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World Class Logistics in Operations – Definition of World Class Standards, Tools and Processes in the Material Flow

Master Thesis

Graz University of Technology

Institute of Production Science and Management

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Graz, December 2014

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Acknowledgement

At this point I want to use the opportunity to express my gratitude to all the people who supported me in the past years during my studies and during the creation of this thesis.

First of all, I want to thank my family and my friends. They supported me during my whole studies, and made all this possible in the first place. Whenever I needed them, they were there for me with their support and advice.

Secondly I want to thank Univ.-Prof. Dipl.-Ing. Dr.techn. Christian Ramsauer and the Institute of Production Science and Management for allowing me to write this thesis on his institute.

Furthermore I want to thank Dr. Jörg Blechinger and his really great team at Magna Logistics Europe for giving me the chance of writing my thesis at Magna. I want to thank them for all the invaluably constructive criticism and friendly advice they gave me during my time in their office.

Also I want to thank all the participants of the different expert meetings, conference calls and interviews. They are the people who made this project possible by assisting me with all of their knowledge and willingly shared it with me. They gave me valuable insights on the work I've done.

Additionally I want to thank my tutors Dipl. Ing. Alexander Pointner and Dipl. Ing. Matthias Friessnig for their patience, their advice and for sharing their truthful and illuminating views on different issues of this project.

Last I want to thank all the unmentioned persons that supported me during this time, regardless of the way they did.

Kurzfassung

Diese Masterarbeit wurde in Zusammenarbeit mit der Firma Magna International Europe AG und im Speziellen mit der Sektion Magna Logistics Europe verfasst.

Diese Arbeit befasst sich mit der Erstellung einer Richtlinie zur Vereinheitlichung von diversen logistischen Prozessen des Materialflusses in einem internationalen Konzern. Das Ziel ist es hierbei, unter der Berücksichtigung von Prinzipien des Lean Management, sogenannte „World Class"- Prozesse für die Bereiche Wareneingang und Lagerhaltung, Linienversorgung, und Verpackungsmanagement des Magna Supply Chain Models zu definieren, welche anschließend in einem Richtlinienkatalog zusammengefasst werden.

Zur Definierung dieser „World Class"- Prozesse wurden von der Führungsebene bei Magna mehrere Expertenteams nominiert, welche dieses Projekt mit ihrer Erfahrung und ihrem Wissen unterstützten. Durch Workshops, Telefonkonferenzen und Interviews mit diesen Experten wurde in Kombination mit einer ausführlichen Literaturrecherche das Ergebnis dieser Arbeit definiert.

Das Vorgehen, um aussagekräftige Ergebnisse für einen solchen Richtlinienkatalog zu erhalten, wird hier in zwei Teilen beschrieben. Im ersten Teil werden die theoretischen Grundlagen für ein solches Projekt beschrieben, wobei ein besonderes Augenmerk auf Lean Management gerichtet wird. In Teil zwei werden sowohl das Vorgehen in einem solchen Project, als auch die Arbeit gemeinsam mit Expertenteams erläutert.

Aus diesem ambidexteren Ansatz resultierte eine Richtlinie, welche auf alle Werke von Magna anwendbar ist. Diese definiert neben verschiedenen logistischen Prozessen sowie Beispielen für bewährtes Vorgehen, gewisse Mindestanforderungen. Der Schwerpunkt wird dabei auf die drei oben genannten Themengebiete gelegt. Mit der Erfüllung aller Anforderungen, welche in der Guideline beschrieben werden, kann ein Werk als „World Class" bezeichnet werden.

Abstract

This master thesis was conducted in cooperation with Magna Logistics Europe, a section of the Magna International Europe AG.

This thesis addresses the creation of a guideline to standardize logistics processes of the material flow in the setting of an international enterprise. The target is the definition of “World Class” processes for the sectors goods receiving and warehousing, line feeding, and packaging management of the Magna supply chain model, under consideration of the principles of Lean Management. These processes were then collected in one standard.

To define these “World Class” processes, different expert teams were nominated by management level of Magna. Their task was to support this project with their deep knowledge and experience in the logistics sector. Using workshops, conference calls and interviews with the nominated experts, in combination with an extensive literature research, the results for this thesis were defined.

The approach to obtain significant results for such a guideline is described in two parts. Part one refers to the theoretical basics that are needed for such a project, whereby high attention was put on the topic of Lean Management. The second part explains the proceedings in such a project as well as the work with expert teams.

This ambidextrous approach resulted in a guideline, which is applicable on all Magna plants. Therein included are, besides the description of several logistics processes and best practice examples, definitions of minimum requirements that should be met by all plants. Herein the emphasis is put on the three above mentioned sectors. By fulfilling all in the guideline described requirements, a plant can be called “World Class”.

Table of Contents

1 Introduction

This thesis was prepared in cooperation with the company Magna Logistics Europe, a division of the Magna International Europe AG. Hereafter a short description of the company Magna and its divisions, the initial situation and reasons for this project, as well as the objectives and non-objectives, and the approach for this thesis are given.

1.1 The Company Magna International Inc.

Magna, as founded by Jack Warrington in 1961 and merged with Frank Stronach's Multimatic in 1969[1], is one of the most diversified automotive suppliers in the world. It designs, develops and manufactures automotive systems, assemblies, modules and components, and engineers and assembles complete vehicles. Customers of Magna are usually original equipment manufacturers (OEMs) of cars and light trucks in North and South America, Europe, Asia and Africa.[2]

With 34.4 billion dollar sales of original equipment parts in 2013, Magna International is currently the third largest global and largest North American OEM parts supplier.[3] Magna International consists now of 317 manufacturing operations and 83 product development, engineering and sales centers allocated in 29 countries and on 5 continents. At the moment more than 120,000 people are employed throughout the different locations.[4]

Magna International is divided in nine different groups, one for each product segment:[5]

- Cosma International (driveline systems, metal-forming solutions, engineering solutions, etc.)
- Magna Powertrain (powertrain design, development, testing and manufacturing)
- Magna Exteriors (bumper fascia systems, exterior trim, modular systems, etc.)
- Magna Interiors (cockpit systems, door panels, garnish & hard trim, etc.)
- Magna Seating (complete seating systems, foam & trim products, etc.)
- Magna Mirrors (interior & exterior mirrors, actuators, electronic vision systems, etc.)
- Magna Closures (door modules, window systems, roof systems, etc.)

[1] Cf. Mappes-Niediek (2004), p.47
[2] Cf. Magna International Inc. (2014c)
[3] Cf. Automotive News (2014), pp. 4
[4] Cf. Magna International Inc. (2014a)
[5] Cf. Magna International Inc. (2014b)

- Magna Electronics (driver assistance systems, engine electronics & sensors, etc.)
- Magna Steyr (fuel & battery systems, vehicle engineering & contract manufacturing, etc.)

1.2 Magna Logistics Europe

Due to the highly decentralized character of Magna International, Magna Logistics Europe (MLE) was founded in 2005 as an independent unit department within the Magna International Europe AG, to use cross group synergy effects and strengthen the decentralized structures.[6] The main objectives of MLE is the support of Magna groups and plants in Europe, Russia, South Africa, Asia (Magna Powertrain plants) and North America (Magna Powertrain plants) with the development and implementation of intelligent concepts in the logistics area, the establishment of a constant and smooth information flow and the harmonization and standardization of work processes, with the overall goal of a successful co-operation between several different plants of different groups.[7]

MLE currently employs 20 people on locations in Graz and Vienna, coordinates seven Magna groups (compare Figure 1) and administers a budget of approx. 367.7 million Euro.[8]

Besides of these main objectives, MLE also provides a number of other logistics services:[9]

- Supply chain design for customer projects
- Transport tender management
- Supply chain optimization inbound and outbound
- Transport and container management
- Optimization of planning processes
- Benchmarking and market studies
- Freight cost controlling
- Logistics reports and controlling
- MLE logistics systems for global use

[6] Cf. Magna Logistics Europe (2014), pp. 2
[7] Cf. Magna International Europe AG (2014)
[8] Cf. Magna Logistics Europe (2014), pp. 8
[9] Cf. Magna International Europe AG (2014)

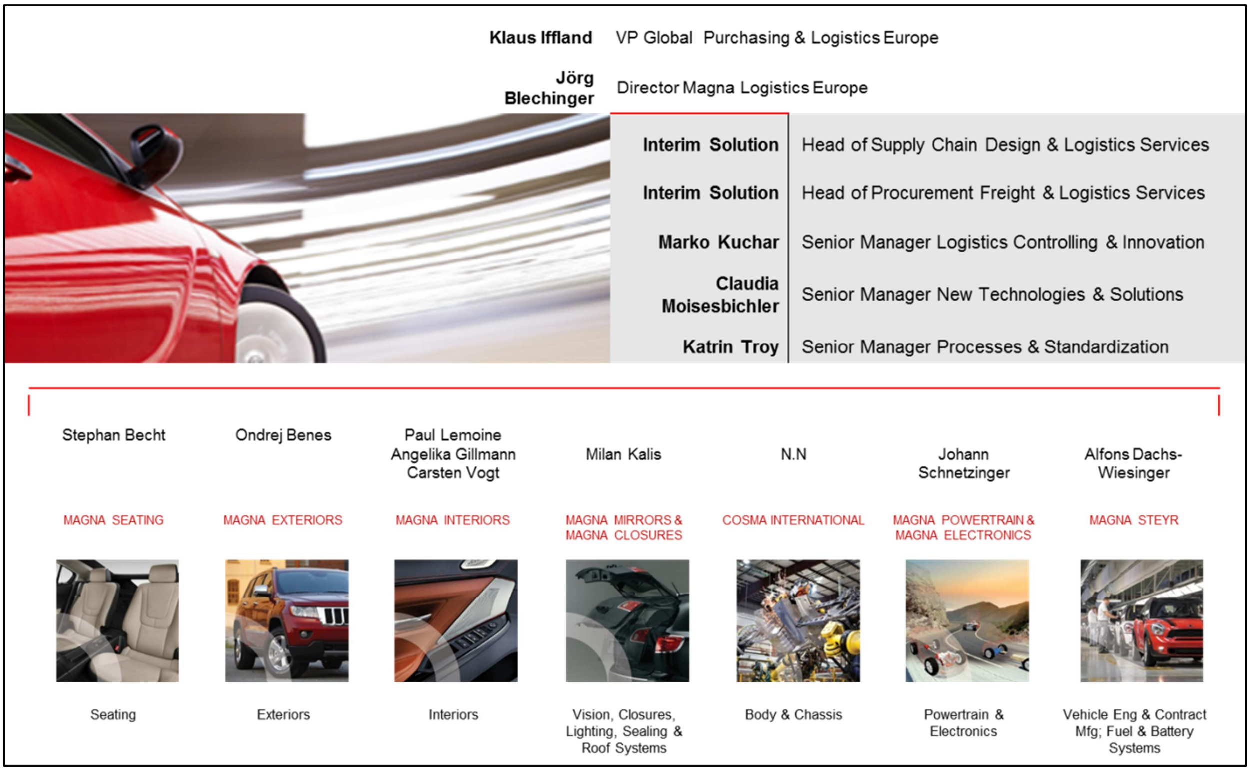

Figure 1: Organization chart MLE[10]

1.3 Initial Situation

In the following the initial situation, which led to the creation of this thesis, is described. For this, the three priorities of Magna are explained first, as the major strategy of Magna International; afterwards a short summary of the first project steps and the reason for the university collaboration is given.

1.3.1 The Three Priorities of Magna International

As a corporate strategy, Magna International set its main focus on three priorities, which are Leadership Development, Innovation Management and World Class Manufacturing (WCM).[11]

[10] Cf. Magna Logistics Europe (2014), p. 8
[11] Cf. Magna International Inc. (2014a)

Leadership Development

Some of the key objectives of the Magna Leadership Development System (LDS) program are:[12]

- Strengthening of competencies
- Succession planning
- Identification of internal talents to accelerate their development and acquisition strategies for talents to fill gaps
- Promotion of employee engagement
- Development of an environment for continuous learning and internal growth

Innovation Management

Magna sees innovation as a major driver of the automotive industry. New technologies like active safety systems which use radar, sonar and video to detect obstructions, electric cars with a range of 400 km and cars that can drive autonomous are good examples for the rapid technological progress within this industry.[13]

There are three areas which are critical for innovation:[14]

- Product development
- Process development
- Material development

Magna tries to be a leader in all of these fields to define its market position.

World Class Manufacturing

WCM was introduced to keep up with the accelerated pace of change that comes with new markets, new technologies and new regulatory requirements. Magna sees WCM as the key to competiveness in the face of change and therefore has embraced it as an operating philosophy, which should drive constant growth.[15]

This WCM initiative consists of nine different fields (compare Figure 2), which underlines its holistic approach.

[12] Cf. Magna International Inc. (2013b)
[13] Cf. Magna International Inc. (2013a)
[14] Cf. Magna International Inc. (2013a)
[15] Cf. Magna International Inc. (2013c)

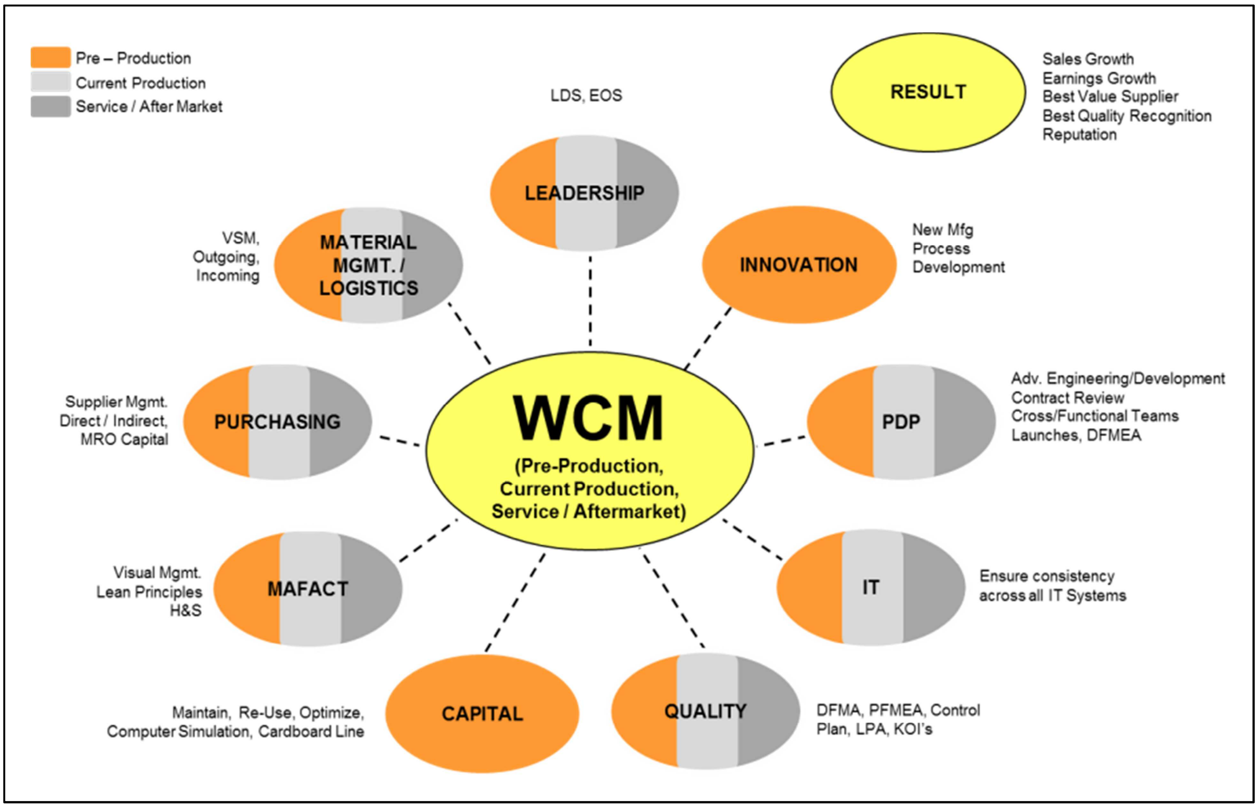

Figure 2: WCM influence factors[16]

Within these 9 fields, Material Management and Logistics lies in the responsibilities of MLE, which decided to introduce the World Class Logistics (WCL) initiative to define, communicate and implement World Class for Material Management and Logistics within the Magna group and thereby contribute to the WCM initiative.

