Production planning dept.) at Heineken Greece, Athens. According to the answers given to this questionnaire, the purpose of the Production resource management is very mature, there is internal integration, which means that they fit to other processes like packaging, utilities, etc. In addition, they are trying to improve the process by integrating with their customer and suppliers: S2P (Source to Pay) and M2C (Market to Cash).

The context of the process is also mature since they know the needs and the requirements of their customers. However, they need to improve the internal mutual performance expectations by sharing or by having some KPIs in common with other processes.

The documentation is something that they do very well. At Heineken Greece the process is documented, the deliverables are implemented, the expectations for their customers are set and they are focused on improving these needs.

As far as the people who perform the resource management are concerned, it is a very mature process. The people know and understand the work environment and they know what they should do to improve it. Not only that, they are skilled in standardization processes and TPM and when something new regarding the resource management has to be applied, the do not need external help.

On the other hand, the manager that is in charge of the resource management process is committed to improving the performance of the process. This manager is highly involved in this process and is focused on continuously improving it. The initiatives to improve the process are for example having meetings with other process managers to align and integrate the processes.

At Heineken Greece, as happens at BUO, they also use SAP for the resource management and Futur Master for the demand and the supply planning.

On the other hand, the infrastructure regarding human resources is focused on aligning the job profiles with the company. Which means that they know what kind of person they need for each job position regarding the resource management.

Finally, it is interesting to point out that the maturity level regarding the KPIs at Heineken Greece is high. They not only set targets on the KPIs or PPIs, but they also try to improve and revise these performance indicators so the process runs smoothly.
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### Questionnaire 6: Questionnaire to assess the maturity of the Production Resource Management Process (Athens)

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<tbody>
<tr>
<td>P1 (Ad-Hoc)</td>
<td>Process ownership is not clear and the responsibilities are defined. Management is reactive.</td>
<td>- Can you define the roles and responsibilities within the process? - How do you ensure that the process is implemented consistently?</td>
</tr>
<tr>
<td>P2 (Managed, repeatable)</td>
<td>Process ownership is defined and the responsibilities are clearly assigned. Management is proactive.</td>
<td>- How frequently are process reviews conducted and what are the outcomes? - How do you measure the performance of the current process?</td>
</tr>
<tr>
<td>P3 (Process standardization)</td>
<td>Processes are well-defined and documented. Management is proactive.</td>
<td>- Are there any documented procedures or guidelines for each step of the process? - How do you ensure that the process is followed as intended?</td>
</tr>
<tr>
<td>P4 (Optimized, improvement)</td>
<td>Process is well-defined, documented, and continuously improved. Management is proactive.</td>
<td>- How do you continuously monitor and improve the process? - How do you measure the impact of process improvements?</td>
</tr>
</tbody>
</table>

### People that perform the process

#### People’s knowledge (Do you know?)
- How well do you understand the current production resource management process?  
- How often do you participate in process improvements?  
- How well do you understand the roles and responsibilities within the process?  

#### People’s skills (Are we skilled?)
- Can you identify any gaps or areas for improvement in the current production resource management process?  
- Are there any training programs available to improve your skills in this area?  
- How do you ensure that your skills are up-to-date?  

#### People’s behavior (Is it performed?)
- How often do you follow the production resource management process as intended?  
- How do you ensure that the process is followed when faced with unexpected situations?  
- How do you handle exceptions or deviations from the process?  

### The systems and infrastructure

#### Information Systems (How do we know?)
- What tools and systems support the production resource management process?  
- How do you ensure data accuracy and integrity?  
- How do you handle data confidentiality and security?  

#### Human Resources (Who do we use?)
- Who are the key personnel involved in the production resource management process?  
- How do you ensure that the right people are assigned to each role?  
- How do you address skill shortages or training needs?  

#### The measures (KPI/KPIs)
- What are the key performance indicators (KPIs) for the production resource management process?  
- How do you interpret the results of these measures?  
- How do you ensure that the KPIs are aligned with the organization’s goals?  

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A methodology to assess the maturity level of brewery business processes
3.3 Product Definition Management

3.3.1 Updated overview of the process

According to the ISA95 Product Definition Management shall be defined as: “the collection of activities that manage all of the Level 3 information about the product required for manufacturing, including the product production rules.”

It is a process that shares the information among the level 4 and level 3. The shared information is regarding materials and products that are required for producing and packaging beer. This process specifies what must be defined to make a product. Heineken distinguishes materials and products. Products being the result of a process stage (only a product or a semi-finished product) and being produced by a recipe or by a bill of materials. While materials being defined as an entity, which can be stored on a storage location. Materials are brewing materials, packaging materials, cleaning materials, etc.

The Figure 21 depicts the Product Definition Management activity model interfaces.

As Figure 21 shows, Product definition management process manages the information required to produce any product at Heineken. Information regarding equipment and process is provided to production level 1&2 functions and information regarding production routing and product production rules is provided to processes within MES layer (level 3): production scheduling, production dispatching and production execution management.

At Heineken, the product production rules are called general, site, master and control recipe. These recipes are methodologies that describe products and how these products are produced. Figure 22 shows the recipe hierarchy at Heineken.
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The General recipe is the basis for the rest of the recipes. It describes the general process instructions, the brewing process standards and packaging process standards to produce beer but without specific knowledge of the process cell equipment that will be used to brew beer.

Below the General recipe, there is the Site recipe, which takes into account the information regarding the specific brewery. It provides the required level of detail necessary for the site and long term production scheduling. This recipe describes the BOM (the list of materials needed to process the product), the routing (the resources, the installation, the equipment and the capacity needed to process the product) and the end of the process stage product specification (used to determine the quality status of the lot of product).

The General recipe along with the Site recipe is managed in level 4. On the other hand, there are two recipes that are managed in level 3. These recipes are Master recipe and Control recipe.

Master recipes specify the required information within the boundaries of process cells, being derived from either Site recipes or General recipes.

The Master recipe is focused on the semi-finished product and contains the following information:

- Recipe name and identification.
- List of unit procedures, with names and identifications.
- List of operations per unit procedure, with names and identifications.
- List of parameters for each operation (Recipe parameters and Process parameters).

Parameters, which are managed in the Master recipe, are the product dependent parameters (Recipe parameters) and the process parameters. Process parameters are the most dynamic installation related parameters.

- List of used materials. The part of the Bill of material used for this recipe.

Every time there is a change in the Master recipe, a new version is created. And information regarding the changes like the originator, the issue date, approvals, and
status is recorded and included in the new recipe. If there is any change in the sequence, it will lead to a new version of the recipe.

The following information must be available before creating/changing master recipes:

- Process stages
- Products
- Unit procedures
- Operations and
- Parameters

The Figure 23 shows the structure of the Master recipe.

![Master recipe structure](image)

The Control recipe is lowest recipe and it contains batch specific information. Initially it starts as a copy of a specific version of a Master recipe and it is then modified with the scheduling and with operational information to a single batch. A user can modify the control recipe, usually only parameter values and only within the given limit settings. And any change should be recorded including this information:

- Recipe identification
- Batch number
- Procedure identification
- Operation identification
- Parameter identification
- Old value
- New value

As mentioned before, information regarding production routing is provided to processes within MES layer (level 3). Processes like production scheduling, production dispatching and production execution management. Production routing is the path that products take from one process stage to the next. And because as within each process stage semi-finished products are described (e.g. Green beer production), the links between them also have to be described. These links are called transitions or mutations and are managed at level 3. A change in a mutation leads to a new version.
In the case of packaging, the BOM is the main part of the recipe and it must contain the following information:

- Process stage (filling, labeling, etc).
- Bill of materials (with base quantities).
- Print bom: Codings that needs to be printed on the packaging materials (product dependent).
- Pallet load information.

The Figure 24 shows an example for the packaging recipe information.

![Figure 24: Packaging recipe information.](image)

Here different levels take part. Level 4 manages the bill of material, print bom and pallet load information. And on the other hand, the cross reference between the process stage and BOM, print bom and pallet load is managed at level 3.

### 3.3.2 The impact of the product definition management process on Heineken’s Supply Chain Star

This process has big influence over the supply chain star. It affects most of the points. The recipe management influences the productivity, therefore the Cost Leadership, it influences the Social Responsibility, due to it affects the consumption of the utilities, and it affects as well the Quality. And this is because the Taste Score Fresh, the Freshness, the quality of the product and processes, etc. are directly related to the recipe that is used to produce the product.
### 3.3.3 Development of a questionnaire to assess the maturity level of the process

**Questionnaire 7: Questionnaire to assess the maturity of the Product Definition Management Process.**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Design of the process</strong></td>
<td><strong>Establishment of the process</strong></td>
<td><strong>Control of the process</strong></td>
<td><strong>Data &amp; Information Management</strong></td>
<td><strong>Process Optimization</strong></td>
<td><strong>Integration &amp; Balancing</strong></td>
<td><strong>Review</strong></td>
<td><strong>Feedback</strong></td>
</tr>
<tr>
<td>Questionnaire 7: Questionnaire to assess the maturity of the Product Definition Management Process.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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3.3.4 Required automation per maturity level

The Table 1 shows the automation required for the Product Definition Management process. The process is divided in three parts. On the one hand, there is the communication with the upper level, which sends the specific information regarding the brewery like the site recipe and the BOM. On the other hand, there is the recipe management and the production routing. The production routing is divided in the cellar routing and the brew house planning. It is important to point out that the production routing is part of the Control layer and not part of the MES layer, which is the scope of this analysis. However, as the Table 1 shows, the production routing affects to the maturity level of the process as well.