1.3.2 The World Class Logistics Project

This project was created with the target to align the existing knowledge and the used systems in the different Magna groups to create cross-divisional benefits as well as a reference work applicable by all Magna plants to face the challenge of World Class Manufacturing from the logistics perspective.[17]

The lead for this project was from the start within the Processes and Standardization department, which started to collect information about World Class Processes within the different Magna groups. Soon it became clear, that the high amount of information available was vague and unsorted and due to the lack of resources within MLE for such

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[16] Magna International Inc. (2014d), p. 1
[17] Cf. Expert interview with Katrin Troy, conducted on Oct.-17, 2014

a project, an alternative solution was considered. Since MLE already had good experiences with university collaborations, it was decided to reach out for a graduate student, who should approach this topic within a scientific research work.

1.4 Objectives of this Thesis

To face WCM from the Logistics point of view, the creation of a document, which describes World Class processes within logistics, was decided. Since it was not possible to calculate the total scope of this project at its start, and the strong focus on university collaborations of MLE, it was agreed to undertake the first project steps in the course of a master thesis.

For this thesis, the following goals were defined:

- Definition of criteria which should be taken into a World Class Logistics (WCL) guideline
    - Literature research
    - Interviews with experts inside and outside of the Magna group
    - Preparation, participation and discussion of outcome of workshops to define WCL criteria
- Development and elaboration of concepts to fulfill those criteria
    - Preparation of concepts for discussion with Magna experts
    - Preparation, participation and discussion of outcome of workshops to find concepts and processes for WCL
    - Interviews with experts inside the Magna group
    - Support of Magna expert groups during the identification of concepts by applying management principles like:
        - Lean management
        - 6R's
        - Avoidance of wastes
- Elaboration and definition of best practice examples
    - Find and define best practice examples within or outside the Magna group, in cooperation with experts in- and outside of Magna
- Documentation of concepts and best practice examples within one guideline
    - Draft of World Class Logistics Processes according the defined structure of the WCL Guideline

1.4.1 Non-Objectives

For a more precise description, which targets should be attained within this thesis, non-objectives were defined:

- Development of a document that is too prescriptive in any detail
- Development of a summary of current known best practices
- Development of a documentation system
- Development of a process controlling system
- Development of WCL trainings
- Consideration of the Non- Conformance Management
- Review of the Magna International Europe supply chain process model
- Review of the vision, mission, values, strategy, and roadmap of Magna Logistics Europe
- Development of process specifications respectively system specifications
- Development of process flow charts for WCL processes

1.4.2 Field of Examination

Besides a clear definition of objectives and non-objectives, a definition of the area which should be examined was required. To define these areas, the Magna Supply Chain Reference Model was used, which describes the processes of the entire supply chain (compare section 3.2.1).

In this supply chain model, the following processes of the supply chain execution phase were considered:

- Goods receiving and warehousing
- Line feeding
- Packaging management

These processes were defined because of their high importance in everyday logistics operations. Additionally for these processes a basis was already build at the beginning of this project, by defining two expert teams who should assist in the work for this thesis (compare section 4.2).

1.5 Approach

The course of action for this thesis was split up in two phases, for each considered field.

Phase one was used to build up the needed knowledge for the concerning field. To accomplish this, literature from the university, MLE or online sources was gathered and read. After this first literature research, preparations for workshops with the Material Flow Expert Team began.

Simultaneously, a first definition of World Class criteria was done, to be presented and discussed during the workshops.

With the end of the first workshop, phase one was completed as well.

In phase two, the findings of the workshops were analyzed, compared with the literature and summarized in one guideline. This was done in accordance with the Material Flow and Packaging Management Expert Teams, which will be introduced later. Therefore, different conference calls and expert interviews were executed to align the findings with all members of the teams.

A more detailed view on the approach can be seen in Figure 3.

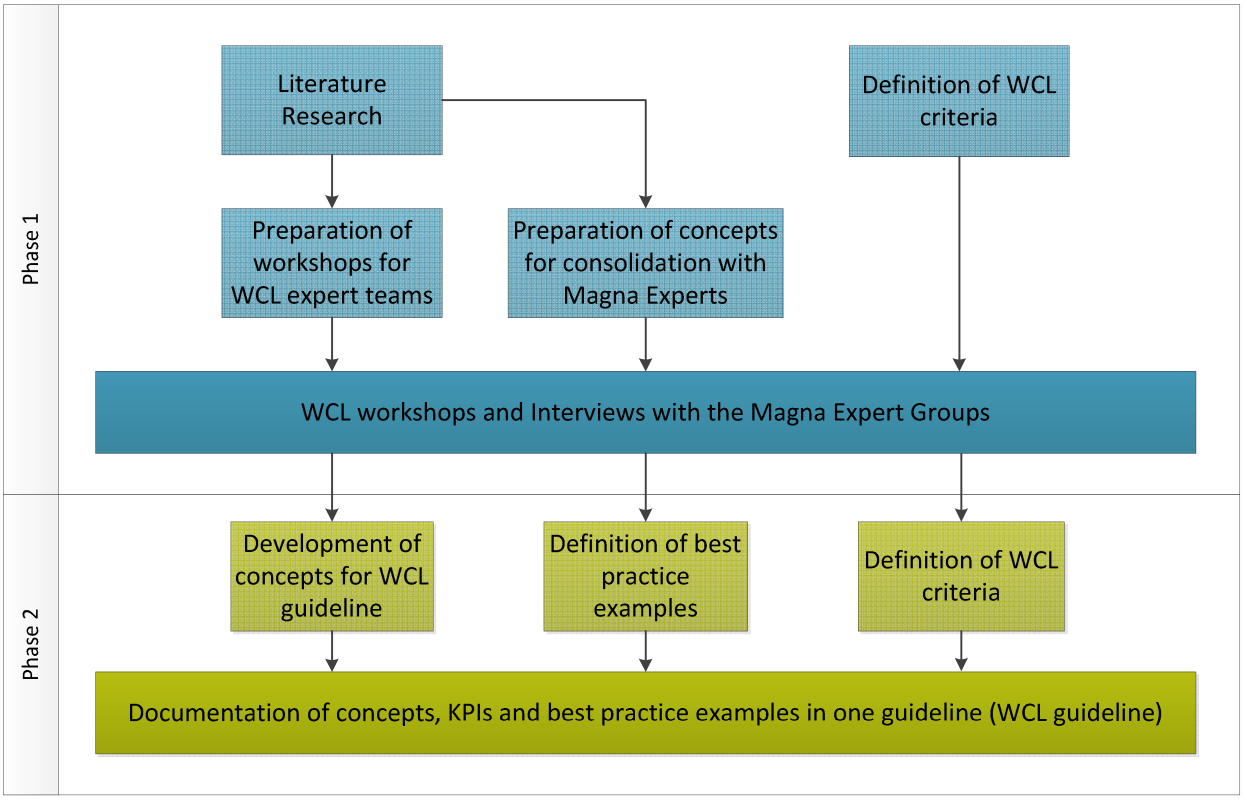

Figure 3: Course of action[18]

[18] Own Illustration

2 Theoretical Principles

In the following section, the theoretical principles which form the basis for this thesis are explained. First the term logistics itself is described and a short historical overview about logistics is given. Then Lean Management and some important tools of Lean Management, as a major part for this thesis, are described. After that, supply chain management and the Magna Supply Chain Reference Model, which is the basis for the structure of both, this thesis and the complete World Class Logistics project, are explained. Based on this, the terms goods receiving, warehousing, line feeding and packaging management are explained, since these points are the topics of the supply chain which were considered in the course of the thesis and whereupon the results refer to.

At the end of this chapter a short explanation on Expert Interviews and workshops is given, because these two methods were mainly used to gather information in the course of this thesis.

2.1 Logistics and Supply Chain Management

To get a good insight into the theoretical principals for this thesis, the term logistics itself should be explained first. In the following the origins of the term logistics, its historical background and importance in modern industries is explained, as well as the tasks modern logistics systems have to fulfill.

2.1.1 Definition of the Terms Logistics and Supply Chain Management

Logistics describes the scientific doctrine of planning, optimization and control of material-, energy-, and information flows in different kinds of systems, networks or processes. It is also a sector denotation for all organizations or divisions of an organization that fulfill logistics services. Besides the transport and handling of goods, customer oriented services like custom-built packaging or information management are provided by logistics systems. The scope in which logistics is considered in this thesis is described in section 2.1.3.[19]

Supply chain management describes all necessary management activities of logistics processes from the supplier to the customer with the target to raise the customer's

[19] Cf. ten Hompel & Heidenblut (2011), p. 185

benefit in an efficient way. By utilizing cross-process communication and planning, the complete supply chain is optimized and inventory along the supply chain is reduced.[20] A detailed description of supply chain management and its function in this project is given in section 3.1.

2.1.2 The History of Logistics

The first origins of the term logistics can be found in the Greek or Latin language (lego respectively logica). In the Roman Empire, Athens and Byzantium officials with the title "logista" had the duty of accounters and distributing edibles.[21]

The oldest definition of logistics goes back to byzantine emperor Leontos VI (886-911) who describes logistics as the third art of war after tactics and strategies, whereby logistics had the task of a comprehensive support of the army.[22]

Antoine-Henri Jomini described logistics as the third of five main parts of the art of war. In his interpretation logistics is the art to keep the army moving or the science to prepare and secure the applications of everybody else.[23]

History shows, that in every decade, military efforts were particularly successful, when military command had a special focus on the organization of troop movements, supply-structures, material provision, material management, and the transport of the sick and wounded.[24]

For the civil sector, a similar assumption can be made. The larger a company becomes, the more they have to focus on their logistics system. The importance of logistics in modern economics can be recognized by taking a look at the German market. The logistics market volume is roughly twice as much as it was in 1995. In 2011, the logistics turnover in Germany was 223 billion Euros, and logistics companies employed 2.82 million people.[25] With these figures, the logistics sector is the third biggest in Germany, after commerce and automotive industry.[26] In Europe, the logistics turnover in 2012 was 930 billion Euros in total, with Germany being the largest logistics market.[27]

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[20] Cf. ten Hompel & Heidenblut (2011), p. 301
[21] Cf. Koch (2012), p. 1
[22] Cf. Zsifkovits (2013), p. 23
[23] Cf. Jomini (2009) pp. 43
[24] Cf. Heiserich, Helbig, & Ullmann (2011), p. 3
[25] Cf. Kille & Schwemmer (2013), pp. 1
[26] Cf. Bundesministerium für Verkehr und digitale Infrastruktur (2011)
[27] Cf. Kille & Schwemmer (2014), pp. 1

In the automotive industry logistics was brought into focus with the beginning of mass production. In this context Henry Ford's famous Model T with an output of 35.000 cars between 1910 and 1911 has to be mentioned. [28]

From a logistics view, Charles E. Sorensen, former companywide chief of production planning and development of Ford's Rouge plant and executive vice president of Ford Motor Company[29], describes the challenges they faced in his autobiography "My Forty Years with Ford":

"[…] the job of putting the car together was a simpler one than handling the materials that had to be brought to it. Charlie Lewis, the youngest and most aggressive of our assembly foremen, and I tackled this problem. We gradually worked it out by bringing up only what we termed the fast-moving materials. The main bulky parts, like engines and axles, needed a lot of room. To give them that space, we left the smaller, more compact, light-handling material in a storage building on the northwest corner of the grounds. Then we arranged with the stock department to bring up at regular hours such divisions of material as we had marked out and packaged. This simplification of handling cleaned things up materially. But at best, I did not like it. It was then that the idea occurred to me that assembly would be easier, simpler, and faster if we moved the chassis along, beginning at one end of the plant with a frame and adding the axles and the wheels; then moving it past the stockroom, instead of moving the stockroom to the chassis. I had Lewis arrange the materials on the floor so that was needed at the start of assembly would be at that end of the building and the other parts would be along the line as we moved the chassis along. […] Then one Sunday morning, after the stock was laid out in this fashion, Lewis and I and a couple of helpers put together the first car, I'm sure, that was ever built on a moving line."[30]

The development of the moving production line with a materials-to-workstation and supermarket principle can be seen as one of the most influencing developments in the automotive industries and is still the only used assembly method used by automotive OEMs.

2.1.3 The Objectives of Logistics

Logistics involves all activities of the holistic planning, steering and control of the material flow, information flow and the value stream within the producing company, or

[28] Cf. Ford & Crowther (1923), p. 74
[29] Cf. Bryan (1993), pp. 267
[30] Sorensen (2006), pp. 117

between different companies (customer-supplier). Therefore Logistics comprises all the operations needed to deliver goods or services, except making the goods or performing the services.[31]

The task of logistics is to assure, that

- the right product, information, or service,
- is in the right place,
- at the right time,
- in the right quality,
- and in the right quantity,
- for the right price,

available.[32] This task is also well known as the 6R of logistics.

Corporate logistics covers the in-house and external logistics. In-house logistics connects goods receiving and dispatch, including all transports needed in between, inside the plant. External logistics, also known as procurement logistics (from supplier to the plant), as distribution logistics (from plant to customer), or as reverse logistics (from customer to plant and from plant to supplier), connects goods receiving and dispatch with different logistics centers, plants and companies (compare Figure 4).[33]

The procurement logistics has to guarantee the companies' provision of materials in terms of material type, quality, quantity and time. Its task is to cover the material requirements of both, the company itself, and the suppliers outside of the company. Procurement logistics has a high strategic importance, since it is at the beginning of the supply chain and is therefore jointly responsible for the company's success.[34]

Production logistics or in-house logistics comprises all parts of the operative material flow and information flow, including administrative tasks, which are needed for production. The target is an on-time and economic provision of the correct materials, at the needed production location, in the right quantity and quality. Production logistics plans, designs, executes and controls the material and information flow in the production, from goods receiving to the distribution warehouse, including all different production and assembly stations, and production warehouses in between.[35]

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[31] Cf. Arndt (2006), p. 36
[32] Cf. Arndt (2006), p. 36
[33] Cf. Gudehus (2010), p. 7
[34] Cf. Wannenwetsch (2010), p. 114
[35] Cf. Martin (2014)

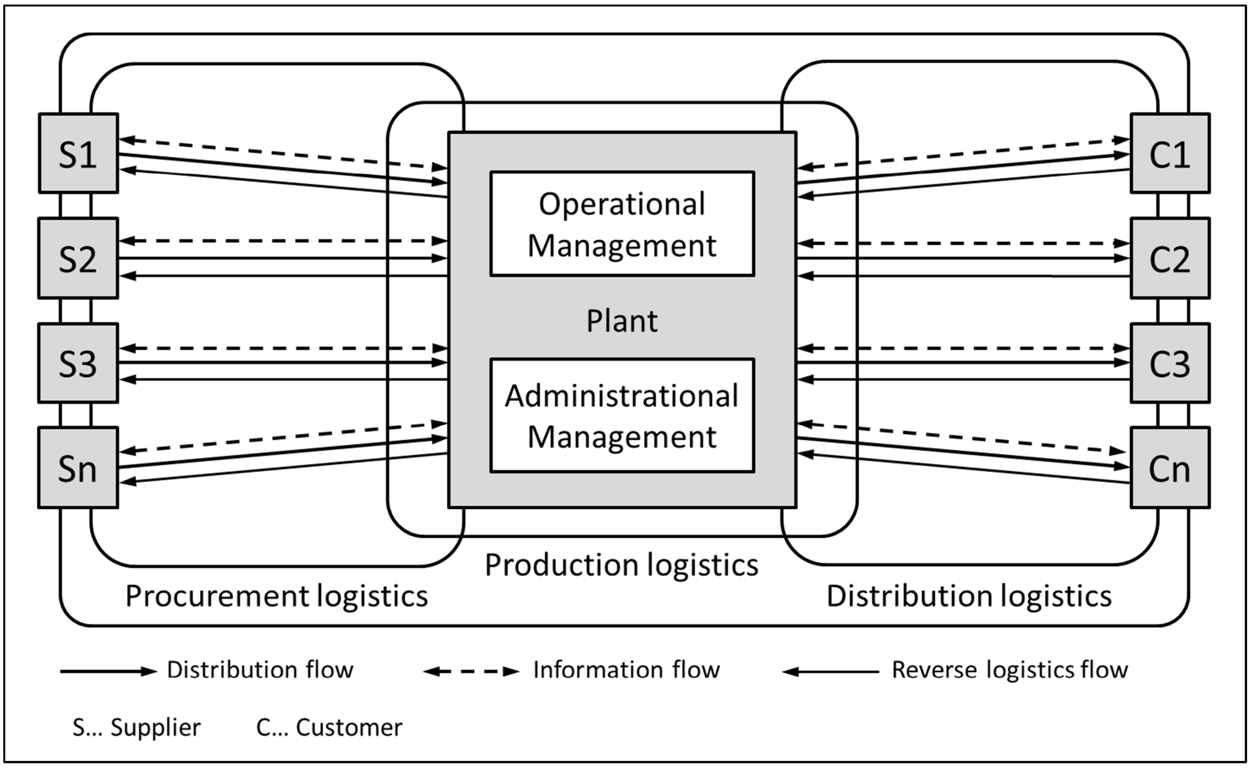

Figure 4: Areas in company logistics[36]

The responsibilities of distribution logistics are to organize and execute the cost-effective and reliable supply of customers. Influencing criteria are the selection and design of distribution processes, the selection of distribution sites, the planning and dimensioning of distribution warehouses and the planning, design and execution of the customers supply.[37]

The reverse logistics tasks are the transportation, storage, processing or depositing in a final depot of the production residues, consumption wastes, wrapping materials, empties, and depleted goods and commodities, which are needed during the production process.[38]

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[36] Own Illustration, revised from Gudehus (2010), p. 7
[37] Cf. Koether (2012), p. 27
[38] Cf. Gudehus (2010), p. 8

2.2 Lean Management

Lean Management is the currently best known production principle. Almost every automotive supplier or OEM tries to implement and interpret Lean Management in his own way.[39]

2.2.1 History of Lean Management

The principles of Lean Management were developed after World War 2 by Toyota, as an answer to mass-production, as it was common practice in the US at that time. The reason for the development was on one hand the weak Japanese economy, where mass-production, in combination with high inventories, a high number of expensive machines and many employees, was too expensive for Toyota.[40] On the other hand, Toyota faced very different challenges. While Ford was focused on producing massive numbers of only a few different car models, Toyota faced the challenge to produce only a few numbers of many different vehicles.[41]

Lean Management became famous when it was introduced in the 1990s MIT study "The Machine that changed the World", by Womack, Jones and Roos.

In their five years study they compare Japanese productions programs with Americans and Europeans, and the results were absolutely devastating. Their study explained a huge gap in productivity between Japanese companies and western ones. Some key figures, which show the difference between European, American and Japanese plants in the early 1990s, can be seen in Table 1, which summarizes the performance of volume producers at assembly plant level in addition to productivity and quality. Striking numbers are the productivity, the needed space for repair work and the number of suggestions of employees.[42]

Two more MIT-studies from 1989, which addressed the same questions, achieved similar results.[43]

What can be seen in these numbers is that the productivity in Japanese plants was twice as much compared to European plants at the beginning of the 1990s, while having far less quality problems.[44]

[39] Compare Nissan Monozukuri, Toyota Production System, World Class Manufacturing, Volkswagen Lean Center, etc.
[40] Cf. Ohno (2013), pp. 35
[41] Cf. Liker (2004) pp. 7
[42] Cf. Womack, Jones, & Roos (1990)
[43] Cf. Graf (1996), pp. 2

This example shows the main reason why European and American companies put a high priority into the implementation of Lean Management.

	Japan	North America	Europe
Performance			
Productivity (hours/ vehicle)	16.8	25.1	36.2
Quality (defects/ 100 vehicles)	60.0	82.3	97.0
Layout			
Space (sq. ft./ vehicle/ year)	5.7	7.8	7.8
Size of Repair Area (% of assembly space)	4.1	12.9	14.4
Inventories (days for 8 sample parts)	0.2	2.9	2.0
Work Force			
% of Work Force in Teams	69.3	17.3	0.6
Job Rotation (0 = none, 4 = frequent)	3.0	0.9	1.9
Suggestions/ Employee	61.6	0.4	0.4
Number of Job Classes	11.9	67.1	14.8
Training of New Production Workers (hours)	380.3	46.4	173.3
Absenteeism	5.0	11.7	12.1
Automation			
Welding (% of direct steps)	86.2	76.2	76.6
Painting (% of direct steps)	54.6	33.6	38.2
Assembly (% of direct steps)	1.7	1.2	3.1

Table 1: Summary of assembly plant characteristics[45]

2.2.2 Advantages, Principles and Strategies of Lean Management

Basically, Lean Management is a combination of the best features of craft production and mass production. It has the ability to reduce the costs per unit and at the same time improve the quality.[46] Processes that were designed to be lean usually are, compared to processes which were not designed with respect to Lean Management, able to:[47]

- Produce less waste or defective parts
- Have shorter cycle and flow times
- Use less material
- Require less investment
- Use less inventories
- Increase customer satisfaction

[44] Cf. Günther & Boppert (2013), p. 14
[45] Revised from Womack et al. (1990), p. 92
[46] Cf. Womack et al. (1990), p. 277
[47] Cf. Wilson (2010), pp. 9; Plenert (2007), p. 145

- Consume less space
- Use less people

To attain any of the above mentioned effects, many different tools exist in Lean Management, which will be described later in section 2.3. However, some basic principles of Lean Management exist:[48]

- Teamwork
- Self-responsibility
- Total information
- Customer orientation
- Standardization
- Continuous improvement
- Immediate correction of errors when they occur
- Ahead thinking and ahead planning
- Small and controlled steps

Therefore six main strategies of Lean Management can be derivated:[49]

- **Customer orientation and slim production**
  Continuous material flow (just-in-time, pull principle)
- **Fast and safe development and introduction of new products**
  Simultaneous engineering
- **Ability to growth and conquest**
  Strategic capital investment
- **Corporate quality in every field**
  Total quality management
- **Acquire new customers and maintain existing**
  Proactive marketing
- **Harmonic inclusion of the company in society**
  Company as family

[48] Cf. Brunner (2011), p. 62
[49] Cf. Brunner (2011), p. 63

2.3 Tools of Lean Management

Lean Management uses a multitude of tools, and the explanation of all of them would go beyond the scope of this thesis. For this reason only a small number of them, mainly which were used for the work and results of this thesis, will be mentioned and explained here.

2.3.1 Reduction of Wastes

The reduction of errors is a major target of every producing company. In general when talking about errors someone talks about defective parts and how to reduce them. Lean Management extends this definition by including errors not only in the final product but in every single work step and also recognizes unproductive behavior.[50]

The first step to a reduction of these wastes and unproductive behaviors is to recognize them. The Japanese word for waste is “Muda” and it always comes with its two relatives “Mura” (unevenness) and “Muri” (overburdening), also known as the three MU’s.

Muda

“Muda” describes all activities that don’t add any value for the customer while still consuming resources.[51] In the Toyota Production System seven different types of waste were defined, more recent literature usually describes eight different types. These eight types of wastes can be adapted for logistic systems:[52]

- Over delivery
- Waiting times
- Unnecessary transports
- Undefined processes
- Oversized inventories
- Unneeded activities
- Errors in terms of the 6 R of logistics (wrong product, wrong time, wrong place, wrong quality, wrong quantity, wrong price)
- Unused potentials of employees

[50] Cf. Ohno (2013), p. 78
[51] Cf. Lean Enterprise Institute (2008), p. 61
[52] Cf. Günther & Boppert (2013), p.46; Brunner (2011), pp. 70

Mura

“Mura” defines the imbalance or unevenness of a process or operation[53] and therefore describes all losses due to a missing harmonization of available capacities.[54]

An example for an imbalanced process is a loading dock that has to handle 10 trucks per day, all of them arriving between 7 and 11 am. Employees working at this loading dock will have to rush their operations in the morning, while they have practically no work in the evening. Balancing the arrival of the trucks over the whole day would reduce the load of employees in the morning and therefore reduce the probability of errors while reducing boredom in the evening simultaneously.

Muri

“Muri” describes the avoidance of overwork and overloading in terms of equipment and employees which result in failures, breakdowns and accidents. In the case of employees it describes physical and mental overstress that results in overfatigue, stress, a higher error probability and a high degree of dissatisfaction.[55] Same principles apply to machines and equipment which show a higher degree of wear when overloaded.

Different Types of MUs

For every MU two different types can be distinguished.

Type one describes tasks which seem essential and cannot be eliminated immediately. Type two describes activities that can be eliminated or changed immediately (e.g. by applying Kaizen, 5 Why, etc.).[56]

In the following some of the most common MUs that occur in companies are described:[57]

- Short term storage
- Observation of running machines
- Carrying of heavy parts
- Long transport routes for parts
- Waiting for materials

[53] Cf. Lean Enterprise Institute (2008), pp. 61
[54] Cf. Brunner (2011), p. 71
[55] Cf. Brunner (2011), p. 71
[56] Cf. Lean Enterprise Institute (2008), pp. 61
[57] Cf. Brunner (2011), pp. 72

- Errors
- Accumulation of inventory
- Part shortages
- Searching for tools
- Down time
- Counting of parts
- Rework
- Overproduction and multiple handling

2.3.2 Poka Yoke

Poka Yoke describes the efforts to reduce errors by using systems, structures or part design, that don't allow an error. The idea of this principle is that it is always cheaper to detect an error in-house, than at the customer.[58]

Poka Yoke can be implemented using surveillance systems like cameras, checking every single part on errors, before sending to the next station or customer. Poka Yoke can also be implemented by designing parts in a way they only fit together in one specific, the right way.[59]

Typical examples for Poka Yoke in everyday life are plugs that can only be inserted in one specific way (e.g. USB stick), or the refueling system at a gas station, which prevents from the confusion between diesel and gasoline by providing spigots with different diameters.

A typical application for Poka Yoke in logistics systems is the commissioning process. Pick-by-light, put-to-light or similar systems do not only help to reduce errors, but also improve productivity of employees, by reducing the time for searching a specific part.[60]

2.3.3 Pull Principle

A pull system is used to support the realization of a flow process and therefore balances the workload along the value stream.[61]

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[58] Cf. Dickmann (2009), p.8
[59] Cf. Lean Enterprise Institute (2008), p. 18
[60] Cf. Günther & Boppert (2013), p. 19
[61] Cf. Günther & Boppert (2013), p.52

When talking about pull systems usually Kanban (compare section 2.3.4) is the first word that comes to mind. But before thinking about implementing a Kanban system, a pull strategy has to be selected. In general three pull systems are differentiated.

Fill-Up Pull/ Supermarket Pull

This is the most common and widespread pull principle. Every process only produces with the purpose to fill up its own supermarket. Typically, material is withdrawn by downstream customer processes to produce the next product stage. The information of the material withdrawal (usually sent via a Kanban or Andon system; compare 2.3.4 and 2.3.5) gives the upward process the authorization to replace these parts in its supermarket. Every process bears responsibility to replenish its supermarket.[62]

The disadvantage of this system is the need of a small storage for all produced parts to guarantee availability for the downstream processes. This might not be possible with high part numbers or in small production areas.

Sequential Pull

A sequential pull system is used if the produced products are too versatile or too large to have one storage location for each. Here products are built “make-to-order” while still reducing the overall inventory. The responsibility of the production planning is to provide the right amount and mix of parts to be produced to fulfill the customer order. Often this is done using Kanban cards in combination with a sequence list. The facilitation of the first-in, first-out principle (FIFO) has to be maintained throughout the whole process.[63]

A FIFO system describes a withdrawal regulation, where always these parts are withdrawn first, which already spent the longest time lapse inside a system (e.g. warehouse). The idea is to have removed the oldest parts first, since almost all commodities underlie temporal transformations (e.g. expiration date of groceries, etc.).[64]

Mixed Pull

This is a combination of the two above mentioned systems. This type of pull is usually applicable if a small amount of part numbers (20%) accounts for the majority of the daily

[62] Cf. Lean Enterprise Institute (2008), p.81
[63] Cf. Lean Enterprise Institute (2008), p. 82
[64] Cf. ten Hompel & Heidenblut (2011), p.99

production volume (80%). This system allows to selectively apply supermarket and sequential systems and to obtain the benefits of each system. Sequential pull and supermarket may run parallel, sequential or alternating.[65]

2.3.4 Kanban

Kanban is the Japanese word for sign or signboard. Therefore Kanban is a signaling system that gives authorization and instructions to produce or withdraw items in a pull system. The information in a Kanban process is always going from a downstream process to the next upstream process, while the material always moves from an upstream process to the next downstream process. This principle can easily be recognized in Figure 5.[66]

In this example, production control sends the demands to the final assembly station, which produces the needed parts for the finished goods inventory. Once, the final assembly station needs replenishment, it sends the information to the next upstream process, fine finishing, which start to produce the needed parts for the assembly. This process is conducted the throughout complete production process, which ensures that no unneeded parts are produced.

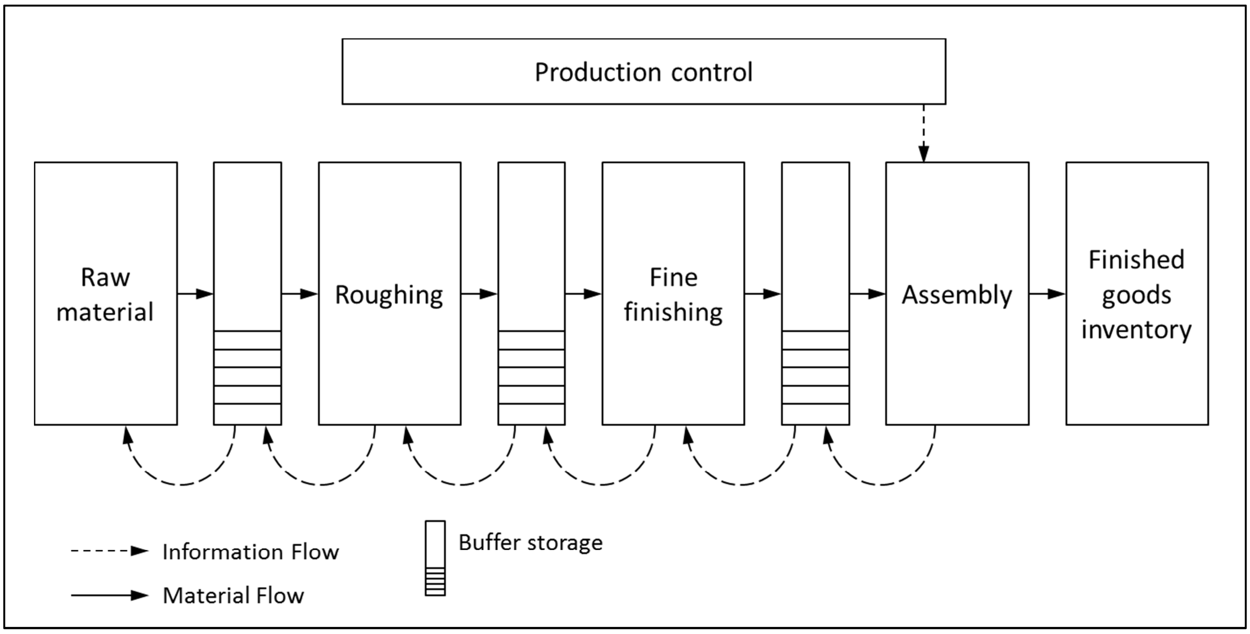

Figure 5: Kanban control cycle[67]

[65] Cf. Lean Enterprise Institute (2008), p. 83
[66] Cf. Gudehus (2010), pp. 370
[67] Own Illustration, revised from Brunner (2011), p. 112

While different Kanban systems exist, every one of these systems has the same two main functions: Initiate the production and movement of items. [68]

The most important systems to realize Kanban are:[69]

- **Classic Kanban system**
  The easiest and most known way to realization is the use of Kanban cards. Empty containers are put on a specific location together with the Kanban card. The type and quantity to replenish is noted on the Kanban card.
- **Two Container Kanban**
  Refill is triggered by emptying the first of the two containers and putting the empty container on a defined position or placing the operations card on a board. The refill is done while the employee empties the second.
- **One container Kanban**
  The card of the container in use is put on a board as soon as its content reaches the order quantity which is noted on the card.
- **Electronic Kanban**
  Electronic Kanban can be realized without the use of Kanban cards. The refill is triggered by scanning of the empty container. The Enterprise Resource Planning (ERP) system forwards the order to the warehouse and arranges the delivery of the new container.