<table>
<thead>
<tr>
<th></th>
<th>P-1 (AD-HOC)</th>
<th>P-2 (Managed, repeatable)</th>
<th>P-3 (Process standardization)</th>
<th>P-4 (Optimized, improvement)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site recipe / BOM data transfer</td>
<td>PAPER (not so important, therefore done by paper)</td>
<td>Manual</td>
<td>Recipe control</td>
<td>Recipe management</td>
</tr>
<tr>
<td>Recipe management</td>
<td></td>
<td>Manual start of transfers</td>
<td>Manual start of transfers</td>
<td>Automatic transfers</td>
</tr>
<tr>
<td>Production routing (cellar)</td>
<td></td>
<td>Manual start of transfers</td>
<td>Manual start of transfers</td>
<td>Automatic transfers</td>
</tr>
<tr>
<td>Production routing (brew house)</td>
<td></td>
<td>Manual start of brew house</td>
<td>Manual start of brew house</td>
<td>Brew house planning</td>
</tr>
</tbody>
</table>

It is not utilized any specific or professional software for the Site recipe and BOM data transfer. This is because it is not carried out so many times and because the information is not so much. Therefore, it is not worth to buy and implement an automation system for this issue.

However, the recipe management can bear different types of automation levels. In an AD-HOC situation (P-1), the recipe is managed manually. And if there is a recipe control (a control of the product), the recipe management is more mature and it is at P-2. If all products are controlled, it means that there is a recipe management and the process is standardized, so the maturity level is higher, at P-3. Furthermore, if additional improvement functionalities like version control and recipe auditing are carried out, then the recipe management is very mature, at P-4.
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The production routing is divided in two, the cellar and the brew house. If there is a manual start of transfers for the cellar, it means that it is not so mature (P-1/P-2). However if the start and the transfer are automatically controlled, it means that it is more mature and it is at least at P-3. Finally, if there is a predictive transfer control, the maturity level should be very high, P-4. The Figure 25 shows the piping, the manual and the automatic transfer. In the manual transfer the routing is done by hosepipes or by manually set pipe routing. Whereas in the automatic transfer the operators do not have to touch the pipes and the transfer is computerized and managed.

Finally, the production routing regarding the brew house can be manually triggered as well. If this occurs, the maturity should be somewhere between P-1/P-2. However, if there is a brew house planning (e.g. 2h/Brew), the maturity is higher and it should be at P-3. Finally, if there is an auto brew house scheduling/planning, which means a fixed planning plus the automatic adjustment (e.g. 2h/Brew + adjusting), the maturity level should be very high, P-4. The Figure 26 shows the information flow for the process of product definition. As explained in Table 1, de BOM information transfer from SAP to MES is always done by paper. Then, the production routing is done and the equipment and process specific information is provided to the PLC/SCADA systems.

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**Figure 25**: a) Automatic transfers. b) Manual transfers.

**Figure 26**: Information flow for Product definition management.
3.4 Production execution

3.4.1 Updated overview of the process

ISA95 makes distinction between Production execution processes and Production data collection and analyzes them separately. However, since these activities are so related, sometimes they can be merged and analyzed together.

According to the ISA95 Production execution process shall be defined as: “the collection of activities that direct the performance of work, as specified by the contents of the production dispatch list elements. The production execution management activity includes selecting, starting and moving those units of work (for example lots, sublots, or batches) through the appropriate sequence of operations to physically produce the product. The actual work (manual or automatic) is part of the Level 2 functions.”

The Figure 27 depicts the interfaces of the Production execution management activity model.

![Figure 27: Production execution management activity model interfaces (ISA95).](image)

The coordination of the manual and automated processes is carried out by the execution management activities and it requires well-defined communication channels to communicate the automated control equipment.

Production execution management directs the performance of work and triggers the Level 2 activities. In the same time, it ensures that the resources (equipment and materials/products, not personnel) are valid for the assigned task and are used correctly.

Production execution management process also communicates with other operation management activities like quality. Quality is implicit within the processes (e.g. checking quality standards) and this way there must be a fluid relationship among quality activities and the rest of the processes.
At Heineken, during production, the administrative status of a batch is managed in such a way that it can be in three different administrative situations: *blank*, *confirmed* or *consolidated*.

The batch starts being *blank*. Then when production personnel have checked its information, it can be changed to *confirmed*. Afterwards, when changes are applied to the batch the status will switch to blank again. And finally, at the end of the administrative period, all batches will be checked and when there is no need to do changes for the batch, the status will become *consolidated*.

Every time a batch is created, production personnel receive the schedule information and the recipe to produce that batch. This corresponding recipe information is registered to the batch.

The following examples show mainly the operational commands and responses.

- Quality information like sample requests and analyses results coming from the laboratory, is collected and related to the batch and to the operation. The result of the quality analysis is either “OK” or “FAIL”. This result is the most important output from quality operations and can block a batch.
- The information about cleaning is collected.
- At the packaging area, material movements are registered: Ingoing packaging materials (labels, boxes, etc.), specific information about these packaging materials (supplier, lot identifier, etc.), outgoing finished product pallets, specific information about these pallets (lot number, timestamps, unique pallet identification, etc.), etc.
- Time accountability for equipment in packaging. When a machine is in a downtime status, the production personnel need to explain this downtime (data like start/endtime, duration, cause, solution, actions and remarks needs to be registered). Downtimes can also be planned (e.g. lunch, meeting, etc). These planned downtimes will also be registered. For planned downtimes only machine, start/ endtime and duration needs to be registered. All time accountability information is related to batches and shifts. All registered data is available for running batches. After a batch is ended, the data is still available for analyses.
- The equipment running hours is collected. This is for the maintenance operations management.
- At the packaging area, the lost counters and the batch counters are registered. The batch and the shift information is registered.

When exceptions occur, personnel need to have the possibility to react. At Heineken there are two types of exceptions managed by level 3 (MES layer):

- Exceptions related to the quality of the batch. These exceptions are produced when the quality of the batch is out of the specification. When this situation occurs, based on trending, the production personnel can do preventive actions on batch or equipment. Even destroy or release a pallet could be an action for a blocked pallet in packaging.
• Exceptions related to the equipment. Every time an equipment exception occurs, production personnel can ask maintenance people for assistance. When this occurs, the downtimes need to be registered for time accountability and analyses.

3.4.1 The impact of the production execution management process on Heineken’s Supply Chain Star

The execution management process has influence over the five points of the Supply Chain Star. This is due to it is a process that ensures that the resources are valid for the assigned task and are used properly. So it affects the productivity (Cost Leadership), it affects the Packaging Conformance to Schedule (Customer Satisfaction), utilities consumption (Social Responsibility), First Time Right (Quality) and also it affect the Organization & People Development, in the sense that ensures that workers are performing the defined task.
3.4.2 Development of a questionnaire to assess the maturity level of the process

### Questionnaire 8: Questionnaire to assess the maturity of the Production Execution Management Process.

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3.5 Production data collection

3.5.1 Updated overview of the process

According to ISA95, Production data collection process shall be defined as: “The collection of activities that gather, compile and manage production data for specific work processes or specific production requests”. Data collection activities are input for almost all other activities like production tracking, production performance analyses, production dispatching, etc. And collected data is necessary to direct the work during production execution. This process collects data regarding production information and production events. As well as information coming from the Level 1-2 functions. Fundamentally, quantities (weights, units, etc.) and its associated properties (rates, pressure, temperatures, etc.) are collected. But also equipment information such as controller, sensor, actuator statuses, operator actions, line statuses, etc.

![Figure 28: Production data collection activity model interfaces (ISA95).](image)

The following examples show generally the main tasks executed by this process. The information is mainly collected from the field and it is available for the personnel for the correct running of the production as well as for the rest of the processes like production performance analysis and production tracking.

- During the execution of the recipe, the operation information is recorded and related to the batch (e.g. Timestamps, durations, etc.).
- During the execution of the recipe, the batch values are measured. This is to analyze and check the set points and the real values.
- During the execution of the recipe, trend data is collected and related to the batch (e.g. yeast graph trend data, apparent extract during fermentation).
- Transfer information is collected, like quantity, time, source and destination batch/unit.
- The material movement information regarding the batch is collected like quantity, time, lot and subplot location and amounts, source and destination batch/unit or lot, etc. (E.g. additions of lactic acid, yeast dosing, rest beer, PVPP, water dosing, etc).
3.5.2 The impact of the production data collection process on Heineken’s Supply Chain Star

The production data collection process focuses mainly on collecting, compiling and managing production data. Therefore, it may affect on any point of the Heineken’s Supply Chain Star. This is because if a measure is taken wrongly, there is going to be an alteration in the corresponding point of the Star. For example, if utilities consumption is not measured properly, it is not going to show the real consumption and therefore it will have impact on the Social Responsibility point of the HStar. And it happens the same for the rest of KPIs. If the collected information does not represent accurately the reality, the KPIs will be somehow corrupted or defective.
3.5.3 Development of a questionnaire to assess the maturity level of the process

**Questionnaire:** Questionnaire to assess the maturity of the Production Data Collection Process.
3.6 Production Performance analysis

3.6.1 Updated overview of the process

According to ISA95, Production Performance analysis shall be defined as “the collection of activities that analyze and report performance information to business systems. This would include analysis of information of production unit cycle times, resource utilization, equipment utilization, equipment performance, procedure efficiencies, and production variability”. When a MES system is applied, it is usually this process the first that is redesigned.