The popularity of Kanban can be explained by the many advantages it brings with it, when implementing it in a pull system. These advantages are:[70]

- Visualization
- IT-system free control possible
- Easy self-adjusting dimensioning
- Decentralized control, on-site responsibilities
- High delivery capacity
- Customer and product orientation
- Reduction of wastes
- Early recognition of errors
- Standardization of easy and recurring processes

[68] Cf. Plenert (2007), pp. 268
[69] Cf. Ohno (2013), p. 167; Lean Enterprise Institute (2008), pp. 42; Gudehus (2010), p. 454;
[70] Cf. Dickmann (2009), pp. 13

To create a fully working Kanban system, the following six rules always have to be considered:[71]

1. Downstream process orders parts only in the amount stated on the Kanban card
2. Upstream processes produce parts only in the amount and sequence defined by the Kanban card
3. No parts are produced or transported without a Kanban
4. Every part, container or skid always has a Kanban attached
5. Defective parts will never be transferred to downstream processes
6. Careful reduction of Kanban cards improves system stability, reveals problems and reduces inventories

2.3.5 Andon

Andon is a management tool that visualizes the status of an operation or task in a specified area whenever an abnormality occurs. Andon signals can be used to indicate the status at the production line. A green light would show everything is working normal while a red light indicates abnormalities like machine downtimes, quality problems, tooling faults, operator delays, material shortages or needed actions like maintenance. It can also be used to visualize the planned versus the actual production.[72]

Andon is the Japanese word for lamp. They usually consist of several rows of lamps on a signboard, whereby every lamp indicates one workplace (compare Figure 6). Depending on the status of each workplace, the color of the lamp may change. The idea of these boards is to summon quick response if assistance is needed.[73]

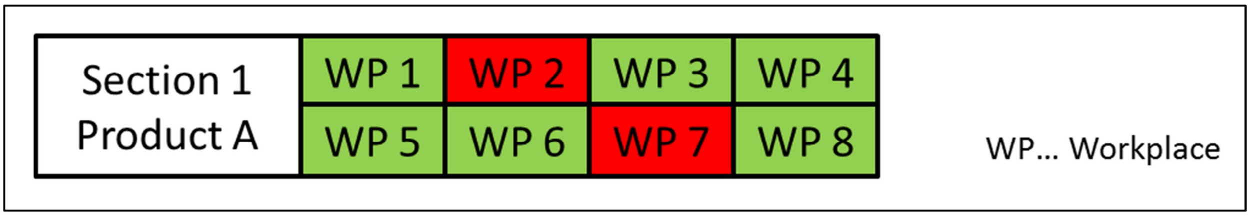

Figure 6: Andon board with stops at workplaces 2 and 7[74]

[71] Cf. Ohno (2013), p. 65
[72] Cf. Lean Enterprise Institute (2008), p. 3
[73] Cf. Lean Enterprise Institute (2008), p. 3
[74] Own Illustration, revised from Lean Enterprise Institute (2008), p. 3

2.3.6 Kaizen

Kaizen is usually translated with continuous improvement.[75] While this translation indeed gets to the heart of the matter, some more complex explanations exist, which describe Kaizen as a state of being constantly uncomfortable with the way things are right now. Therefore an ideal state of perfection is pursued, even if the achievement of this state is unrealistic.[76] The idea of Kaizen is to integrate it into the daily work routine, with the focus of reducing wastes (compare section 2.3.1) and creating standards.

The usually small and subtle improvements achieved by Kaizen help to ensure a strong competitive market position towards rivals and can therefore create better, larger and more long-lasting results over time. Figure 7 shows a “Kaizen wheel”, where Kaizen is used to avoid and reduce the eight types of waste. Reducing wastes results in progress, moving the wheel upwards. Standardization of achieved skills protects from going downward again, if problems occur.[77]

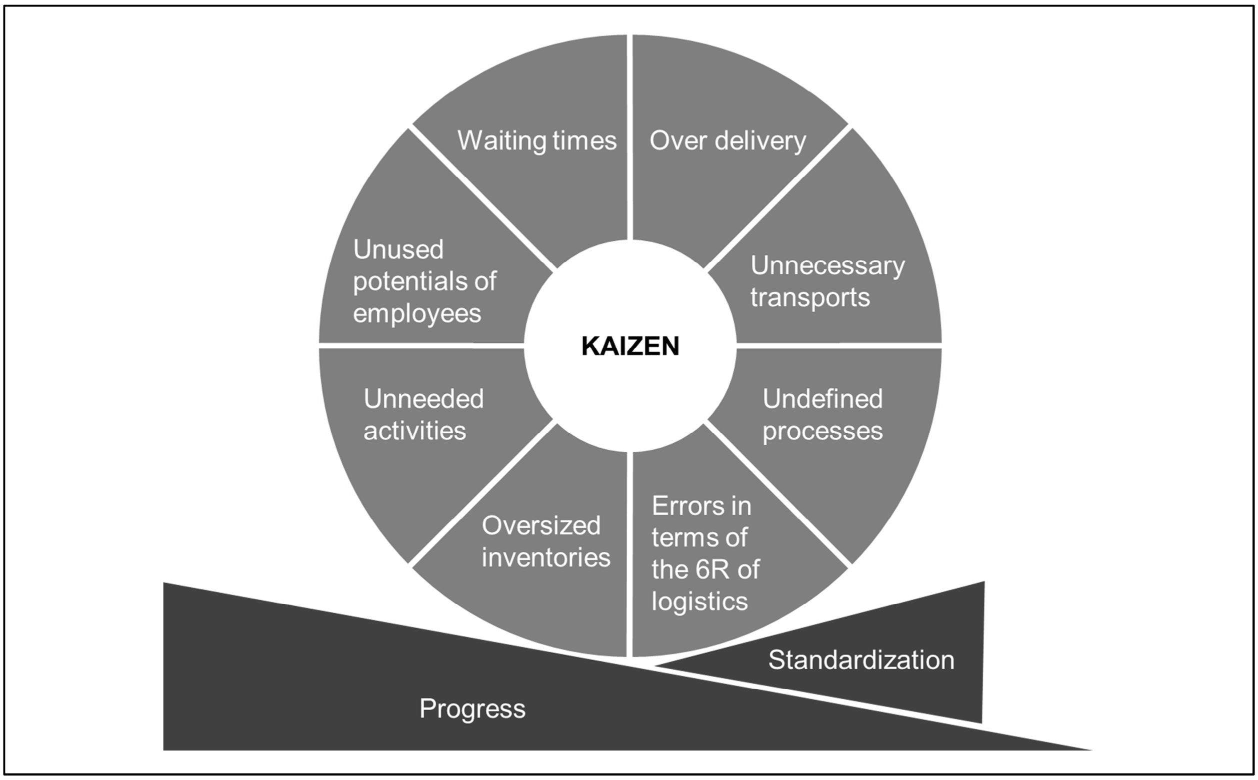

Figure 7: Progress through Kaizen[78]

[75] Cf. Lean Enterprise Institute (2008), p. 40
[76] Cf. Medinilla (2014), pp. 4
[77] Cf. Ortiz (2006), p. 7
[78] Own Illustration, revised from W. A. Günther & Boppert (2013), pp. 11

2.3.7 Plan Do Check Act Cycle

The Plan Do Check Act (PDCA) cycle or Deming-cycle was formulated by US-physicist and structural engineer William Deming in the 1950s. Today, the PDCA-cycle is the basic of every improvement process, due to its systematic problem solving approach.[79]

A PDCA cycle consists of four phases (compare Figure 8)[80]:

1. Plan: In the first phase, the current situation is analyzed by collection and evaluation of all available data. Based on this analysis, an improvement plan is defined.
2. Do: The improvement plan is executed in cooperation with the employees.
3. Check: Evaluation to ascertain, whether the defined objectives have been attained during the “Do-phase”.
4. Act: A standardization of the successful measures, which are the basis for future improvement processes, is done in this phase.

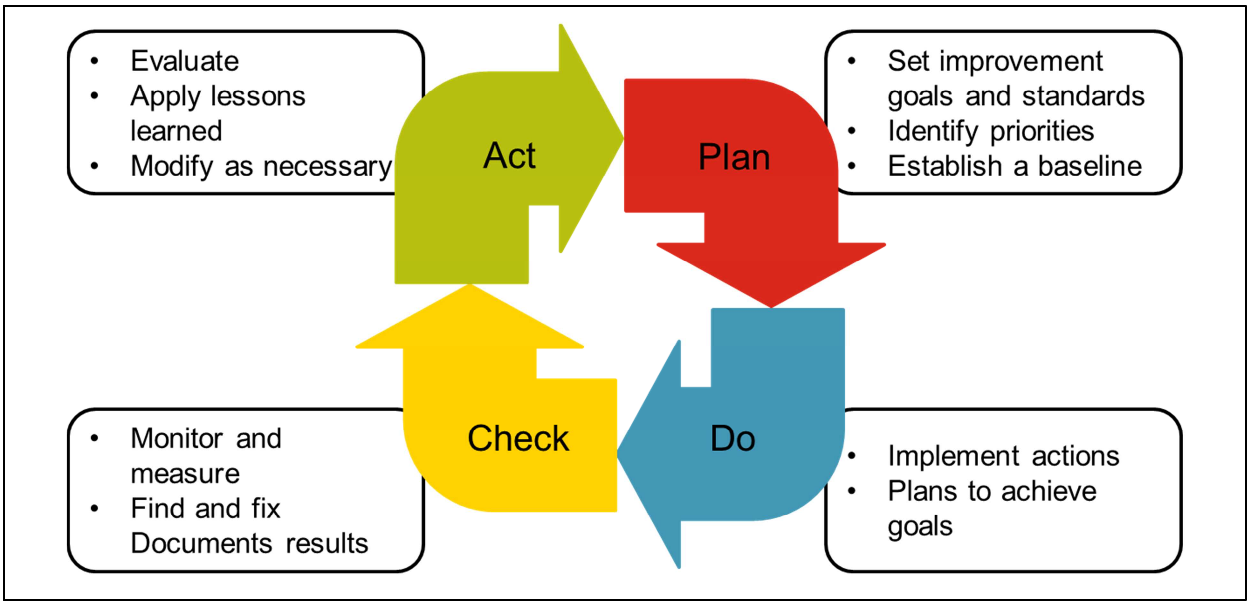

Figure 8: PDCA-cycle[81]

2.3.8 Just-In-Time

In a just-in-time (JIT) system, the ordered materials are delivered exactly in the right time and place needed. This helps reducing wastes like waiting times or high

[79] Cf. Zollondz (2006), p.253
[80] Cf. Koch (2011), pp. 118; Brüggemann & Bremer (2012), p. 16
[81] Own Illustration, revised from Brunner (2011), pp. 3

inventories, and therefore inefficiencies.[82] Even if the principle of JIT is simple, a high discipline is needed for implementation.[83]

Advantages of JIT are:[84]

- Drastic reduction of inventories of vendor parts, semi-finished parts and finished parts
- Higher flexibility, while having less utilized capital
- Reduction of lead time in production
- Reduction of utilization in production and warehouse
- Higher quality awareness of employees
- Higher transparency of processes

2.3.9 Just-In-Sequence

Just-in-sequence (JIS) can be explained as a stricter version of JIT. In a JIS system, not only the time and place of a delivery has to be considered, but also the sequence.[85] JIS is one answer to the rising number of variants in the automotive industry (this trend is described in Table 2).

	Old model	New model	Difference
Part or assembly	no. of options	no. of options	increase in %
Door covering, front left	608	18,816	3,095%
Door covering, front right	608	4,704	774%
Door covering rear	76	1,764	2,321%
Glove compartement	20	152	760%
Driver's side depot	10	54	540%
Fuel tank	13	54	415%
Door handle cover	132	432	327%
Seats	3,696	10,880	294%
Exterior mirror adapter	38	76	200%

Table 2: Number of different features in the old (C5) and new (C6) Audi A6[86]

These high numbers of different alternatives for the customer are much easier to handle, if they are delivered to the point of use in the exact sequence as they are

82 Cf. Dickmann (2009), p. 10
83 Cf. Lean Enterprise Institute (2008), p. 39
84 Cf. Kühne + Nagel Management AG (2013), p. 103
85 Cf. Klaus & Krieger (2008), p. 249
86 Revised from Automobil-Produktion (2005), p. 39

needed. This reduces the need for double handling at the customer, but generates the necessity for suppliers to adjust their production, to be able to fulfill these needs.[87]

2.3.10 Supermarket Principle

A supermarket is a commissioning system, where employees pick items according to a pick list from aisles, to supply downstream processes (production, customer, etc.) with the exact needed parts and amount. The idea of a production supermarket was transferred from classic supermarkets as they already exist in malls for a long time. As in a classical supermarket, a picker walks through the aisles, and takes the needed items according to his pick list from the shelves. The pick list tells the employee which parts he/she has to take, the quantity, and the place (aisle no., etc.). The pick list can be maintained online from a warehouse management system (WMS), which also makes a simultaneous route optimization between different picking items. The alternative is to print a list, which already contains all parts to pick for commissioning. In this case, the employee tries to find the optimal route through the warehouse by himself. For transportation of the picked items, material handlers can use carts, power pallet trucks or order pickers, depending on the requirements.[88]

Characteristics of a supermarket system are:[89]

- Picking according the person-to-goods principle
- Shelving system puts no demands on packaging
- Pick lists can be sorted by routes
- Often in combination with a kitting process for line delivery (reduction of material at line site, while improving productivity of employee)
- Represents another warehousing stage, if used for materials preparation of the line

Replenishment of the supermarket and removal of empty trays is done either by the material handlers, by extra employees who are only responsible for replenishment or might even be done automatically.[90]

[87] Cf. Koether (2012), pp. 76
[88] Cf. Koether (2012), pp. 141; Lean Enterprise Institute (2008), pp. 98; Fischer & Dittrich (2004), pp. 142
[89] Cf. Koether (2012), pp. 141; Göpfert, Braun, & Schulz (2013), pp. 423
[90] Cf. Fischer & Dittrich (2004), pp. 143

3 Initial Situation of the World Class Logistics Project

This section describes the situation at Magna Logistics Europe at the beginning of the World Class Logistics Project.

First an explanation of Supply Chain Management in the context of MLE is given in section 3.1.

Secondly, the fundamental models to describe a supply chain are described (compare section 3.2, since they create the basis for the Magna Supply Chain Reference Model (SCR-M).

The Magna SCR-M is then described in section 3.3, since it builds the basis for the structure and approach for this thesis is given.

This section is concluded with a description material flow processes, which are included in the Magna SCR-M and which were considered in this thesis.

3.1 Supply Chain Management at Magna Logistics Europe

The target of the WCL- project is to cover the complete supply chain. For a better understanding of the scope of this huge project, an overview about supply chain management (SCM), and the Magna Supply Chain Reference Model, which is the basis for the structure of both, this thesis and the complete WCL-project, should be given on the following pages.