This process receives data from other production processes, including the shopfloor and it uses this information to create productions analyses to develop KPI reports. The main KPIs are OPI (Overall performance Indicator) and FTR (First Time Right). OPI is based on time accountability and production counters, while FTR measures the amount of batches produced the first time right. The outcome of the process is used to improve and optimize production and the use of the resources.

The Figure 29 shows the interface of the Production Execution Management activity model.

![Figure 29: Production performance analysis activity model interfaces (ISA95).](image)

This process includes a number of activities that every brewery should carry out:

- **FTR**: obtaining and developing KPI reports, like First Time Right.
- **BCS**: Brewery comparing system. This is a benchmarking that it is generated among breweries to compare each other and to standardize the good practices of the leading sites.
- **Cockpit/dashboards**: Leading breweries use dashboards (performance monitor systems) to measure and understand operational goals and use scorecards to keep the business focused by monitoring the execution.
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- **Management Control and Reporting System.**
- Performing **performance tests** where necessary to determine capacity.
- **Resource traceability analysis.** This analysis traces the history of the resources (material and equipment) in terms of the process actions and events that dealt with the resources in production. At Heineken, it is called “material genealogy”. Tracing forward from malt silos to finished products pallets and tracing backwards from finished product pallets to malt silos is possible. For each batch in the genealogy tree, the used raw material, brewing material, and packaging material information, used equipment information and other batch information is available (like operation data, batch values, and quality data). This makes it possible to do a trace back action for a blocked finished product pallet to identify the problem.
  Analyze utility consumption rates (water, CO2, Electricity, Steam, etc.).
- **Product analysis.** This activity is an important operation activity because it is part of the quality assurance. It can be online and/or offline. If it is offline, there are different methods to control the quality, for example SQC data (Statistical Quality Control). However, in real time control, the applied method is the SPC (Statistical Process Control). Here three different situations can be described. The lowest level is when all the process information is check and showed. The next level checks and shows only the exceptions. Because it is not necessary to show and give information when everything goes well. Finally, the upper level focuses only on trends and patterns, so it does not check all the exceptions but the possible situations that could force an alarm going off. This last level tries to avoid future possible errors.
- **Process analysis.** The aim of this activity is to check the manufacturing processes, improve, and optimize them. Here production runs are analyzed to determine the possible root causes of the problems. SPC and SQC tools are applied in order to monitor and improve the quality of the processes.
- **Production performance simulation.** The simulation is many times used to model the plant and to see how the material flows through it. It is a very powerful tool because it gives the opportunity to evaluate how the process responds to changes. These changes may be changes in the process, changes in the production routing and even changes in the manufacturing procedures. Simulation gives the opportunity to play with the system and perform tests that in real world it would require longer time and higher costs. Therefore, it gives the opportunity to eliminate bottlenecks by realigning or using the existing assets better, evaluate quality improvement, cost reductions, improve the ability to meet deadlines or change customer requirements, etc. Another interesting benefit of the performance simulations is that it helps to educate operators without putting personnel, the environment and the production at any risk.
- **KPI/PPI generation.** As mentioned before, **Performance Indicator** generation is one of the main tasks of this process. This information is used in the breweries, within manufacturing operations, for improvements and optimizations. In the case of KPIs,
these are sent to higher-level business processes for further analysis and decisions. Important KPIs from the Cost Leadership perspective are OPI, Production productivity and Supply chain stock level (days). First time Right is as well a very important indicator that is generated and analyzed at this activity model.

General examples of process and production indicators are:
- Production schedules met (percentage of time)
- Productivity: units per labor hour
- Actual versus planned volume
- Actual production rate as a percentage of the maximum capable production rate

- Performance management. These activities deal with managing and presenting the KPIs in a consistent framework. For example monitoring the visibility of the KPIs, root cause analysis, prediction of future KPI values and bottleneck indication, etc.

Apart from these activities, there are other ones that are mainly focused on improvement initiatives. Usually, the way it is carried out is by gathering a polyvalent and dedicated team and letting them study and improve the different production operation activity models (resource management activities, product definition management activities, scheduling activities, etc.).

### 3.6.1 The impact of the production performance analysis process on Heineken’s Supply Chain Star

The production performance analysis process may have influence over all the points of the Supply Chain Star. The reason for this is that as this process analyses the information and makes reports, an error in this process could alter any KPI. So apparently, although it should not have any influence over the Star, indirectly it has. Any error here could lead to the production of a wrong KPI.
3.6.2 Development of a questionnaire to assess the maturity level of the process

Questionnaire 10: Questionnaire to assess the maturity of the Production Performance Analysis Process.
3.7 Production Dispatching

3.7.1 Updated overview of the process

According to the ISA95 Production Dispatching shall be defined as: “The collection of activities that manage the flow of production by dispatching production to equipment and personnel.”

It is important to highlight the fact that Production Dispatching, production scheduling and the production planning activities at level 4 are very relate to each other. This means that some functionality may be performed either in one activity model or in the others.

The Figure 30 depicts the Production Dispatching activity model interfaces.

![Figure 30: Production dispatching activity model interface (ISA95).](image)

It is the process to create a batch out of a process order. To schedule batches to start the production line.

Production dispatching activity model receives information regarding the resource availability, the production routing and the scheduling. And the final result is the dispatching list.

Depending on which type of schedule, different dispatch methods are used. For example, for the brew house, filtration and packaging batches are created when the process order is dispatched. However, tank room dispatching is done in another way. It takes place after selecting a route and starting the transfer to a new empty tank. So, the filling start of an unit will trigger the batch creation.

On the other hand, the Figure 31 shows a dispatching example for the packaging area. Here, dispatching process orders (PO) are split into batches for each workcell of a production line.

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The batch of a workcell is a grouping of process orders with the same product characteristics. And finally, as it can be checked in the Figure 31, at the last workcell of the production line (packaging line in this case) the batch is equal to the process order.

Process Orders:

![Diagram showing batch creation and process orders]

Figure 31: Batch creation packaging.

It is important the fact that for tracing purposes the transfers between the batches are registered. These transfers are known when process orders are dispatched. Finally, when process orders are dispatched the need for packaging material is ordered at the warehouse.
3.7.1 The impact of the production dispatching process on Heineken’s Supply Chain Star

The production dispatching is extremely related to the scheduling process, and so is its impact over the HStar. The dispatching has influence on the productivity (Cost Leadership), on the utilities consumption (Social Responsibility), on the First Time Right (Quality) and on the Organization & People Development. On this last one, the relationship may be not so clear and direct as it is in the rest.
3.7.2 Development of a questionnaire to assess the maturity level of the process

**Questionnaire for assessing the maturity of the Production Dispatching Process**

**Process Elements**

<table>
<thead>
<tr>
<th>Design of the process</th>
<th>P-1 (Plan)</th>
<th>P-2 (Manage, co-ordination)</th>
<th>P-3 (Process standardization)</th>
<th>P-4 (Continuous Improvement)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voice of the process</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Description</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Identification</td>
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<tr>
<td>Development</td>
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<tr>
<td>Standardization</td>
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<td>-</td>
</tr>
<tr>
<td>Continuous improvement</td>
<td>-</td>
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</tr>
</tbody>
</table>

**Knowledge**

- Use the information that is captured to align the production dispatching process with the production plan.

**Skills**

- The person who manages the production dispatching process should have the following skills.

**Skills required**

- Experience in production dispatching.
- Knowledge of production planning.
- Understanding of production control.

**The process**

- Is there a structured and documented process for production dispatching?
- Is there a process for reviewing and updating the production dispatching process?
- Is there a process for handling exceptions and deviations from the plan?

**Questions**

1. How many hours per week do you spend on production dispatching?
2. How many orders do you manage in a typical week?
3. How many orders are fulfilled within the due date?

**Questionnaire 11**

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3.8 Production tracking

3.8.1 Updated overview of the process

According to ISA95, Production tracking shall be defined as “the collection of activities that prepare the production response for Level 4. This includes summarizing and reporting information about personnel and equipment actually used to produce product, material consumed, material produced, and other relevant production data such as costs and performance analysis results”. Production tracking also provides information to detailed production scheduling and Level 4 scheduling activities so schedules can be updated based on current conditions. Transfer information and material movement information data is also reported to level 4. And consumption of materials (raw materials, brewing materials, packaging materials) are used to update stock of these materials.

The Figure 32 shows the interface of the Production tracking activity model with the rest of the processes.

![Figure 32: Production tracking activity model interface (ISA95).](image)

A production tracking activity model should perform the next tasks:

- **Material movement tracking.** This activity consists of following the movement of the material through the plant. And describing what is in each vessel at specific times as well as tracing the path of all materials within production. At Heineken, batch information, transfer information and material movement information is used to track materials/products through the plant. Here it is interesting to point out that production personnel need to have a clear overview of the batch data, both current and past batch data.
Recording start and end of movements. It consists of registering the beginning and finishing of the movements as well as collecting updates to lot and sublot quantities and locations.

Information reception from data collection and performance analysis. The received information is regarding materials consumed in the production of a lot and regarding the plant environmental conditions during lot production.

Production performance and production response generation. This activity consists of providing on demand or on a defined schedule information about what actual production was achieved. This information, can be provided to people, to applications (SAP) or to other activities.

Records generation. This includes generation of records for regulatory and quality management processes.

There are several ways to present the compiled information by the production tracking process. The Figure 33 shows two examples. The example on the left, a), shows production history from multiple production lines used to complete a single order, which is combined to produce a single production response for the order. On the other hand, the example of the right, b), shows information from a single production run split into multiple production performance reports, one report for each shift used in the production.

The resource history data includes in-work inventory, raw material usage and energy usage.

An example of a created batch data:
- Start time
- End time
- Production volume
- Produced product
- Etc.

Figure 33: a) Merging production-tracking information. b) Splitting production-tracking information.
3.8.2 The impact of the production tracking process on Heineken’s Supply Chain Star

The impact of the production tracking on the HStar, could be seen the same way as the impact of Data Collection and Performance Analysis. This is because production tracking is a collection of activities that prepares reports and provides information to Level 4 activities. Therefore, a deviation from the reality for the personnel, equipment, processes and products could influence any point of the Supply Chain Star. For instance, a deviation in the produced amount of beer could influence the Production Productivity and therefore the Cost Leadership.
### 3.8.3 Development of a questionnaire to assess the maturity level of the process

**Questionnaire for assessing the maturity of the Production Tracking Process.**

<table>
<thead>
<tr>
<th>Process Maturity Level</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>P-1 (Ad-hoc)</strong></td>
<td>The process is not standardized, and process-related data are not available. The process is reactive and driven by immediate needs.</td>
</tr>
<tr>
<td><strong>P-2 (Managed, repeatable)</strong></td>
<td>The process is documented and standardized, with a focus on consistency and repeatability. Data are collected and analyzed for process improvement.</td>
</tr>
<tr>
<td><strong>P-3 (Process standardization)</strong></td>
<td>The process is standardized and documented, with a focus on continuous improvement. Data are used to make informed decisions.</td>
</tr>
<tr>
<td><strong>P-4 (Optimized, improvable)</strong></td>
<td>The process is optimized, with continuous improvement and data-driven decision making. Data are used to drive process and system improvements.</td>
</tr>
</tbody>
</table>

#### Process Maturity Levels

- **P-1 (Ad-hoc)**: The process is not standardized, and process-related data are not available. The process is reactive and driven by immediate needs.
- **P-2 (Managed, repeatable)**: The process is documented and standardized, with a focus on consistency and repeatability. Data are collected and analyzed for process improvement.
- **P-3 (Process standardization)**: The process is standardized and documented, with a focus on continuous improvement. Data are used to make informed decisions.
- **P-4 (Optimized, improvable)**: The process is optimized, with continuous improvement and data-driven decision making. Data are used to drive process and system improvements.

#### Questionnaire

**Questionnaire 12:** Questionnaire to assess the maturity of the Production Tracking Process.

**A methodology to assess the maturity level of brewery business processes**
Chapter 4: Conclusions and future work

This document presents a methodology to assess the maturity level of the brewery business processes. It has been prepared a tailored questionnaire for beer production activities that belong to production operations management (also called Level 3 activities or even MES layer). These beer production activities (also called beer production business processes) are: Detailed Production Scheduling, Production Resource Management, Product Definition Management, Production Execution, Production data Collection, Production Performance Analysis, Production Tracking and Production Dispatching.

The fact of being a qualitative development project shows that the pragmatism level of the questionnaires has been increased as the course of the project went on. This means that last questionnaires are made up by questions that are more specific. Although the time devoted to the first questionnaires is larger than for the rest. The reason for this relies on the learning curve and on the fact that firstly, longer time was devoted to the designing of the structure of the questionnaires, rather than to the development of the questions.

It has been analyzed the possible impact of the activities over the Heineken’s Supply Chain Star. Every activity influences the HStar in some way or another. However, it can be seen that the activities influence or may influence the HStar directly, but also indirectly. The activities that can influence the HStar directly are Detailed Production Scheduling, Production Resource Management, Product Definition Management, Production Execution and Production Dispatching. For example, the KPI called Supply chain stock levels, is influenced by the scheduling in the sense that doing a good scheduling the stock levels can grow. And in the opposite way, if a wrong scheduling is done, the stock levels can go down and we can run out of products.

On the other hand, there are activities like Production Data Collection, Production Performance Analysis and Production Tracking, that although apparently may not have a direct influence, if they are performed wrongly they can influence any point of the HStar. As an example, if utilities consumption is not measured properly, it is not going to show the real consumption and therefore it will have impact on the Social Responsibility point of the HStar.

Once the production operations management for beer production activity model is analyzed, the next step in this analysis is to proceed with the operation management for packaging activities. The experience shows that for this kind of projects, it is very positive to meet many people and discuss with them about the general picture of the project as well as about particular topics like activity models. This is because different departments, areas and groups may have different point of view about the same process and it helps to obtain a better picture of the real process by doing this.
A methodology to assess the maturity level of brewery business processes

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[This website contains information about Heineken’s annual report] http://www.annualreport.heineken.com

[This website contains information about Heineken International] http://www.heinekeninternational.com


A methodology to assess the maturity level of brewery business processes
Appendix A: PEMM™ methodology

This appendix describes the PEMM™ methodology that is utilized to assess the maturity levels of the different business processes. In this study, the MLA Questionnaire that is described in the Appendix B, is based on the PEMM™ methodology.

The framework called PEMM™, Process and Enterprise Maturity Model is a management assessment tool that can be useful to assess the maturity level of the business processes of a company as well as the maturity level of the organization.

It is a model that allows executives to review the progress a business is making in transforming or altering the way that it operates. Unlike the Capability Maturity Model Integration (CMMI), the PMMI can apply to business lines other than software and technology. “PEMM is different from other process maturity frameworks, such as Carnegie Mellon’s Capability Maturity Model Integration (CMMI) framework, which applies to specific processes like software development and acquisition. The CMMI model identifies the best practices for specific processes and evaluates the maturity of an organization in terms of how many of those practices it has implemented. By contrast, PEMM applies to companies in any industry and doesn’t specify what a particular process should look like.” (Hammer, 2007).

The Process and Enterprise Maturity Model™ is a tool to help organizations plan and manage their transitions to process. It consists of two parts: a framework for assessing the maturity of any particular business process, and another for assessing the maturity of an enterprise as a whole. PEMM is described in the article called The Process Audit. This article by Michael Hammer was published by Harvard Business Review in 2007 (Hammer, 2007).

The model makes a distinction between the maturity of a process and the maturity of an enterprise. It identifies five enablers of process performance: the design of the process, its metrics, the capabilities of the people who are its performers, the infrastructure that supports the performers, and the executive who is the owner of the process. And it also identifies four enterprise capabilities: leadership, culture, expertise and governance.

A fundamental insight of PEMM is that the stronger and the more robust these enablers are, the higher the performance of the process will be. That is, better trained performers, more sophisticated metrics, a more powerful owner, etc., all enable a stronger process that in turn is able to deliver better results. PEMM identifies four levels of enabler maturity (referred to as P1 through P4), which are defined in terms of testable propositions. An enabler is said to be at P2, for instance, if the P1 and P2 statements about that enabler are true, but some of

11 http://www.hammerandco.com/pemm.html
Appendix A: PEMM™ methodology

the P3 statements are not. Organizations can assess any process in terms of these five enablers and four maturity levels to identify gaps and plan actions to fill them.

Another insight of PEMM is that enterprise maturity is a prerequisite for process maturity. It needs the four enterprise capabilities in order to improve the maturity.

Corresponding to the four levels of process maturity, there are four levels of enterprise maturity (E1 through E4), similarly defined by a set of propositions. Achieving enterprise maturity E2, for instance, is a prerequisite for advancing a process to level P2.

Organizations can use the enterprise part of PEMM for assessment and planning similar to how they use the process part.
Appendix B: Maturity Level Assessment Questionnaire (MLA Questionnaire)

This appendix describes the Maturity Level Assessment Questionnaire (MLA Questionnaire). The aim of this questionnaire is to assess the maturity level of the different brewery business processes and to provide a qualitative feedback as an answer.

The MLA Questionnaire is based on the PEMM™ structure. Four possible maturity levels are defined depending on five process performance enablers. These enablers are the design of the process, the people that perform the process, the person that owns/manages the process, the system we need, the infrastructure and the metrics (KPIs/PPIs). The enablers are explained below.

- **The design of the process**
  This enabler provides direct information about the process. Its purpose, its context and its description.
  
  - **Purpose of the process:**
    This part aims at measuring the maturity level of the purpose for the operations management processes. Whether the process is designed on an end-to-end basis, whether it is designed to fit with other enterprise processes like packaging, utilities; or customer and supplier processes like S2P (Source to Pay) and M2C (Market to Cash), internal/external integration, etc.
  