Supply chain management describes the administration of all logistics processes within the supply chain. [91] It covers all aspects from the information- and material flow, across the complete value stream; starting with the collection of raw materials, including all finishing steps, down to the customer. Therefore, SCM describes all processes necessary to supply customers with products, commodities or services. In contrast to the term logistics, SCM includes all order transition and cash flow processes, besides the physical transport of goods.[92]

On one hand, SCM refers to processes within a company (internal supply chain); on the other hand it also includes the company’s interaction with its environment (external supply chain).[93]

[91] Cf. ten Hompel & Heidenblut (2011), p. 301
[92] Cf. Hennig et al. (2013), p. 140
[93] Cf. Werner (2013), p. 7

3.1.1 External Supply Chain

Physically seen, a supply chain consists of several stages, where items are produced, converted, assembled, packed and distributed to the customer. The external supply chain is the interface of the company with its suppliers on one end, and with its customers at the other end of the value stream. This model also includes the supplier's supplier and the customer's customer.[94] Therefore the performance of the complete supply chain depends strongly on its complexity and the arrangement of the manufacturing system, as it can be seen in Figure 9. It is easily comprehensible that the performance of the complete supply chain depends on the performance of every single node. If for example plant number 3 has production problems and can't compete with the performance of the other plants, the production speed of the complete supply chain will be slowed down.[95]

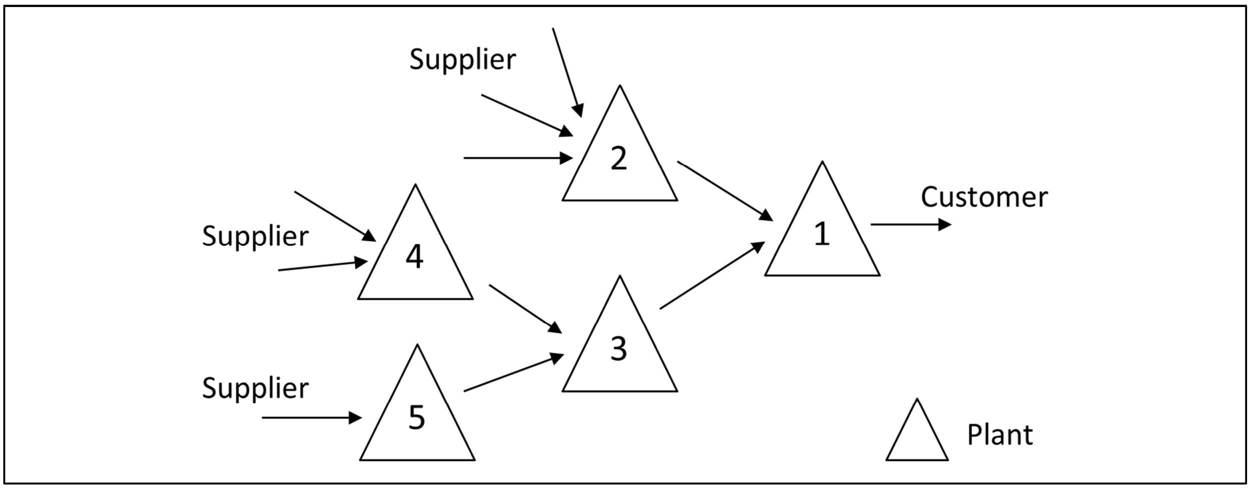

Figure 9: Supply chain structure with different finishing steps[96]

3.1.2 Internal Supply Chain

As the external supply chain, the complexity of the internal depends on the number of nodes that have to be paced. Similar to the external supply chain, upstream processes supply their respective downstream processes. The physical material flow runs in the same direction and with every process step, value is added.[97]

[94] Cf. Werner (2013), p. 7
[95] Cf. Brandimarte & Zotteri (2007), pp. 6
[96] Own Illustration, revised from Brandimarte & Zotteri (2007), pp.6
[97] Cf. Werner (2013), p. 7

To complete a holistic view on supply chain management, the main are:[98]

- Minimization of costs
- Market-conform delivery times
- High adherence to delivery dates

3.2 Description of the Magna Supply Chain Model

To keep an overview about all different processes, which take place within the value stream from the supplier to the customer, Magna Logistics Europe uses the Magna Supply Chain Reference Model (SCR-M).

This model was used, to describe the course of action for this thesis and for the WCL-project. The Magna SCR-M was firstly developed to represent all processes of the complete supply chain, to simplify costs budgeting for logistics processes. After several development steps, it is now in everyday use, to explain logistics processes in different Magna plants. In the development of this model, both the Supply Chain Operation Reference Model (SCOR-model) and the Supply Chain Management Reference and Assignment Model were considered. Therefore a description of these two models should be given first, before the Magna SCR-M will be introduced.

3.2.1 Supply Chain Operations Reference Model

The SCOR- Model is used to describe all processes of the supply chain, independent of the company's borders. Additionally it supports the identification of improvement potentials along the supply chain. The target of the development of the SCOR- model in 1996 by the Supply Chain Council (SCC) was the creation of a basis to design cross-companies supply chain with one homogeneous method, from the user's view. It describes all basic functions to create a competitive supply chain and provides the basis for analysis, improvements and implementation of supply chain processes.[99]

The SCOR- Model consists of four levels, which are described hereinafter.

[98] Cf. Gudehus (2012), p. 8
[99] Cf. Lawrenz, Hildebrand, Nenninger, & Hillek (2001), p.115

Level 1: Processes

The top level defines the scope and the content of a supply chain. Five main processes are specified in this level, which can be used to adapt and define the organizational units in those areas, where an inter-divisional standardization is needed.[100]

These five processes are:[101]

- **Plan**: Description of planning activities like gathering of customer requirements, collection of information about available resources, determination of planned capabilities, etc.
- **Source:** Description of ordering, scheduling, goods receiving and service processes.
- **Make**: Description of production processes or creation of service content.
- **Deliver**: Description of processes to satisfy customer orders.
- **Return**: Description of processes for the reverse flow of materials (defectives, surpluses, etc.).

Level 2: Sub-Processes

At the basis of level 1, standard modules to configure possible supply chains are defined on this level. Therefore the complete supply chain is divided in sub-processes; for the process categories, the bundle of activities from level 1 is used.[102]

Level 3: Process-Element Level

In this level the operative details are added to the design of level 2. Specific process steps, their sequence and the input and output information are described separately. Additionally, appended Key Performance Indicators (KPIs) and assistance to adequate information systems are described on this level.[103]

Level 4: Implementation Level

This level describes the transition of standardized cross-industry processes into company-specific processes.[104] This level must always be adapted to the strategies and

[100] Cf. Werner (2013), pp. 65; Cohen & Roussel (2006), p. 81
[101] Cf. Supply Chain Council Inc. (2010), p. 12
[102] Cf. Werner (2013), pp. 66
[103] Cf. Cohen & Roussel (2006), pp. 85; Lawrenz et al. (2001), p. 127
[104] Cf. Lawrenz et al. (2001), p. 128

challenges of a company and is therefore not part of the SCOR-Model published by the Supply Chain Council.[105]

3.2.2 Supply Chain Management Reference and Assignment Model

This model faces the challenge of companies to select the right alternative, out of many different and difficult comparable structures, to represent the own supply chain. The basis of this model, which was developed by the Fraunhofer-Institute IML Dortmund, is the SCOR-model. While the SCOR- model allows a uniform description, assessment and analysis of supply chains, this is only done roughly. The SCM- Reference and Assignment Model enables a detailed description of the supply chain, by assigning specific requirements, regarding the SCM-systems, to every level of the SCOR-model.[106]

The model consists of three major levels:[107]

- Strategic network design
- Supply chain planning
- Supply chain execution

Strategic Network Design

The task of the strategic network design is the creation of an economic supply chain, which is oriented on the strategies and targets of the SCM. Therefore, long term planning decisions, like large investments, build-up of distribution centers, etc., which strongly affect the overall costs and performance of the complete supply chain, can be made independently of the operative planning tasks. By simulating different "what-if" scenarios, effects like the loss of a customer, change of suppliers, etc. can be assessed.[108]

Supply Chain Planning (SCP)

After fixing the strategic deliberations in the strategic network design phase the tactical and operative implementation on planning level starts. In this phase, the demands, inventories and capacities have to be adjusted, to be able to fulfill a present or predicted

[105] Cf. Cohen & Roussel (2006), p. 81
[106] Cf. Hertel, Zentes, & Schramm-Klein (2011), p. 110
[107] Cf. Beckmann (2004), p. 103
[108] Cf. Beckmann (2004), pp. 103; Hertel et al. (2011), pp. 111

customer demand.[109] The following planning topics are considered in the supply chain planning:[110]

- **Requirements planning**
  This involves the short-, mid-, and long-term projection of demands of all collaborative actors. Especially the mid-, and long-term planning is problematic, since all available data is from the past. These past data is projected to the future with statistical methods.
- **Network planning**
  The coordination of different partners of the supply chain is done with the network planning. A major point of the network planning is the optimization of demands, resources and capacities, what results in the generation of a quantity structure. Based on sales volumes, the quantity structure results in an assignment of production volumes per different plants.
- **Sourcing strategy (general and detailed)**
  The general sourcing strategy is based on the requirements and network planning. Its task is to secure the supply of materials, while keeping stocks low. The planning horizon for the general planning is some days to weeks. In the detailed planning, short term planning like just-in-time or just-in-sequence is realized.
- **Production planning (general and detailed)**
  The target of the general production planning is to realize a high utilization of the production, while maintaining a high flexibility to change the production. The planning period is between several days to weeks. In detailed planning, a vernier adjustment of the production on manufacturing level is done, several hours to some days before production.
- **Distribution planning (general and detailed)**
  The general distribution planning coordinates the material flow to the customer on a daily or weekly base. Different supply scenarios, including logistics service provider, can be reviewed for optimization. In the detailed planning, route scheduling and means of transport planning are done.
- **Order promising**
  This is a feasibility or availability study, whereat available-to-promise gives a promise to the customer, to provide goods and services at defined terms (e.g. delivery within 24 hours). Capable-to-promise on the other hand defines the

[109] Cf. Arnold, Isermann, Kuhn, Tempelmeier, & Furmans (2008), p. 463
[110] Cf. Werner (2013), pp. 82; Beckmann (2004), pp. 105

capability of a company to keep a promised delivery. While available-to-promise is directed to the customer, capable-to-promise is directed inwards.

- **Collaborative planning**
  The target of the collaborative planning is the harmonization of all actors of the supply chain. Therefore a synchronization of the distribution flow and the reverse material flow is done.

Supply Chain Execution (SCE)

This field of the supply chain involves all operational activities between the start-of-production and end-of-production. This excludes design, planning controlling and monitoring activities during this phase.[111] In the SCE all tasks are combined, which allow an order fulfillment and a control of the supply chain, or serve the operative process execution. Therefore the tasks of the SCE are warehouse management, production execution and transport execution.[112]

The targets of the SCE are:[113]

- Guarantee defined product availability
- Reduction of order fulfillment costs
- Improvement of utilization of working capital

3.3 The Magna Supply Chain Reference Model

The Magna Supply Chain Reference Model was introduced by MLE to represent all processes of the complete supply chain (compare Figure 10).

The target of the implementation of the Magna SCR-M was to have a supply chain model which suits the specific demands of the automotive industry. Additionally, the focus of the product development cycle should be directed to the planning phase, since 90% of the logistics costs of a project are defined in the project planning phase and only 10% in the operational phase. This model should support the logistics planning process and therefore help to reduce costs by providing a structured approach.[114]

This model describes the supply chain enable processes and the different phases of the product lifecycle, the supply chain development and supply chain execution phase. To

[111] Cf. Expert interview with Katrin Troy, conducted on Oct.-17, 2014
[112] Cf. Beckmann (2004), pp. 111
[113] Cf. Klaus & Krieger (2008), pp. 19
[114] Cf. Blechinger (2010), p. 90 ; expert interview with Katrin Troy, conducted on Oct.-17, 2014

facilitate the transfer of the status of the product life cycle into the right phase of the Magna SCR-M, a timeline, illustrating the different stages in the product life cycle, is put over the phase descriptions.

Not included in this model is a description of the financial flow, since the logistics systems can hardly make any impact on these structures within Magna.[115]

In the following the different parts of the Magna SCR-M are briefly described.

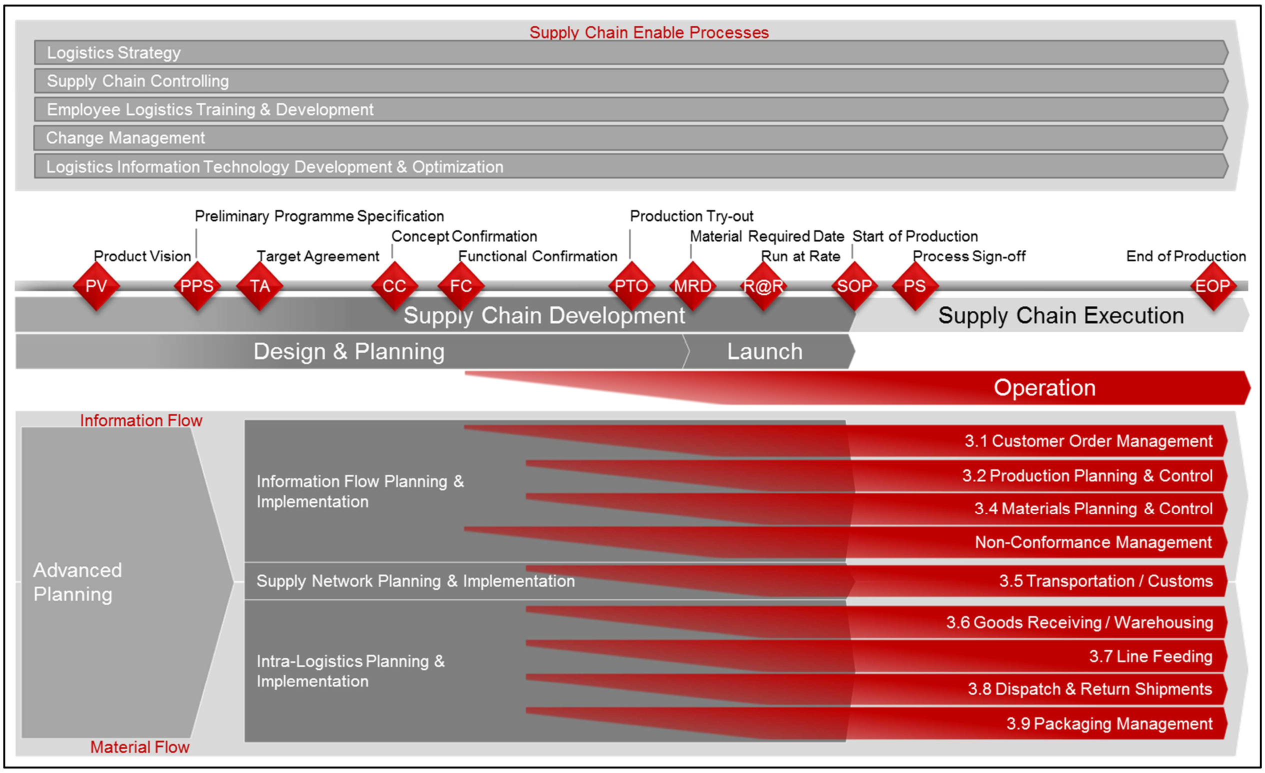

Figure 10: Magna Logistics Europe supply chain model; phase orientation[116]

3.3.1 Supply Chain Enable Processes

This part of the model describes processes on management level, where the strategic positioning of the company takes place. The logistics strategy, supply chain controlling, employee logistics training and development, change management, and the logistics information technology development and optimization processes are described in this phase.[117]

[115] Cf. Expert interview with Katrin Troy, conducted on Oct.-17, 2014
[116] Magna Logistics Europe (2012)
[117] Cf. Blechinger (2010), pp. 80; Expert interview with Katrin Troy, conducted on Oct.-17, 2014

3.3.2 Supply Chain Development

This phase is divided in the design & planning phase and the launch phase. It begins with the product vision and includes all supply chain planning, designing and implementation activities before the start of production, as they were described in 3.2.2.

The design and planning phase starts with the project entry or the decision to realize a project. It involves all planning activities that come along with the development of a new product or the realization of a new project. Parts of the information and material flow are considered ab initio, which underlines the holistic idea of the Magna SCR-M. After the advanced planning and the development of the target agreement, the planning and implementation phase starts, with the main points information flow planning and implementation, supply network planning and implementation and intra-logistics planning and implementation.[118]

Within these processes, a smooth transition into the launch phase takes place. The beginning of the launch phase is defined with the Material Required Date and it ends with the Start of Production.

It is very important to put a high focus on the development phase of a supply chain, since the majority of the overall logistics costs are defined during this phase.[119]

3.3.3 Supply Chain Execution within the Magna Supply Chain Reference-Model

The job of the supply chain execution (SCE) is to perform the tasks given by the supply chain management.[120]

In the Magna SCR-M, the supply chain execution phase describes all processes that are conducted between the start and end of production. Additionally, processes after the end of production, like spare parts management, are considered within this phase.[121]

[118] Cf. Magna Logistics Europe (2012)
[119] Cf. Expert interview with Katrin Troy, conducted on Oct.-17, 2014
[120] Cf. Hertel et al. (2011), p. 113
[121] Cf. Expert interview with Katrin Troy, conducted on Oct.-17, 2014

3.3.4 The Timeline of the Magna Supply Chain Reference Model

The timeline of the Magna Supply Chain Reference Model serves as an orientation in which phase of a product development process one is located. The timeline consists of different gates and sub-milestones, whereby the first gate in the timeline the Product Vision is, and the last gate the End of Production. In the following, the terms of this timeline are explained:[122]

- **Project Entry/ Decision to realize a project**
  Even if this milestone is not described in the supply chain model, the decision on the realization of a project is the first step to make. With the project entry, a contract or a letter of intent is available, the feasibility has to be confirmed and different framework conditions have to be defined.
- **Product Vision (PV)**
  The innovation and strategy phase is complete and an adequate description of the program or project is already available. With the PV, the project targets are assigned to the responsible departments and internal constraints are determined. A first draft of the project structure and organization is available.
- **Preliminary Program Specification (PPS)**
  The PPS closes the feasibility phase of the project. With this milestone, all functional departments' strategies, the chances and the risks of the project were evaluated and a detailed project plan is available.
- **Target Agreement (TA)**
  With the target agreement, the concept phase is completed and a detailed development and production concept was agreed by all departments. Project targets are confirmed and a complete parts list is available. With this milestone, the development of the product industrialization starts.
- **Concept Confirmation (CC)**
  The customer confirms the achievability of the project targets according the vehicle concept. Detailed design data is available, the list of parts with long lead times is confirmed and logistics concepts are available at the suppliers.
- **Functional Confirmation (FC)**
  The design and simulation work is finished and the module integration of the complete vehicle is confirmed.
- **Production Tryout (PTO)**
  The first vehicles for the PTO are painted and assembled on the production line. The launch planning and target date for the market entry are confirmed.

[122] Cf. Magna Steyr Fahrzeugtechnik (2010)

- **Material Required Date (MRD)**
  The first preproduction series vehicle is manufactured with volume production conditions.
- **Run at Rate (R@R)**
  Performance tests are completed, development targets are verified and the parts supply for the assembly of launch sign-off vehicles is guaranteed.
- **Start of Production (SOP)**
  The first parts/ vehicles for the customer were produced and are ready for distribution. The parts/ vehicles fulfill the end customer requirements. With this milestone starts the supply chain execution phase.
- **Process Sign-off (PS)**
  Process conformity of selected criteria is achieved and documented. The needed number of vehicles/ parts for the market entry have been produced and delivered, all project targets were achieved. The final approval of the customer is given.
- **End of Production (EOP)**
  With this milestone the production is finished, no more vehicles/ parts are produced. Usually this milestone indicates the end of the supply chain execution phase, and therefore of the project. But subsequent processes like the storage and distribution of spare parts could extend this phase for several months to years.

3.4 Material Flow Processes in the Supply Chain Execution

The SCE phase in the Magna SCR-M has three major parts (compare Figure 10), namely the information flow, the transportation and customs and the material flow. In these three main elements, the information and material flow have several sub-categories, while the transportation and customs processes contain elements of both, the material and information flow.

Elements of the information flow are:

- Customer order management
- Production planning & control
- Materials planning & control
- Non-conformance management

Elements of the material flow:

- Goods receiving and warehousing
- Line feeding
- Dispatch & return shipment
- Packaging management

Within these different phases, the focus of this thesis was put on the material flow, since this was the only phase for which an expert team was already established.

The material flow is defined as the combination of all processes during excavation, processing and finishing, storing, and distribution of goods within defined areas. By way of example, this involves transporting, handling, warehousing and testing as operative parts of the production logistics. Material flow processes effectuate a change in the logistics base items type, amount, place and time of materials and goods.[123]

Due to reasons of responsibility within the organization, dispatch and return shipment was wholly excluded of the research, which left the points goods receiving and warehousing, line feeding, and packaging management.

Therefore, an explanation of these three processes should be given in the following.

3.4.1 Goods Receiving and Warehousing

Goods receiving is the interface between the external procurement logistics and the internal production logistics. The main tasks of goods receiving are the acceptance of delivered materials from a supplier or carrier, all the processes included during this procedure (control of identity, quantity, quality, booking of material, etc.) and the subsequent transfer of these materials into the warehouse or directly to the line.[124]

The targets that are pursued by goods receiving are:[125]

- Automatic collection of material data
- Equalization and smoothing of truck delivery
- Avoidance of congestion at loading bays
- Reduction of turnaround time
- Improvement of transparency
- Harmonization of internal and external information flows

[123] Cf. Klaus & Krieger (2008), p. 418
[124] Cf. Klaus & Krieger (1998), pp. 509
[125] Cf. Klug (2010), p. 204

- Avoidance of handling

For a better understanding of the goods receiving process, an example for a standard goods receiving process should be given in the following:

Notification of Receipt of Goods and Delivery Date

Depending on the delivery situation, a precise delivery date was arranged. This is especially important for companies with a high delivery frequency and a goods receiving department with a low capacity. Using such a fine-tuned schedule helps to reduce waiting time for suppliers. At the receiving side, it helps to harmonize the workload and to reduce load peaks.[126]

A realization of such a desirable system has different influencing factors:[127]

- Size and value of consignment
- Distance to the supplier
- Public traffic situation
- Authorities working hours (customs, etc.)

Therefore an ideal realization is sometimes only possible in a limited way.[128]

Reception of Goods

If the goods receiving was informed in advance about an incoming shipment (e.g. by a notification of receipt of goods), goods receiving can prepare itself properly. This is especially important for large deliveries, delayed deliveries of needed goods, or hazardous goods. Special preparations (especially for hazardous goods), printing of the needed shipping documents and the assignment of forklift drivers are also done before the arrival of the truck.[129]

[126] Cf. ten Hompel & Schmidt (2010), p. 23
[127] Cf. H.-O. Günther & Tempelmeier (2005), pp. 273; ten Hompel & Schmidt (2010), pp. 23
[128] Cf. ten Hompel & Schmidt (2010), pp. 23
[129] Cf. ten Hompel & Schmidt (2010), p.25

Unloading

Unloading is the transshipment of goods from a means of transport to a fixed location (e.g. goods receiving). For the process of unloading itself, a special infrastructure (ramps, forklifts, buildings, etc.) is needed.[130]

During or after unloading, but before warehousing, the following processes are conducted:[131]

- Identification of received goods
- Control of the received goods (quality check, weight check, outline control, etc.)
- Booking of materials
- Assignment of a bin location

Warehousing

After unloading, received goods, which are not needed at the line immediately, are taken into the warehouse.

A warehouse consists of rooms or areas to store materials and goods for the purpose of stocking, buffering and distribution. Additionally a warehouse protects against external influences like weather conditions and against unwanted interferences like unauthorized withdrawal.[132]

In general, two types of warehouses exist: floor storage and rack storage. Especially for rack storage systems a further differentiation of systems should be done, due to the high amount of different systems.[133]

In general, a rack warehouse is used to improve the space utilization, by improving the possible height of the warehouse, with the height varying between 2m and 50m. With the use of storage facilities (shelving systems), every storage unit can be put in a single rack bay. This allows the storage of not stackable parts above each other and facilitates the direct access to every single storage unit. [134]

In the following, the floor storage and four different systems for rack storage systems are explained:[135]

[130] Cf. Ahrens (n.d.)
[131] Cf. Koether (2012), p. 124
[132] Cf. ten Hompel & Heidenblut (2011), pp. 166
[133] Cf. ten Hompel, Schmidt, & Nagel (2007), pp. 55
[134] Cf. Wannenwetsch (2010), p. 273 ; ten Hompel & Schmidt (2010), p. 76
[135] Cf. ten Hompel & Schmidt (2010), pp. 74; Wannenwetsch (2010), pp. 269; ten Hompel et al. (2007), pp. 61; Fischer & Dittrich (2004), pp. 134

- **Floor storage**
  Goods are stored or stacked directly on the floor. The possible stacking height is dependent of the properties of the goods, the packaging, the used materials handling equipment (crane, forklift, etc.), and the layout of the warehouse. This storage type has low investment costs and can be easily adapted to the local conditions. It has a low susceptibility to failure and only needs little labor. Disadvantages are a low transparency, the difficult retrieval of materials and the lack of automation.
- **Block rack storage**
  The block rack storage is a kind of static rack storage. It consolidates different loading units to a compact block. Because of the arrangement of the rack, it is only possible to access the bock form one or two sides. Depending on the access form (one or two sided), last in first out (LIFO) or first in first out can be realized. The advantage of these systems is the high volume utilization, while needing only small areas of space. On the downside, parts are only supported on their edges, what creates the need for robust packaging.
- **Row rack storage**
  A row rack storage system is like the block rack storage a type of static rack storage. In row rack-warehouses, every storing unit is stored in a single shelf compartment, which are arranged side by side and one upon the other. Storage and retrieval is solely done at the front of the rack, which enables direct access to all loading units. This allows the use of different warehouse strategies, using an IT-solution. A physical realization of a warehousing strategy is not intended with this system.
  Depending on the size, type (palette, container, etc.) and weight of the used loading devices a different type of row rack storage system may be chosen (palette warehouse, high-bay warehouse, cantilever racking, etc.).
  The realizable space utilization is dependent on the aisle width and therefore from the used manipulating equipment (manual, forklift, shelf access equipment, etc.).
- **Dynamic rack storage with moving rack**
  In a dynamic rack warehouse, loading units are moved after storage, during the warehousing process. Advantages of this system are the reduction of routes during picking, a higher picking performance, high handling capacity and the utilization of advantages of block and row rack storage.
  For this type of rack system usually different types of carousel racks and mobile racks are used.

- **Dynamic rack storage with moving loading unit**
  This group includes all types of flow racks. Loading units are stored homogeneous on a conveyor. Goods are put on the conveyor on the higher part of the rack and are retrieved from the lower part. When a loading unit is removed, the consecutive goods move up, because of gravity. When removing parts, the back pressure of the remaining goods inside the rack has to be considered. To prevent high velocities when loading units move up, the pulleys may need braking.

A comparison of the different storage systems and their range of use can be found in Figure 11.

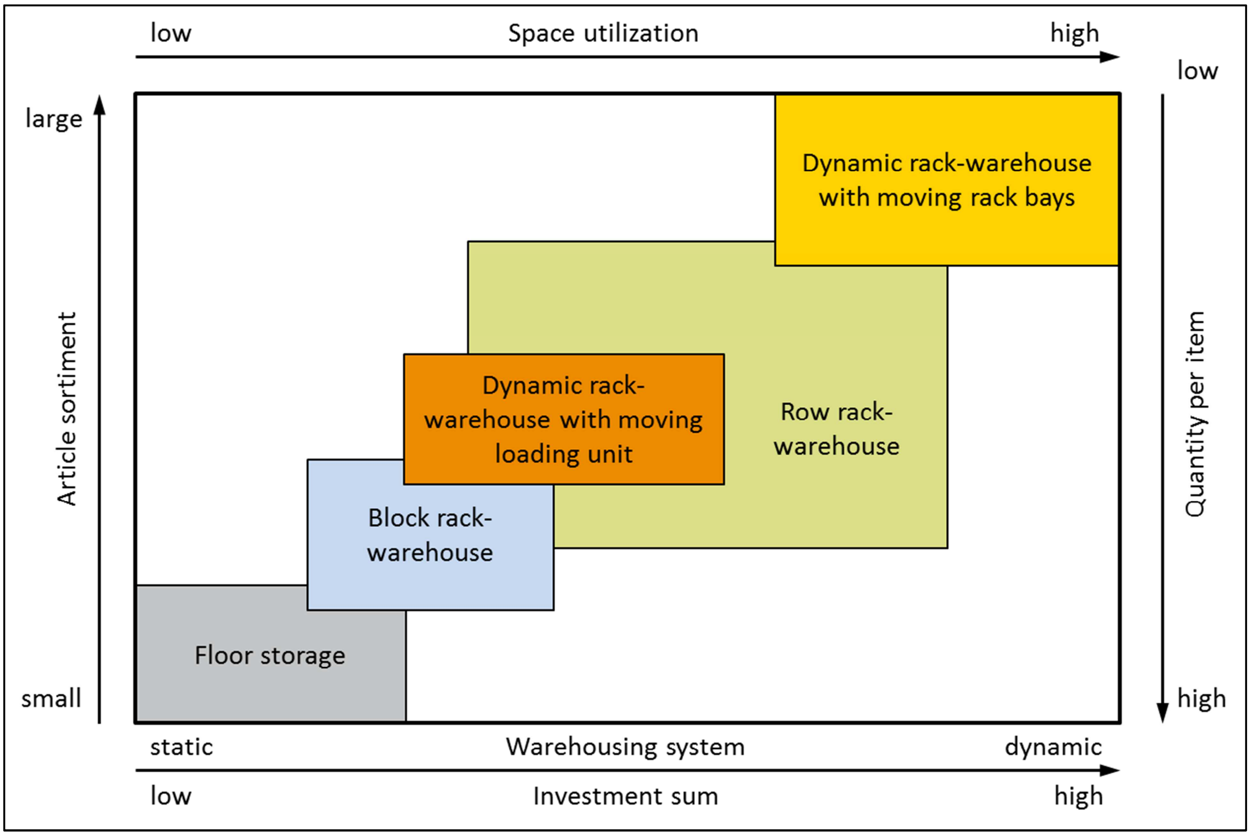

Figure 11: Comparison of different storage systems[136]

3.4.2 Line Feeding

All materials that are stored at the line in small amounts are stored in warehouses in larger quantities. The task of line feeding is to supply these goods to the point where

[136] Own Illustration, revised from ten Hompel et al. (2007), p. 114; Magna Steyr Fahrzeugtechnik (2013)

they are used in accordance to the 6R. Usually this means to ensure that production is provided with the needed goods at the right point and time in the most efficient way. The presentation of material in the production has to be designed in a way that ensures optimal access for the operator, as well as it reduces wastes in the production and logistics processes.[137]

Therefore, the material presentation has to fulfill the following criteria:[138]

- Ergonomic picking of parts for the operator
- Ergonomic handling of packaging units by logistics operator (type of packaging, dimensions and weight)
- Reduction of all 8 types of waste, namely short walkways for the operator (high runner parts to be closest to the work place)
- Fix and clearly marked part locations (no searching of parts)
- Minimum handling of parts and packaging units
- As much integration of material presentation into the workstation as possible
- Clear and simple flows for full and empty packing units

Depending on chosen process, the logistics effort varies.

The line feeding process itself can be differentiated in three different parts:

- Order picking
- Line delivery
- Presentation of goods at the line

Order Picking

Order picking or picking is the arrangement of individual items to one assembly to create a specific form needed for sales or consumption.[139] This process is especially needed, if a collective line delivery system is used.[140] During this picking process different activities might have to be performed:[141]

- Counting, measuring, weighting
- Kitting
- Labeling

[137] Cf. Golz (2014), pp. 11
[138] Cf. Expert interview with Katrin Troy, conducted on Oct.-17, 2014
[139] Cf. ten Hompel, Sadowsky, & Beck (2011), pp. 3
[140] Cf. Golz (2014), pp. 11
[141] Cf. ten Hompel & Heidenblut (2011), p. 152

Order picking is the most cost- and labor- intensive activity in a warehouse with estimated order picking cost of about 55% of the total warehousing costs.[142] Since most warehouses differ in size parts range and throughput, picking methods and strategies are very broad ranged. Figure 12 gives an overview about the currently most used picking methods in warehouses.