  - **Context of the process:**
    This part aims at measuring the maturity of the process’ context. Whether the inputs/outputs, suppliers/customers are identified, the needs/requirements for the resource management processes’ customers are known, whether there are internal/external mutual performance expectations among the process and other beer production processes like packaging or utilities, or even among customer and supplier processes like S2P (Source to Pay) and M2C (Market to Cash), etc.
  
  - **Documentation / description of the process:**
    This part aims at measuring the maturity level of the documentation that supports the process. Whether it is primarily functional, whether the documentation/deliverables of the process are implemented, whether there are some targets on the needs, whether we are focused on improving these targets etc.

- **The people that perform the process**
  This enabler provides information about the people that perform the process. Emphasizing the capabilities, the skills and the behavior.
Appendix B: Maturity Level Assessment Questionnaire (MLA Questionnaire)

- People’s knowledge (Do we know?):
  This part aims at measuring the knowledge that people in charge of a particular process have regarding the process performance indicators (PPIs) and the key performance indicators (KPIs). This part aims as well at identifying whether people know the effects of performing well the process and its influences on the enterprise’s performance, on customers’ performance etc.

- People’s skills (Can we?):
  This part aims at measuring the skills of people that manage the particular process. Whether they are just trained to solve their tasks, whether they are part of a team and versatile enough to replace each other, whether they are skilled in problem solving and process standardization, TPM, change implementation, continuous improvement philosophy etc.

- People’s behavior (Do we want?):
  This part aims at measuring the behavior of people that manage the particular process. Whether they have allegiance to the process or just to their task, whether they follow the process design and perform it correctly, whether they propose improvements so a better process management and execution could be done etc.

- The person that owns/manages the process
  This enabler provides information about the behavior of the person that is in charge of the process.

  - Identity:
    This part aims at identifying the person that is in charge of the process. It also aims at assessing his/her commitment towards the process.

  - Activities:
    This part aims at identifying the maturity of the activities performed by a particular process. Whether the owner documents the process, whether he/she articulates performance goals, whether he/she plans improvement projects aligned to other business processes goals and enterprise’s goals, etc.

  - Authority:
    This part aims at measuring the owner’s authority over the process. Whether the owner can make changes or just influence the managers, whether he/she has any control over the technology budget, whether he/she controls the IT system, the personnel assignments and the correct alignment of these assignments, etc.

- The systems we need, the infrastructure
  This enabler provides information regarding the supporting elements that are required for the well functioning of the process.
Appendix B: Maturity Level Assessment Questionnaire (MLA Questionnaire)

- Information systems (how do we do IT support?):
This part aims at measuring the maturity level of the information systems that support the process. Whether SAP is utilized for the communication between different departments, whether advanced planning tools like Futur Master are used for demand & supply planning, etc. For some processes this is an open question. They can answer the question and give an explanation, so later the maturity level assessment can be done.

- Human resources (how do we arrange the required skills?):
This part aims at measuring the maturity of the human resources that support the process. It tries to find out whether the process is based on “heroes”, whether there are detailed job descriptions for the beer production resource management, whether there are job profiles aligned with the process needs and balanced against the enterprise’s needs and requirements, etc.

- The metrics (KPIs/PPIs)
This enabler provides feedback regarding the degree of control that we have over the process.

  - Definition:
This part aims at measuring the metrics that are used to control the process. Also whether any metrics regarding the process are available, whether the metrics are derived from other processes, whether there are any established targets on these metrics, whether these metrics are being revised and improved, etc.

  - Use / utilization of the metrics:
This part aims at measuring the implementation degree of the metrics. Whether the metrics are being used to check the process, whether these metrics are being used for the strategic planning, etc.

All the processes have been analyzed using this MLA Questionnaire. However, the standard questionnaire has been tailored to fix each process. Therefore, each questionnaire is based on specific and pragmatic questions and sentences.
These are the possible four maturity levels:

**P-1:** *Initial (AD-HOC):* Inconsistent management

**P-2:** *Managed, repeatable:* Project management

**P-3:** *Defined, Process standardization:* Process management

**P-4:** *Optimized, improvement:* Change, improvement management

The Figure 34 shows the maturity levels.

![PEMM maturity levels](image)

**Figure 34:** PEMM maturity levels.

The *Appendix E: Maturity models,* provides further information regarding the characteristics of each maturity level.

The Figure 35 gives as an example of how to answer the questionnaire. In this case, it is a questionnaire for assessing the maturity level of the *Detailed Production Scheduling,* answered by Mrs. Anna Kyriakopoulou (Production planning dept.) at Heineken Greece, Athens. As it can be seen, depending on the truthfulness of the provided answer the respective box has to be colored in green (largely true, >80%), in yellow (somewhat true, 20-80%) or in red (largely untrue, <20%).

In this case, the obtained conclusion is that it is a relatively mature process, around P3. However, it is visible that they still need to put some more stress to improve certain areas to be able to jump to the next maturity level.
Appendix B: Maturity Level Assessment Questionnaire (MLA Questionnaire)

Figure 35: Example questionnaire.

A methodology to assess the maturity level of brewery business processes
Appendix C: ISA-95

This appendix describes the ISA-95 international standard for the integration of enterprise and control systems. In addition, straight afterwards there is a summary about how to apply ISA-95 as an analysis tool.

The following information has been extracted from ISA-95.com.

ISA-95 is the international standard for the integration of enterprise and control systems. ISA-95 consists of models and terminology. These can be used to determine which information, has to be exchanged between systems for sales, finance and logistics and systems for production, maintenance and quality. This information is structured in UML models, which are the basis for the development of standard interfaces between ERP and MES systems. The ISA-95 standard can be used for several purposes, for example as a guide for the definition of user requirements, for the selection of MES suppliers and as a basis for the development of MES systems and databases.

Different languages

All over the world, every manufacturing company is organized differently, and uses different automation systems. There are no companies with exactly the same names for departments, activities and functions. The information that is exchanged also has different names in different companies and automation systems.

One company speaks of charges; another company will call it batch or a production run. And even within one company you could say office people speak ‘a different language’ than shop floor personnel. They also use different automation systems that each has their own terminology.

Information exchange

Although they speak different languages, both levels will have to communicate with each other. The office will have to provide information about new customer orders, raw materials that have been ordered, specific customer demands for products, and so on. The shop floor will also have to send information to the office. For example, information about the status of orders, about the exact amounts of raw materials that were used in the production process and so on.

Automated interfaces

With the appearance of new technologies, it is getting easier to automate the exchange of information between the office and the shop floor. An automated interface between enterprise and control systems can lead to a lot of advantages. Important information
becomes accessible at the right time and the right place. The enterprise has access to real
time information such as information about raw materials and end products, which enables
optimum usage of storage capacity.

The solution

The international standard ISA-95 has been developed to address the problems encountered
during the development of automated interfaces between enterprise and control systems.
This standard has been developed all kinds of manufacturing environments, all over the
world. It can be applied in all industries, and in all sorts of processes, such as batch,
continuous, and repetitive or discrete processes.

ISA-95 part 1, 2, 3, 4 and 5

There are 5 parts of the ISA-95 standard. Part 1 consists of standard terminology and object
models, which can be used to decide which information, should be exchanged. Part 2
consists of attributes for every object that is defined in part 1. The objects and attributes of
part 2 can be used for the exchange of information between different systems, but these
objects and attributes can also be used as the basis for relational databases. Part 3 focuses
on the functions and activities at level 3 (Production / MES layer). It is an excellent guideline
for describing and comparing the production levels of different sites in a standardized way.
The SP95 committee is developing part 4, which is entitled "Object Models and Attributes of
Manufacturing Operations Management". The SP95 commission has also started the
development of part 5 of ISA-95, entitled "Business to manufacturing transactions".

C1. ISA-95.01 Models & Terminology

The paper called Enterprise-Control System Integration Part 1: Models and Terminology by
ISA explains in detail this part regarding models & terminology. The next information is the
summary of this part and it has been extracted from ISA-95.com.

Part 1 of ISA-95 consists of models with standard terminology. The models can be used to
define the exact boundary of the enterprise systems and the control systems. Which tasks
are executed by which function? And which information must be exchanged from where to
where? These questions can be answered by using the models and terminology of part 1 of
the ISA-95 standard.

Hierarchical model

The different models all focus on a specific aspect of the integration requirements. For
example: there is a model that depicts the different levels of a manufacturing enterprise.
This gives a clear picture of where in a specific company, in which department and by which
system specific activities take place.
Appendix C: ISA-95

Functional model

There is a functional model, which can be used to define which functions are executed within the company, at which department and which system is responsible for the execution of this function. You can also use it to find the local names for the functions. Compared to the hierarchical model, the functional model focuses on functions, without taking into account the different levels within the enterprise. By combining the hierarchical and functional model, you will get a complete view of the company.

Information flows

The functional model clarifies which information flows from one function to another. ISA-95 has determined standard terms for these information flows. You can use these to decide what are the local names of these information flows, for example the name used by the ERP system, or the name used by the Scheduling system. You already know which functions are performed by which systems, so now it becomes clear which information flows are involved in the interface.

Categories and objects

Interface information can be divided into three categories. It typically consists of information is concerning Production capacity, Product definition or Production. This, in turn, consists of the object’s Equipment (tools, machines, devices, etc.), Personnel (people with certain skills) and Material (raw materials, energy, end products, waste materials, etc). Every information flow is built up from one or more of these 3 resources. ISA-95 defines object models for these resources, which can be used to exchange the information. The resource object models are the basis for a consistent set of more complex object models that make logical groups of the information that has to be exchanged.

Conclusion

ISA-95.01 is an excellent method to determine which information must be exchanged between enterprise systems and production control systems. The object models of part 1 are the basis for part 2 of the standard (ISA-95.02), which defines the attributes for the objects defined in part 1.
Appendix C: ISA-95

A methodology to assess the maturity level of brewery business processes

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Figure 36: Outline of models in the standard.

C2. ISA-95.02 Object Model Attributes

The paper called Enterprise-Control System Integration Part 2: Object Model Attributes by ISA explains in detail this part regarding object model attributes. The next information is the summary of this part and it has been extracted from ISA-95.com.

With part 1 you can determine which information must be exchanged between the enterprise and the control system. After this information analysis, you can start to build the interface between both systems. The standard does not tell which technical solution you should choose (an example of a technical solution could be XML/B2MMI). But part 2 does offer a basis for this technical solution, because it determines the attributes of all the objects defined in part one. You can use these objects and attributes for the exchange of information, but they are also an excellent basis for developing relational databases.

Objects and attributes

Part 2 has determined the attributes for the following object models:

- Production capability model
- Process segment capability model
- Personnel model
- Equipment model
- Material model
- Process segment model
- Product definition information model
- Production schedule model
- Production performance model

With these objects and attributes you can build all the information flows defined by the functional model of part 1.
Appendix C: ISA-95

<table>
<thead>
<tr>
<th>Attribute name</th>
<th>Description</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>ID</td>
<td>A unique identification of a specific material sub lot, within the scope of the information exchanges (production capability, production schedule, production performance...). The ID shall be used in other parts of the model when the material sub lot needs to be identified, such as the production capability for this material sub lot, or a production response identifying the material sub lot used.</td>
<td>1999-10-27-a67-B6653</td>
</tr>
<tr>
<td>Description</td>
<td>Additional information about the material sub lot.</td>
<td>Pallet 2 of 6</td>
</tr>
<tr>
<td>Status</td>
<td>Status of the current material sub lot. For example, released, approved, blocked, in process, in quality check.</td>
<td>Released</td>
</tr>
<tr>
<td>Storage Location</td>
<td>An identification of the storage location of the material sub lot.</td>
<td>“Warehouse 1 Rack 12 Slot 4”</td>
</tr>
<tr>
<td>Quantity</td>
<td>The quantity of the material sub lot.</td>
<td>40</td>
</tr>
<tr>
<td>Quantity Unit of Measure</td>
<td>The unit of measure of the associated quantity, if applicable.</td>
<td>Sheets</td>
</tr>
</tbody>
</table>

Table 2: Attribute name and description.

Abstract, so it can be used for all kinds of interfaces

The attributes are abstract; they do not define any specific data types. That’s why the standard can be used in all kinds of manufacturing facilities. For every different project, you have to determine how the information is going to be depicted. For example: an attribute could be shown as a string in one implementation, and it could have a numerical value in another implementation. A date or time value could be shown in the sequence Day-Month-Year, or Year-Month-Day. ISA-95.02 gives examples for every attribute. It will not always be necessary to use every attribute in every implementation. This depends on how many models you are using. It is allowed to leave out models that you don’t need. You can also add attributes by using properties. ISA-95.02 offers tables for properties. These can be used for information that is very specific for the company. This way the standard can be used in all kinds of industries.

C3. ISA-95.03 Activity Models

The paper called Enterprise-Control System Integration Part 3: Activity Models of Manufacturing Operations Management by ISA explains in detail this part regarding activity models. The next information is the summary of this part and it has been extracted from ISA-95.com.
Appendix C: ISA-95

ISA-95.03 defines production activities and information flows. Within production areas several activities are executed and a lot of information is exchanged. ISA-95 part 3 provides reference models for production activities, quality activities, maintenance activities and inventory activities. With these models you can make clear what is the actual situation within your company. E.g.: the following questions can be answered when using the ISA-95.03 models:

- Which department is responsible for which activities?
- Which automation systems are responsible for which systems?
- What is the focus of various projects within the company and are there gaps or overlapping responsibilities?
- Which functionality is represented in more than one information system?
- What are the boundaries between our automation systems?
- What are our user requirements for the new system?
- Which supplies is suitable, based upon our requirements?

**Advantages**

ISA-95 part 3 provides terminology and a consistent set of models for the definition of activities that are aimed at the exchange and processing of production information. Usage of the standard can give you the following advantages:

- Suppliers can develop suitable tools for production activities
- End Users can identify their needs more easily
- End Users can compare the solutions of different suppliers
- You can develop a more complete definition of production activities and information within your / a company
- You can make clear which automation systems are used within the production area and what is the exact responsibility of each system
- End users can improve communication with suppliers, and with colleagues.
- ... and so on.

**C4. ISA-95.04 Object Models & Attributes**

ISA95 part 4 is still being developed. It is entitled "Object Models and Attributes of Manufacturing Operations Management". It defines object models that determine which information is exchanged between MES activities (which are defined in part 3 by ISA-95). The models and attributes from part 4 are the basis for the design and the implementation of interface standards and make sure of a flexible lapse of the cooperation and information-exchange between the different MES activities.

**C5. ISA-95.05 B2M Transactions**

The next information is the summary of part 5 of ISA-95 called "Business to manufacturing transactions". This part has been extracted from ISA-95.com.
This Part 5 standard is based on the use of ISA-95 abstract models previously defined in the ISA-95 Part 1 and Part 2 standards, combined with OAGi verbs to define transaction models for information exchange. It is recognized that other, non-ISA-95 Part 5 transaction protocols are possible and are not deemed invalid as a result of this standard. Transactions occur at all levels within the enterprise and between enterprise partners, and are related to both required and actual activities, but the focus of this standard is the interface between enterprise/business systems and manufacturing systems. This standard defines business-to-manufacturing transactions and manufacturing-to-business transactions that may be used in relation to the objects that are exchanged between Level 4 and Level 3, as defined in the object models of the Part 1 and Part 2 standards. Models are introduced that provide descriptions of the transactions and explanations of the required transaction processing behavior. Technology-specific implementations to provide this behavior are not defined in this standard. This standard has the intent of providing insight into the level of work required to construct information messages in business-to-manufacturing transactions.

C6. Applying ISA-95 as an analysis tool

Reasons for applying ISA-95 analysis tool

There are companies that have communication problems among the different departments as well as communication problems with customers and suppliers. A reason for this is that they may use different terminology for similar concepts. Therefore, they need to agree on standards and apply them across the organization to avoid the communication problems and misunderstandings.

ISA95 helps to exchange the different perspectives that the departments have and align them in one direction. It helps to get everyone pointing to the same direction.

By applying the ISA95 analysis, organizations can study the As-Is situation and for example analyze which ERP, MES, LIMS (Laboratory Information Management System) they are currently using within the different plants, what the requirements for a new MES system are for a specific plant, which information flows need to be automated, etc.

Therefore, there is not a specific reason for companies to apply the ISA95 analysis. But however, it allows organizations to implement solutions tailored to their specific company-issues.

More examples of companies that perform the ISA95 analysis tool:

- To determine whether SAP provides sufficient functionality to support the production activities within a company.

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12 The original analysis tool can be consulted in the next book: Scholten, Bianca (2007). “The road to integration: a guide to applying the ISA-95 standard in manufacturing”. ISA, NC
- To determine whether a scheduling application being offered provides sufficient and correct functionality to replace the Excel scheduling application.

- To translate the current enterprise and application terminology to ISA95 terminology in order to standardize Level 3 automation and to determine which information flows will be exchanged automatically, etc.

**Steps in the ISA-95 analysis**

Bianca Scholten, suggests that these steps should be taken in order to carry out a successful ISA-95 analysis:

- Firstly, it is interesting to start the analysis with a tour of the plant. This way, people who do not know the factory well can get a global impression. However, the details will be covered in depth during the analysis.

- Next, describe the Business Drivers in order to gain insight into the company objectives. These factors are also called *critical success factors* and clarify what the company must do well in order to have its strategy succeed. Depending on the characteristics of the specific company, one business driver will be more important than another. For instance: available-to-promise, reduced cycle time, asset efficiency, quality and traceability, etc.

- Afterwards, Make a list of the automation systems that the different departments in the company use (both office and manufacturing), and make an overview of which departments and systems bear responsibilities on which automation levels.

- Describe the physical structure of the company to help forming a picture of the nature and complexity of the processes that take place there. This is called to obtain The Equipment Hierarchy model. Once the physical description is done, next is to focus on the process segments.

- Describe the Functional Enterprise-Control model. Figure 37 illustrates the Functional Enterprise-Control model. This is used to determine which functions are relevant and which people can provide the required information for the analysis.

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13 ICT and Management consultant and author of “The road to integration: a guide to applying the ISA-95 standard in manufacturing” and “MES Guide for Executives: Why and How to Select, Implement, and Maintain a Manufacturing Executions System”.
Appendix C: ISA-95

A methodology to assess the maturity level of brewery business processes

- Describe the Production Operations Management activity model.
  This model is the first of four operations management models in ISA95. It is used to
describe and analyze the production activities of the company.

- Describe the Maintenance Operations Management activity model.
  This model is also part of the operation management models in ISA95. It describes
and analyzes the maintenance activities that are carried out in the organization.