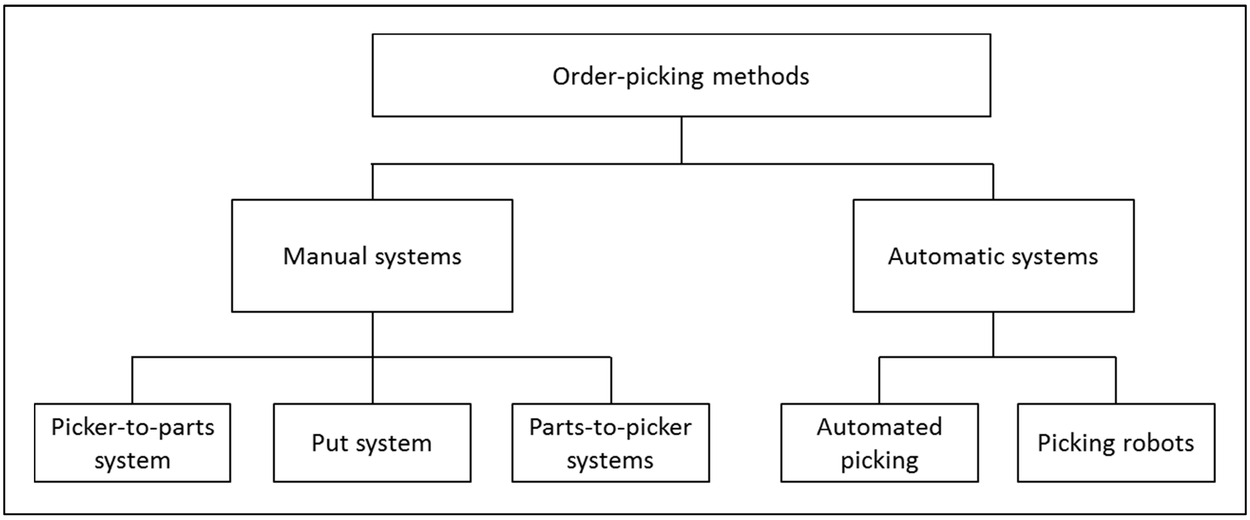

Figure 12: Different picking methods[143]

Line Delivery

Line delivery is the transport of materials from the warehouse or picking location to the point of use at the production line. This can be done as single delivery or as collective delivery. In a single delivery, exactly one replenishment delivery of a material is handled, which is usually done with forklifts. In a collective delivery, replenishment deliveries of different materials are combined and delivered together. For these deliveries floor conveyors are used mostly. At the beginning of his route, the floor conveyor has to enter a station (usually warehouse or picking location) where it is loaded with the materials that are needed at the different stations along his route. The advantage of combined deliveries to single deliveries is the shorter cumulative driven distance, which leads to less traffic in the production. But for realization a system for consignment has to be used.[144]

Figure 13 gives a small overview about different line feeding systems. Besides from the options described below, the planning type, chosen route for resupply, the kind of material provision (single piece, assembly, etc.) and many more may also have to be

[142] Cf. de Koster, Le-Duc, & Roodbergen (2007), p. 481
[143] Own Illustration, revised from de Koster (2008)
[144] Cf. Golz (2014), pp. 11

considered. Depending on the layout of the production, the type of produced parts, the amounts, etc. a different strategy for line feeding may be chosen.[145]

<table>
<tr><th>Criteria</th><th colspan="12">Alternatives</th></tr>
<tr><td>Provision amount</td><td colspan="6">Packaging oriented</td><td colspan="6">Exact piece-count</td></tr>
<tr><td>Type of provision</td><td colspan="6">Demand-oriented (push principle)</td><td colspan="6">Consumption-based (pull principle)</td></tr>
<tr><td>Provision source</td><td colspan="3">Close to workplace</td><td colspan="3">Entrepot</td><td colspan="3">Neutral work system storage</td><td colspan="3">Other upstream processes</td></tr>
<tr><td>Place for provision</td><td colspan="4">At the workplace</td><td colspan="4">Close to workplace</td><td colspan="4">In the work system</td></tr>
<tr><td>Mode of transport</td><td colspan="6">Single delivery</td><td colspan="6">Collective delivery</td></tr>
<tr><td>Transport process</td><td colspan="4">single-level</td><td colspan="4">Multi-level without storage</td><td colspan="4">Multi-level with storage</td></tr>
<tr><td rowspan="2">Provision trigger</td><td colspan="9">Line delivery by logistics employee</td><td colspan="3">Pick by operator</td></tr>
<tr><td colspan="3">Superordinate central system</td><td colspan="3">Decentralized, upstream process</td><td colspan="3">Decentralized, Shop floor supervisor</td><td colspan="3">Decentralized, assembly</td></tr>
</table>

Figure 13: Alternative line feeding systems[146]

3.4.3 Packaging Management

At the beginning of all flows of goods and materials is the necessity to protect produced goods from any quality influencing strains during transport, transshipment and storage (TTS). Usually this is realized by choosing a suitable packaging, and by creating loading units.[147]

Besides this main function, several other functions, like protection of humans and the environment from hazardous goods or efficient handling of goods is a target of modern packaging. A listing of different functions for packaging can be found in Figure 14.

Since these listed functions of a packaging partly pursue completely different goals, different types of packaging are used to fulfill all these requirements.

In general three different types of packaging can be distinguished:[148]

- **Transport packaging**
  This packaging is used to protect parts during the transport between supplier and customer. In the VDI-guideline 2700 different loads are defined, a packaging has to withstand to protect its contents.

[145] Cf. Golz (2014), pp. 31; Gudehus (2010), pp. 43
[146] Own Illustration, revised from Golz (2014), pp. 32
[147] Cf. ten Hompel & Schmidt (2010), pp. 19
[148] Cf. ten Hompel & Schmidt (2010), p. 21; Martin (2014), p. 72

- **Sales packaging**
  It serves as protection of goods until the end-customer, and is also used by him for transport to the point of use.
  A clear distinction between transport and sales packaging is not always possible, since an already early existing packaging of goods can still be used as sales packaging (e.g. papered candy in a candy bag)
- **Outer packaging**
  These are additional packaging around the sales packaging, which can be used as protection against theft or to enable self-service.

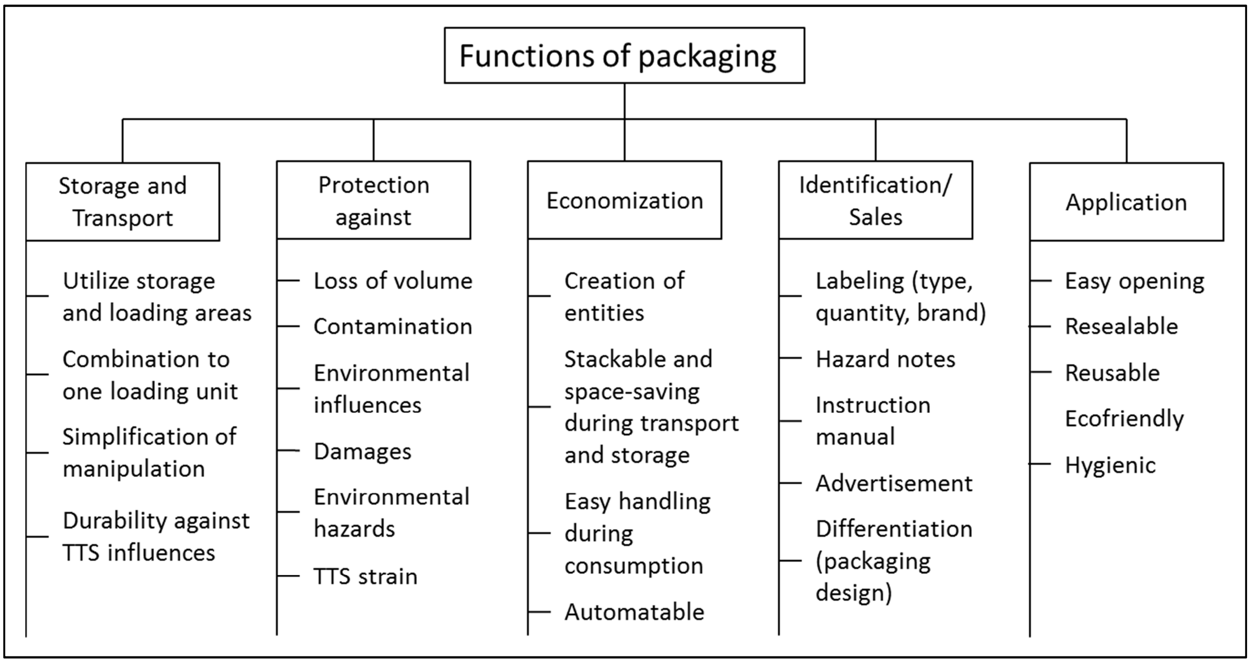

Figure 14: Different functions of packaging[149]

For this thesis mainly the transport packaging was considered, since all other types are defined by the customer and therefore Magna has no influence on them.

[149] Own Illustration, revised from Martin (2014), p. 71

4 Practical Approach

This section describes the work that was conducted with the different expert teams to obtain the results and recommendations for Magna, which are described in section 5.

First an explanation on the approach to workshops and expert interviews, and how they were performed during the work for this thesis is given in section 4.1. This section also includes a description of different Magna plants that were visited during this thesis.

Section 4.2 gives an overview on the different expert teams that were deployed by Magna and explains the composition of these teams.

The last part of this section describes in more detail the workshops and conference calls that were conducted.

4.1 Methodology

To obtain results for this thesis, a combination between literature research, workshops, conference calls, interviews and observation was done. This was done to gain as much information as possible about specific topics and to align knowledge found in literature with the knowledge in the Magna plants.

The first step of preparation for every chapter of the WCL-guideline was a comprehensive literature research and investigation in relevant logistics magazines, in addition to the already above described literature. To be able to fulfill the demand of World Class for this research, it was attempted to comprise mainly new literature for these researches.

The second step was the holding of workshops (compare section 4.1.1) with expert teams, which are described more detailed in section 4.2. In these workshops, the findings of the literature research were presented and aligned to real processes inside of Magna. Experts attending these workshops have a lot of experience in their field of work. They were able to explain best practice examples from different plants they visited or they work in and gave important input for the further proceedings in the project. Additionally, the Logistics Absolutes, as basis for each chapter of the WCL-guideline were defined in these expert team meetings. The input of these expert teams during the workshops was one of the most important factors in the creation of the WCL-guideline.

The findings of these workshops were then gathered in a draft version of the WCL-guideline, together with the concepts developed during the literature research.

The different findings were consistently checked on their validation during different plant tours and company visits (compare section 4.1.3), always adapting the guideline to new findings.

After finishing the draft version of the WCL-guideline, the document was sent to all members of the concerned expert teams, asking for feedback. In personal interviews, final adjustments to the guideline were made and final acknowledgements for the guideline were obtained (compare section 4.1.4).

In the following a short explanation on the topics workshops and expert interviews is given. Then the different companies that were visited are described. And subsequently the validation process for the guideline is explained.

4.1.1 World Class Logistics- Workshops

Workshops are a major component of the World Class Logistics strategy to gather knowledge.

A workshop is a moderated event, which can be developed, held, evaluated and documented in close elaboration with the concerning expert team.[150]

The advantages of a workshop are:[151]

- Detailed discussion of results
- Good knowledge transfer within the group
- Participants are involved active by motivating them to give feedback
- High acceptance of results
- Acceleration of decision processes

The workshops held, were usually two days long and were held in different Magna plants. An agenda was sent out several days previous to the workshop to let participants know what to expect, and to give them the opportunity to prepare on certain topics.[152]

After each workshop, minutes of meetings were sent to all participants, and to members of the expert team who were unable to join, which listed the discussed topics, a summary of consensus and achievements and a list of next steps, as well as the next dates.

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[150] Cf. Magerhans, Merkel, & Cimbalista (2013), p. 390
[151] Cf. Magerhans et al. (2013), p. 390
[152] Cf. Andler (2011), pp. 350

Additionally to the workshops, telephone conferences were held with the members of the expert team. At least one call was done prior to each workshop as a warm-up, and one after each workshop for follow-up.

4.1.2 Expert Interviews

As described previously, workshops are an important component to gather a lot of knowledge in one room and therefore gather information in a short time span. As many advantages workshops have, they also have a disadvantage. Some people might not get heard, and therefore their opinion could be overlooked. Expert interviews give a good opportunity to align the findings from a workshop in a tranquil setting. Additionally, questions that arose during the workshop and couldn't be answered there can be addressed during an expert interview, when both parties had time to prepare.

An expert interview comprises the systematic preparation, execution and post processing of conversations, which are conducted with a specific target. For the interviewer, the gathering of knowledge, development of work contents, alignment of findings and preparation of next steps have the highest priorities.[153]

In general, four different types of interviews are distinguished:[154]

- One-to-one interview (most known standard type of interview)
- Group interview (more than one interviewer is conducting the interview)
- Serial interview (two or more consecutive interviews are held with the same candidate)
- Problem-solving and role-play interview (candidates have to demonstrate their abilities)

In the course of this thesis, the first interview type was chosen for most interviews. This was done to get the highest output in short time, which was an important factor due to the crowded schedule of most candidates.

To align the findings of the workshops, interviews with all workshop participants were held. To ask similar questions and to have comparable results, a guideline for these interviews was issued. Besides some general questions to the WCL project, detailed feedback to particular points of the WCL-guideline were asked.

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[153] Cf. Schawel & Billing (2011), p. 102; Andler (2011), pp. 111
[154] Cf. Infinite Ideas (2012)

Additionally to the structured interviews, unstructured interviews, with almost no preparations were conducted. These interviews were held especially with experts, which were only available short-termed, or for less complex and extensive questions.[155]

4.1.3 Company Visits and Plant Tours

Visiting shop floors in different Magna plants and get direct input from employees of these plants was a major factor when writing this thesis and when validating concepts for the WCL-guideline.

These visits were especially important due to the diversity of the different Magna groups, resulting in very different requirements every group has on its logistics processes.

In the following, the Magna plants that were visited, besides the plants where the different expert team meetings were held, are described.

Magna Steyr Fahrzeugtechnik

Since Magna Logistics Europe is located in the same compound, the Magna Steyr Fahrzeugtechnik (MSF) plant offered the best opportunity to get a deep first-hand understanding for high-end logistics processes in an automotive production plant.

MSF is the largest plant of Magna with roughly 3,600 employees and is situated in the south of Graz, Austria. MSF develops and produces complete vehicles and vehicle components and can therefore be seen as a 0.5 tier.[156] At the moment, the production of MSF comprises three different vehicles, the Mini Countryman, the Peugeot RCZ and the Mercedes G-Class.

As the only plant of Magna that produces complete vehicles, it can be seen as an exception in many cases.

[155] Cf. Infinite Ideas (2012)
[156] Cf. FirmenABC.at (2014)

Cross Docking Center of Magna Steyr Fahrzeugtechnik

The cross-docking center is located in the Styriastraße in the eastern part of Graz, Austria. The center has an area of 30,000m² and is operated by the TLC Temmel GmbH which employs approximately 60 people.[157]

The tasks of the logistics center are to provide a fast turnover of incoming trucks and a perfectly timed JIS delivery to the exact point of use in the MSF plant in Graz. The visit gave a deep insight in the logistics work in a cross-docking and distribution center.

Magna Obertshausen

Magna Obertshausen is a plant of the Magna Exteriors group, located close to Frankfurt, Germany.

Magna Obertshausen produces the complete spectrum of exterior facings like bumpers, victim covers, spoilers, front end modules, etc. Customers are OEMs like Mercedes-Benz, Audi, Opel, Chrysler, etc.[158]

Magna Obertshausen is currently implementing a new tugger train systems and simultaneously pursuits several lean-projects. The visit at Magna Obertshausen was used to understand the different projects the plant conducts at the moment and to learn from the difficulties the plant was facing. Additionally the visit was used to get in contact with the World Class Manufacturing Manager of Magna Obertshausen, who was able to give a lot of input for the development of the WCL-guideline, especially in the field of the goods receiving process.

Magna Ebergassing

Magna Ebergassing is a Magna Interiors plant, located next to Vienna, Austria. It produces tufted velour, pillar trims cargo trims, and door panels back foamed floor trims. Customers are Audi, Mercedes-Benz, Rolls-Royce, etc.[159]

Magna Ebergassing was chosen for a visit because of its carpet production which represents a special case within Magna. On one hand it has extremely high lead times due to its manufacturing process, on the other hand, the plant implemented one of the most sophisticated JIS productions within Magna. Also its proximity to Graz, which made a visit possible on short notice, was decisive.

[157] Cf. TLC Temmel Logistik GmbH (2014)
[158] Cf. Magna International Inc. (2014f)
[159] Cf. Magna International Inc. (2014f)

4.1.4 Validation of Results

To align and verify the results that should be taken into the guideline, a multistage approach was chosen.

First of all, the results from each workshop or conference call were discussed in the subsequent one. This allowed experts at an early stage to discuss amendments of parts of the guideline.

Secondly, a draft version of the guideline with first results was sent to all experts, asking them for their input on the current status and asking for the approval of this draft version. After receiving the feedback to this question round it was decided that a third and final round for approval will be held. This round was conducted holding interviews with all experts to receive a feedback that was as precise as possible and simultaneously get an approval for the results.

Therefore, in this final round personal interviews were conducted, mostly via phone calls. This was the final stage to get all approvals for the results. Calls with every single expert were conducted to assure, not missing any opinions or inputs on any topic of the guideline. Therefore, the interviews were executed in accordance to a guide, which was created to ask everybody the same questions (compare section 4.1.2).

Since no major changes to any points of the guideline were recommended, this final version was printed to be presented at different occasions to the management of Magna.

4.2 The Magna Expert Teams for Logistics

When starting the World Class Logistics project, it was decided to create work groups with members of all different Magna groups. Therefore each group nominated at least one expert for every topic of the World Class Logistics project to participate in workshops and assist during this project with his or her detailed knowledge about logistics processes within their specific group. This approach was done to assure a broad knowledge base which includes findings, exceptions and best practices from all groups and uses the dissimilarities of the different groups as an advantage.

The nominated experts were assembled in so called expert teams, whereby each expert team represents one specific field of the Magna SCR-M.

Tasks for the expert teams are the active participation during workshops concerning their respective field, collaboration with other team members of the expert team, support in the creation of the WCL-guideline and to give their final approval to their concerning part of the guideline.

Besides the different expert teams, a steering committee was established, to align findings of the work of the expert teams, issue approvals for their work or to eliminate roadblocks.