- Describe the Quality Test Operations Management activity model.
  In the same way, this activity model describes the Level 3 quality activities.

- Describe the Inventory Operations Management activity model.
  This one describes the Level 3 Inventory activities.

- Describe the rest of activities, other enterprise activities affecting manufacturing
  operations.
  These activities are for instance: management of security, management of
  information, etc. Support activities in general.

Figure 37: The Functional Enterprise-Control Model.
Finally, when the current state analysis is carried out, it is time to think how we would like the future state to be. Therefore, the Future State design is the next step in the process. And once it is known how the future state should look like, the roadmap to achieve that Future state needs to be developed. The Figure 38 and the Figure 39 give an example of the To-Be situation and the roadmap required to achieve that situation.

The Figure 38 shows that in this example, the tracing activities, the performance analysis activities and the data collection activities will have more importance than the rest of activities in the To-Be situation; for production, maintenance and quality operations. Therefore, in this case it seems that according to the conclusions obtained by the analysis, the roadmap to successfully achieve the To-Be situation is the one described in the Figure 39. We can check how it gives priority to tracking and data collection activities followed by performance analysis activities.
Appendix C: ISA-95

A methodology to assess the maturity level of brewery business processes

Figure 38: Description of the future state, To-Be situation.

Figure 39: The roadmap to achieve the To-Be situation.
Appendix D: The SCOR model

Heineken’s business processes are described in the company’s supply chain navigator, which is based on the SCOR model. This Appendix explains the SCOR model.

SCOR is a management tool for analyzing supply chains, spanning from the supplier's supplier to the customer's customer. It is developed by the Supply Chain Council (SCC), an independent, not-for-profit, global corporation with membership open to all companies and organizations interested in applying and advancing the state-of-the-art in supply chain management systems and practices (Supply Chain Council, 2010).

It provides a unique framework to support communication among supply chain partners and to improve the effectiveness of supply chain management and related supply chain improvement activities (Supply Chain Council, 2010).

SCOR integrates the concepts of business process reengineering, benchmarking and best practices analysis into a cross-functional framework, as it can be seen in the Figure 40.

![Figure 40: SCOR, concept integration.](image-url)

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Appendix D: The SCOR model

Three levels represent this framework. Level 1 defines the scope and content for the SCOR-model. Here basis of competition performance targets are set and management processes are defined. These processes are: planning, sourcing, production, delivering, and return (see Figure 41).

![Diagram of SCOR top level]

**Figure 41:** SCOR top level.

The Table 3 shows the definition of each management Process.

<table>
<thead>
<tr>
<th>SCOR Process</th>
<th>Definitions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plan</td>
<td>Processes that balance aggregate demand and supply to develop a course of action which best meets sourcing, production and delivery requirements.</td>
</tr>
<tr>
<td>Source</td>
<td>Processes that procure goods and services to meet planned or actual demand.</td>
</tr>
<tr>
<td>Make</td>
<td>Processes that transform product to a finished state to meet planned or actual demand.</td>
</tr>
<tr>
<td>Deliver</td>
<td>Processes that provide finished goods and services to meet planned or actual demand, typically including order management, transportation management, and distribution management.</td>
</tr>
<tr>
<td>Return</td>
<td>Processes associated with returning or receiving returned products for any reason. These processes extend into post-delivery customer support.</td>
</tr>
</tbody>
</table>

**Table 3:** Process Definitions (Supply Chain Council, 2010).

The Level 2 is the configuration level and here the business processes are “configured-to-order”, for instance: make-to-order, make-to-stock or engineer-to-order.

The third level is the process element level, here it is defined the company’s ability to compete successfully in its chosen markets. It is in level 3 where companies “fine tune” their operations strategy.

Finally, there is a forth level, which is not part of the SCOR model. This level is the implementation level where companies define their activities and supply-chain management practices. Figure 42 describes the SCOR levels.
Appendix D: The SCOR model

# Appendix D: The SCOR model

A methodology to assess the maturity level of brewery business processes

<table>
<thead>
<tr>
<th>Level</th>
<th>Description</th>
<th>Schematic</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Top Level (Process Types)</td>
<td><img src="image.png" alt="Plan Source Make Deliver Return" /></td>
<td>Level 1 defines the scope and content for the Supply Chain Operations Reference-model. Here basis of competition performance targets are set.</td>
</tr>
<tr>
<td>2</td>
<td>Configuration Level (Process Categories)</td>
<td><img src="image.png" alt="Configuration level schematic" /></td>
<td>A company’s supply chain can be “configured-to-order” at Level 2 from core “process categories.” Companies implement their operations strategy through the configuration they choose for their supply chain.</td>
</tr>
</tbody>
</table>
| 3     | Process Element Level (Decompose Processes) | ![Process element level schematic](image.png) | Level 3 defines a company’s ability to compete successfully in its chosen markets, and consists of:  
- Process element definitions  
- Process element information inputs, and outputs  
- Process performance metrics attributes and definitions  
- Best practices definitions  
Companies “fine tune” their Operations Strategy at Level 3. |
| 4     | Implementation Level (Decompose Process Elements) | ![Implementation level schematic](image.png) | Companies implement supply-chain management practices that are unique to their organizations at this level. Level 4 and lower defines specific practices to achieve competitive advantage and to adapt to changing business conditions. |

Figure 42: SCOR-model levels.

These four level of detail that SCOR provides, makes it possible for a company to analyze and configure its supply chain according to its production type and to its specific needs and requirements (Forme, La et al., 2007). Companies describe their actual processes in order to compare them to the “standard processes” described by the SCOR-model and use the performance indicators and best practices, they consider as pertinent, to attain optimized processes (Forme, La et al., 2007). Through a common set of definitions, performance indicators and best practices, the SCOR-model is a framework for a common language between supply chain partners (Forme, La et al., 2007).
Appendix E: Maturity models

This appendix explains and describes the maturity models.

A maturity model is a structured collection of elements that describe certain aspects of maturity in an organization. It is usually used as a benchmark for comparative assessments of different organizations where there is something in common.

Much of the work on process maturity takes inspiration from the Software Engineering Institute’s Capability Maturity Model (SEI CMM.). CMM was developed for software engineering disciplines before the arrival of the Business Process Management systems (BPM).

The CMM was originally intended as a tool to evaluate the ability of government contractors to perform a contracted software project. Though it comes from the area of software development, it can be, has been, and continues to be widely applied as a general model of the maturity of processes (i.e. business processes).

The Figure 43 shows the historical evolution of the Maturity Models.

![Figure 43: Evolution of Maturity Model](image)
Appendix E: Maturity models

Figure 43 shows the degree of involvement within the organization against the time. The tendency is to involve more parts of the organization. Starting from the software applications and IT in general until reaching business processes and management.

There are five levels defined for classifying the Maturity models like PMM or CMMI\textsuperscript{15}. According to the SEI: "Predictability, effectiveness, and control of an organization’s software processes are believed to improve as the organization moves up these five levels. While not rigorous, the empirical evidence to date supports this belief."

These levels are:

Level 1: \textit{Initial (AD-HOC)}

Processes at this level are usually chaotic and undocumented. This provides a chaotic or unstable environment for the processes.

\quad \Rightarrow \textit{Repeatable practices} \quad \Rightarrow

Level 2: \textit{Managed, repeatable}

The process is managed according to the metrics described in the Defined stage. The process may not be rigorous.

\quad \Rightarrow \textit{Common engineering processes} \quad \Rightarrow

Level 3: \textit{Defined, process standardization}

The process is defined/confirmed as a standard business process. These standard processes are in place (i.e., they are the AS-IS processes) and used to establish consistency of process performance across the organization.

\quad \Rightarrow \textit{Quantitative understanding and control} \quad \Rightarrow

Level 4: \textit{Quantitatively managed}

At this level using process metrics, management can effectively control the AS-IS process. Management can identify ways to adjust and adapt the process to particular projects without measurable losses of quality or deviations from specifications. Process Capability is established from this level.

\quad \Rightarrow \textit{Continuously improving practices} \quad \Rightarrow

\textsuperscript{15} (March 2002 edition of CMMI from SEI), chapter 2 page 11.)

\textit{A methodology to assess the maturity level of brewery business processes}
Level 5: Optimized, improvement

Processes at this level focus on continually improving process performance through both incremental and innovative technological changes/improvements.

In the case of this study (as explained in the Appendix B: Maturity Level Assessment Questionnaire), there are four levels instead of five. This fact makes the assessment quite easier and however, it is not a weakness since it is possible as well to get a good feedback on how good things are being done in an organization. In addition, the benefits of moving to a higher maturity level are the same. These benefits can be seen in the Table 4.

<table>
<thead>
<tr>
<th>MATURITY LEVEL</th>
<th>IMPROVEMENT IMPLEMENTED</th>
</tr>
</thead>
<tbody>
<tr>
<td>5. Optimized, improvement</td>
<td>• Develop change infrastructure</td>
</tr>
<tr>
<td></td>
<td>• Evaluate and deploy improvements</td>
</tr>
<tr>
<td></td>
<td>• Eliminate causes of defects</td>
</tr>
<tr>
<td>4. Quantitatively managed</td>
<td>• Manage processes quantitatively</td>
</tr>
<tr>
<td></td>
<td>• Establish capability baselines</td>
</tr>
<tr>
<td>3. Defined, process standardization</td>
<td>• Establish improvement infrastructure</td>
</tr>
<tr>
<td></td>
<td>• Identify required software processes</td>
</tr>
<tr>
<td></td>
<td>• Define common software processes</td>
</tr>
<tr>
<td></td>
<td>• Deploy and manage processes</td>
</tr>
<tr>
<td></td>
<td>• Collect process-level data</td>
</tr>
<tr>
<td></td>
<td>• Provide organization-wide training</td>
</tr>
<tr>
<td></td>
<td>• Coordinate with non-software groups</td>
</tr>
<tr>
<td>2. Managed, repeatable</td>
<td>• Manage requirements</td>
</tr>
<tr>
<td></td>
<td>• Plan and track projects</td>
</tr>
<tr>
<td></td>
<td>• Manage suppliers</td>
</tr>
<tr>
<td></td>
<td>• Manage product configurations</td>
</tr>
<tr>
<td></td>
<td>• Measure projects</td>
</tr>
<tr>
<td></td>
<td>• Assist and assure policy compliance</td>
</tr>
<tr>
<td>1. Initial (AD-HOC)</td>
<td>No required processes</td>
</tr>
</tbody>
</table>

On the other hand, the Table 5 shows the improvements that an organization could achieve in the case of moving to a higher maturity level.

<table>
<thead>
<tr>
<th>MATURITY LEVEL</th>
<th>IMPROVEMENT IMPLEMENTED</th>
</tr>
</thead>
<tbody>
<tr>
<td>5. Optimized, improvement</td>
<td>• Continuously targeting improvements required to meet business objectives</td>
</tr>
<tr>
<td>4. Quantitatively managed</td>
<td>• Predictable results, knowledge of factors causing variance and reuse</td>
</tr>
<tr>
<td>3. Defined, process standardization</td>
<td>• Meeting cost and functionality targets as well as improved quality</td>
</tr>
<tr>
<td>2. Managed, repeatable</td>
<td>• Meeting schedule and reduced turnover resulting from less overtime</td>
</tr>
<tr>
<td>1. Initial (AD-HOC)</td>
<td>• No benefits: Inconsistency, schedule and budget overruns, and defective applications</td>
</tr>
</tbody>
</table>

Table 4: Benefits of improvements.

Table 5: Improvements per maturity level.
Appendix E: Maturity models

Moving to the next maturity level is not as easy as it may look like. It takes time to the organization to get used to work and do things in the new way. The Figure 44 gives an example regarding the usual time required to progress to the next maturity level. In this case, software organizations are being analyzed and the applied framework is the Capability Maturity Model Integration (CMMI). The example shows that the deviation in months is the largest when moving from level 1 to level 2. And it decreases for the rest.

Figure 44: Usual Time Required to progress to Next Maturity Level (Source: Software Engineering Institute).
Appendix F: The process of making beer

This appendix describes the process of making beer from the natural ingredients: malted barley, hops, yeast and purified water. This process consists of the following parts: malting, brewing, fermenting, lagering and filtration. And in the same time, some of this parts are divided into several steps.

Figure 45: The natural ingredients required for making beer.

F1. Malting

The barley grain, coming from the fields, contains starch and proteins. Both elements are necessary for the production of beer. The problem is that both elements are insoluble and must be transformed to soluble matter. This is done by various types of enzymes, which are developed and/or activated during the malting process. The three main steps in the malting process are steeping, germinating and kilning. Before the barley is malted, it must be cleaned. The purpose of this process is the removal of not only pollution like dust, straws and little stones, but also of broken, too thin or irregular grains. The cleaned and sorted grains are washed and put in an open steeping tank for two days. During these days the steeping water is regularly refreshed and fresh air is blown through the barley at regular intervals. The barley grains absorb so much water during this period, that 45% of their weight consists of water when the steeping is completed. This content is important for the following step: germinating.

Germination takes place in a germination box. This is an open rectangular tank with a perforated bottom. Through this bottom, air can be blown upwards, through the germinating barley. The air is saturated with water vapor. Both elements are used to control the essential germinating conditions. The germination is stopped as soon as sufficient enzymes have been formed in the barley grains. The sprouted barley is now called green malt.

The green malt is moved to a kiln in which it is dried with hot air. When the kilning process is completed, the water content of the malt has dropped from 45 to 4%. This lack of water temporarily inactivates the enzymes, with the result that the transformation of the starch and the proteins is stopped. The malt can be preserved in silos or polythene bags. Due to this property of malt, it is not necessary to have a malt house in the same place as a brewery.
Appendix F: The process of making beer

F2. Brewing

Like malting, the brewing also consists of several phases. The following phases are to be distinguished: crushing, mashing process, filtering, boiling and sludge removal. The process during the different phases will be described below. The starch, which is stored in the malt grains, has to be transformed into soluble sugars by enzymes. For this, the starch needs to be reached easily. This is accomplished by crushing the malt. The object of crushing is to liberate the contents of the malt grains from their husks, so that these contents can come into immediate contact with the brewing water during mashing. The contents of the grain should be crushed into grits and flour, but the husks should not be broken more than is necessary, because then they can be used as filter material later on. The result of the crushing process is malt grist. In the brew house water is added to the malt grist in a mash tun (thus creating mash), and, during mashing, optimum conditions are created for the enzymes in the mash, so that the starch and the insoluble proteins are broken down into sugars and soluble proteins, respectively. These optimum conditions are reached at different temperatures for different enzymes. The different temperatures are created by pumping part of the mash into the brewing copper. In the brewing copper, the mash is slowly heated and brought to boiling temperature. After boiling, the hot mash is pumped back into the mash tun and mixed with the larger part of the mash. This process is repeated a number of times so that the temperature in the mash tun gradually becomes higher. When the mashing process is finished the mash is pumped into the lauter tun.

The mash is filtered in the lauter tun, which consists of two bottoms. The upper bottom is perforated. The husks settle on this bottom, with a natural filter bed as a result. The extract filters through the filter bed and runs through the perforations to the lower bottom. There are one or more drains in the lower bottom through which the extract (wort) flows into the wort copper. The husks that remain are removed from the lauter tun and sold as cattle-fodder.

In the wort copper, the wort is brought to its boiling point. Just before this point is reached, hop is added. This hop has several functions, such as: it creates the bitterness of the beer, it contributes to the scent, it determines the brightness, it contributes to the natural tenability, and it helps to create froth. During the boiling the hop is dissolved, the wort sterilized and the enzymes inactivated. Boiling also facilitates the removal of the excess proteins and excess water is evaporated. The boiling is stopped when the wort has reached the desired extract level.

The wort is pumped into a whirlpool (or wort separator), where sludge removal takes place. The wort is rotated in this tank. As a result of the rotating movement the sludge moves towards the centre of the tank. When the rotating movement slows down, the sludge starts to settle on the centre of the tank bottom. The hot wort is reasonably clear now and is transported to the fermenting cellar.
F3. **Fermenting**

During the fermentation process, the fermentable sugars which are dissolved in the wort are transformed and broken down into alcohol and CO2. This process takes place in the fermenting vessels. The length of this process partly depends on the desired alcohol percentage. Before fermentation can take place, the hot wort is first cooled in a heat exchanger plate. After the wort has been cooled, it is saturated with oxygen and then yeast is added to it. When the yeast is added, it is transported to a fermentation tank. The added air activates the yeast growth in the beginning of the fermentation process. Only after all air has been used transformation into alcohol and CO2 will take place. During this period, the temperature is kept below 10 °C. This temperature is characteristic of low fermentation beer. After this conversion has taken place, the wort is further cooled so that fermentation stops. The leftover yeast coagulates, sinks to the bottom and settles in the cone of the fermenter from where it can be removed (purging spent yeast). After this, the young beer can be transported to a lagering tank.

F4. **Lagering**

Lagering (also called conditioning or storage) can take place in the fermentation tank or in one or more lagering tanks. Secondary fermentation starts at the moment the beer is transferred, for it is a continuation of the fermentation process that did not stop in the fermenter, but that was reduced to a low pitch when the young beer was cooled. This secondary fermentation takes place at a low temperature, so that the process develops slowly. Because of this, and the pressure in the vessel, CO2 is produced and dissolves in the beer until the beer is saturated. The abundant CO2 bubbles upwards and takes unwanted flavorings along with it. During the lagering process, yeast cells and coagulated protein particles flow to the bottom where it forms sediment called geläger. After this, one treatment is still necessary: the beer is not yet bright, it must still be filtered.

F5. **Filtration**

Filtration does not necessarily improve the taste and flavor of the beer. It is primarily done to give the beer its bright, sparkling appearance. In most cases, a kieselguhr filter is used for this. Kieselguhr is a mineral, which is formed from the skeleton remnants of very small forms of life that existed in the lakes. The kieselguhr must be cleaned, processed and ground into a fine powder before it can be used for filtration. Kieselguhr is available in several gradations, ranging from very fine to a coarse powder. Before filtration may be started, a coat of kieselguhr must be prepared on the surface of the filter leaves. Kieselguhr is also added to the beer that is to be filtered, which is deposited on the filter coat. This way the filter coat is kept porous and thus remains in working condition for much longer. The result of all this is clear beer that can be bottled.