Due to the diversity of topics in the different areas of a supply chain, one expert team should have been created for every part of the Magna SCR-M. But since the needed resources for the coordination of such a high number of expert teams does currently not exist within Magna Logistics Europe, the start with only a small number of teams was decided. At the beginning of this thesis, two expert teams already existed, two more were under construction and a fifth was already discussed.

The different expert teams are:

- Information Flow Expert Team (IFeT)
- Transportation and Logistics Expert Team (TLeT)
- Supply chain Engineering Expert Team (SCEeT)
- Material Flow Expert Team (MFeT)
- Packaging Management Expert Team (PMeT)

The IFeT and TLeT were still under construction, when the work for this thesis began. The IFeT meanwhile had its kickoff meeting on July-14, including the first workshop; the team leader is Claudia Moisesbichler of Magna Logistics Europe, and the main tasks are the standardization of information flow processes as well as the definition of World Class processes and best practice examples for the information flow.

The TLeT, which is under the lead of Angelika Schadler (MLE), had its kickoff meeting for World Class Logistics on June-3rd. Besides the cooperation in the World Class Logistics project, the mission of the TLeT is to leverage the size and market power of a 30 billion dollar enterprise by bundling volumes and creating group overlapping and cross-divisional synergies. Besides that, the major goal is the definition of standards, processes, tools and methods as well as the roll out of these.[160]

The SCEeT, which is under the lead of Manfred Mally of MLE, will have its kickoff meeting in the end of November. The major targets for this team are the standardization of processes and tools for supply chain engineering, as well as their rollout.

[160] Cf. Expert interview with Natalie Steiner, conducted on Nov.-20, 2014

The MFeT had its kickoff meeting in the course of this thesis and the PMeT was already introduced in 2013, and is therefore the first and longest existing expert team.

Since the focus of this thesis was on the material flow processes, only the MFeT and PMeT were involved in the development of results. Therefore these two expert teams should be described more detailed in the following:

Material Flow Expert Team

The area of responsibilities for the MFeT are the creation of world class standards and processes for material flow processes, as well as the discussion of best practice examples. Additionally the support in the creation of the WCL-guideline, by giving feedback and approvals lies in the field of duties of the MFeT.

Participants of the MFeT as they were nominated by the different groups are:

- Thomas Eder, Magna Logistics Europe, team leader of the MFeT
- Florian Kuntke, Magna Seating, Logistics Manager
- Marcel Knabner, Magna Exteriors & Interiors, Team Leader Export[161]
- Milan Kalis, Magna Mirrors & Closures, Logistics Manager
- Severin Lux, Magna Powertrain, Supply Chain Manager
- Rainer Bruns, Magna Powertrain, Vice President Global Operations and Quality
- Jochen Urich, Magna Electronics, Head of Logistics
- Michael Grassl, Magna Steyr, Senior Process Engineer Logistics
- Peter Puntigam, Magna Steyr, Head of Supply Chain Engineering

Packaging Management Expert Team

The PMeTs responsibility is the harmonization and improvement of packaging within the different Magna groups. This includes the design, used materials, and definition of application cases for one way and returnable packaging.

The PMeT consists of 45 people which participate irregularly. The main team members are:[162]

[161] The Magna Exteriors and Interiors groups were split up in June of this year. For this reason Marcel Knabner, stays responsible for both groups, even if he is now part of the Interiors group. It was decided to keep this interims solution until the end of this thesis and to nominate new and additional candidates ones the results of this thesis are available.

[162] Cf. Expert interview with Ronald Beck, conducted on Oct.-10, 2014

- Ronald Beck, Magna Steyr Fahrzeugtechnik and currently engaged with Magna Logistics Europe, team leader of the PMeT
- Thomas Babener, Magna Exteriors and Interiors, Specialist World Class Manufacturing - Supply Chain Management[163]
- Milan Kalis, Magna Mirrors & Closures, Logistics Manager
- Hans-Jörg Schmölzer, Magna Powertrain, Supply Chain Manager
- Oswald Friedl, Magna Steyr Fahrzeugtechnik, Lead Packaging Engineer

4.3 Workshops and Conference Calls with Magna Expert Teams

As already described before, workshops and conference calls with the different expert teams were used to get the first major results for the WCL-Guideline.

In the following the setup and the work in these workshops and conference calls is described.

4.3.1 Goods Receiving and Warehousing Workshop at Magna Slovteca

The workshop at Magna Slovteca was the first workshop for the Material Flow Expert Team and also the first workshop that had his agenda solely dedicated to World Class Logistics.

A short description on Magna Slovteca and the workshop as basis for the section goods receiving and warehousing should be given in the following.

The participants of the workshop were:

- Jörg Blechinger, Magna Logistics Europe, Head of MLE
- Thomas Eder, Magna Logistics Europe, Team Leader MFeT
- Ronald Beck, Magna Steyr Fahrzeugtechnik, Team Leader PMeT
- Marcel Knabner, Magna Exteriors & Interiors, Team Leader Export
- Jochen Urich, Magna Electronics, Head of Logistics
- Milan Kalis, Magna Mirrors & Closures, Logistics Manager
- Severin Lux, Magna Powertrain, Supply Chain Manager
- Michael Stock, TU Graz, Diploma Student

[163] Compare footnote 161

Magna Slovteca

Magna Slovteca is a plant of the Magna Mirrors group and is situated in the northwest of Slovakia. The plant was founded in 1994 and currently employees 643 people. Its main products are inside and outside mirrors, as well as turn signals and illuminators, which are produced on a total area of 22,618 square meters. Magna Slovteca was distinguished in 2010 by the German trade journal Automobil Produktion and the business consulting company Agamus Consult with the Automotive Lean Production Award in the global companies' category.[164]

Definition of World Class

The first point on the agenda was the definition of a common view on what World Class is and to define some major points for World Class Logistics. The results of this discussion were:

- Logistics is a core competence
- Focus on standards, processes and tools
- Standardization of processes and tools in all Magna Plants
- Definition of contact persons for World Class Logistics
- Clear process descriptions
- Definition of KPI's
- Including of all plants
- Best practice sharing
- WCL can only be achieved together
- Target is cost reduction

Scientific View on World Class Logistics

The second point on the agenda was a presentation of the scientific view on the topic of World Class. This included a detailed explanation of Lean Management, as it was defined that lean should build the basis for all research done in the World Class Logistics project. Furthermore, some innovative logistics concepts were presented, to have a basis for discussion during the rest of the workshop.

[164] Cf. Agamus Consult GmbH (2010)

Plant Tour

Since Magna Slovteca is known to be “a very lean company”, the implemented tools and methods in use were presented by Milan Kalis during a plant tour. Some major points that were observed were the high level of visualization throughout the whole plant, and the effective use of lean tools like 5S and Poke Yoke. An example for the implementation can be seen in Figure 15, showing colored floor markings to assure the right placement of all work equipment.

Other observations that were made during the plant tour were:

- Labelling is a major waste factor (reprinting, relabeling, etc.)
- WCL has to be applicable on different levels of complexity, due to the high product spectrum of Magna (complexity of production processes, complexity in product variants, etc.)

Figure 15: Colored floor markings at Magna Slovteca[165]

[165] Own Illustration, picture taken at Magna Slovteca

Definition of First Contents for the WCL-Guideline

As the final point on the agenda, a first version of the Logistics Absolutes, as they are described in 5.2.1, were defined and some of the first logistics concepts and best practice examples were discussed.

4.3.2 Conference Call for Line Feeding Processes

To align findings in the goods receiving and warehousing processes and to discuss the approach for the line feeding processes, a conference call was conducted on July-11.

The participants of this conference call were:

- Jörg Blechinger, Magna Logistics Europe, Head of MLE
- Florian Kuntke, Magna Seating, Logistics Manager
- Marcel Knabner, Magna Exteriors & Interiors, Team Leader Export
- Milan Kalis, Magna Mirrors & Closures, Logistics Manager
- Severin Lux, Magna Powertrain, Supply Chain Manager
- Jochen Urich, Magna Electronics, Head of Logistics
- Michael Stock, TU Graz, Diploma Student

Status of the World Class Logistics Guideline

To align the findings that were made so far in the WCL-project, the current status of the WCL guideline was presented, followed by a discussion round.

Input was given on different topics of the Goods Receiving process; especially the receiving areas for the unloading process were revised. Secondly the labeling of loading units with standard VDA labels was discussed. It was agreed that even if not all suppliers are yet able to use VDA labels, the target for World Class is to have only suppliers, which are using these labels.

Definition of First Contents for Line Feeding Processes

The topics that should be addressed in the chapter of line feeding were discussed. It was agreed that a partitioning of the line feeding process in the two sub-processes Line Delivery and Picking should be done, and that for the picking process a close consideration on cost effectiveness should be done.

Besides that the Logistics Absolutes for line feeding were defined.

4.3.3 Workshop for Line Feeding at Neovia Logistics Services

Since it was not possible to organize an expert meeting for line feeding, a visit at the logistics service provider Neovia Logistics was undertaken on July-8.

Neovia Logistics is an international operating contract logistics company. It was founded in 1986 as Caterpillar Logistics Services to support Caterpillar and external customers as a third-party supplier for logistics services. Neovia Logistics is a global present enterprise, operating on 6 different continents and from 25 different countries. It has more than 100 sites throughout the world with approximately 6000 employees and roughly 1.6 billion euros of inventory held in warehouses all around the world for their customers.[166]

Neovia Logistics was chosen for the visit because of its Neovia Production System, which is based on the Toyota Production System and Lean Management. This system, that uses continuous improvement and six sigma as one of its basic pillars, is unrepresented in the logistics industry. Neovia Logistics claims to have installed the same process standards in all facilities around the world, resulting in highly reliable operations, response, and identification and correction of wastes.[167]

The following should give a short overview about the visit at Neovia and the findings.

Following persons participated at this workshop:

- Jörg Blechinger, Magna Logistics Europe, Head of MLE
- Thomas Eder, Magna Logistics Europe, Team Leader of the MFeT
- Michael Kluger, Neovia Logistics, Vice President Neovia Logistics
- Hajnalka Kiss, Neovia Logistics, Plant Manager of Budapest Plant
- Michael Stock, TU Graz, Diploma Student

Introduction

The first point of the meeting was an introduction about Neovia Logistics, explaining their range of business, both international and especially in Budapest. Customers of Neovia are Bombardier, Chrysler, Daimler, Ford, Hyundai, KIA Motors, Mercedes-Benz and many more.

The main field of business for Neovia Logistics in Budapest is the storage and shipping of spare parts for automotive industry. Since orders for spare parts are very diverse, a

[166] Cf. Neovia Logistics Services LLC (2014b); Neovia Logistics Services LLC (2014a)
[167] Cf. Neovia Logistics Services LLC (2014c)

high number of picking operations has to be performed by the employees every day. For this reason, Neovia puts a high focus on the optimization of these processes.

Neovia Operating System

The Neovia Operating System is based on 15 guiding principles:[168]

- **Chase Waste**
  Drive for the continuous and relentless elimination of waste in all processes, with priority on safety and quality-related wastes
- **Pull**
  Use Pull replenishment to control the flow of parts in the value stream, moving what is required when it is required
- **Make Value Flow**
  Simplify the processes to quickly identify problems and increase process efficiency
- **Drive Standard Work**
  Standardize tasks and utilize common processes as the foundation for Continuous Improvement
- **Even the Load**
  Balance the workload to level operations and reduce process variability
- **Validate Our Processes**
  Prove the process and technology work before introducing them into operation
- **Put Safety First**
  Build a Safety First culture by placing the highest priority on eliminating safety-related waste
- **Take the Customer's View**
  Make decisions based on the customer's view and the long term Neovia strategy, even at the expense of near-term goals
- **Go, See, Act**
  See it first-hand to ensure thorough understanding
- **Stop to Fix**
  Cease operation when a problem occurs to correct it in process
- **Develop People**
  Identify, attract and develop people and teams to build Neovia's long-term capability

[168] Cf. Neovia Logistics Services LLC (2014a)

- **Actively Listen**
  Conduct process improvement dialogues at all levels, demonstrating the value of people’s ideas by quickly implementing them
- **Make it Visual**
  Build the visual workplace so no problems are hidden and opportunities can be realized
- **Align the Targets**
  Deploy cascaded metrics and targets across the organization aligned to the Strategic Imperatives and supporting People, Quality, Velocity and Cost
- **Act Decisively**
  Make decisions by consensus, thoroughly considering all options, and implement with a sense of urgency

Employees

Employees are continuously trained in the topics Lean Management, Six Sigma and the Neovia Operations System. Depending on the strengths and motivation of employees, they receive additional training. Depending on the degree of training, employees receive yellow, green or black belts. Currently Neovia Logistics employs roughly 3000 yellow belt, 500 green belt and 50 black belt employees.

Plant Tour

Neovia Logistics gave a tour through its plant and was happy to answer all questions that came up.

It was easy noticeable from the beginning that the plant put high effort in a clear visualization of all different spaces. Besides from walkways, all areas for handling and working were distinguishable by their floor markings. Combining Poke Yoke and visualization in the goods receiving and outgoing goods areas is used to avoid errors during shipping or receiving.

Neovia Logistics sends full trucks to the same countries every day. To avoid any errors when preparing the goods for each truck, the logistics areas where the goods to be transported are prepared, are marked with the flag of the country the truck leaves to. Since trucks leave to all countries usually every day at the same time, this helps employees to distinguish the different loading areas for each truck.

For incoming materials, a visualization of arrival times for incoming trucks is installed, which assures a leveling of the arrival times and therefore a fast handling of the incoming trucks.

All workstations at Neovia Logistics are equipped with instructions, explaining the specific tasks for the particular work place. This ensures that new employees can start with their duties as fast as possible and can be error free from the beginning.

The warehouse of the Neovia Logistics plant in Budapest is allocated according size and throughput of parts. This means that different storage areas exist for different sized parts. Within these storage areas, fast running parts are put more closely to the point of use to improve access times and therefore reduce needed resources for warehousing operations.

After the observations that were made during the plant tour it is safe to say that the high efforts Neovia Logistics puts into the development of their Neovia Operating System and in the reduction of all eight types of wastes pay off. Therefore the plant can be seen as “very lean”.

4.3.4 Packaging Management Workshop at Magna Slovteca

The workshop at Magna Slovteca with the PMeT took place on 16th and 17th September. Besides the discussion of different new packaging systems, the presentation and validation of the results that were elaborated with Ronald Beck were discussed.

The participants of the workshop were:

- Claudia Moisesbichler, Magna Logistics Europe, Senior Manager New Technologies and Solutions
- Ronald Beck, Magna Steyr Fahrzeugtechnik, Team Leader PMeT
- Markus Kern, Magna Steyr Fahrzeugtechnik, Senior Packaging Engineer
- Oswald Friedl, Magna Steyr Fahrzeugtechnik, Lead Packaging Engineer
- Milan Kalis, Magna Mirrors & Closures, Logistics Manager
- Livia Vavrincikova, Magna Mirrors & Closures, Packaging Engineer
- Lukas Kristof, Magna Mirrors & Closures, Packaging Engineer
- Thomas Babener, Magna Interiors, Specialist World Class Manufacturing - Supply Chain Management
- Andrej Ertel, Magna Interiors, Packaging Engineer
- Marek Hypl, Magna Exteriors, Head of Logistics
- Jan Turek, Magna Exteriors, Specialist Logistics Projects

- Michael Stock, TU Graz, Diploma Student

Presentation of the Status of the WCL-Guideline

The current status of the WCL-guideline was presented to the PMeT, with a detailed focus on the results of the work in the field of packaging management. Afterwards the results were discussed until a vast consensus existed.

Particularly a detailed discussion on the system days calculation (compare section 5.4.3) was done, as different approaches existed. The final version, which is also explained here, can be seen as the most detailed an exact version, while other systems discussed can be used as a rough and first estimation.

As last point of the workshop, the chapter packaging management was approved by the PMeT.

5 Recommendations for Magna Logistics Europe

In this section the results and recommendations for Magna Logistics Europe are described.

First the recommended structure of the WCL-Guideline as it was developed during this project is explained, followed by the detailed description of recommended contents for this guideline.

For reasons of clarity, these recommendations are structured in the same sequence as they appear in the Magna Supply Chain Reference Model. Starting with the goods receiving and warehousing processes, continuing with line feeding and concluding this section with the results for packaging management.

5.1 Definition of the Structure for the Guideline

Before the first workshop and meeting with the experts of Magna, a structure for the guideline had to be defined.

Soon it became clear, that a high amount of information needs to be processed and that it will be difficult to create a document which is easy comprehensible. For this reason an apportionment according the Magna SCR-Model was decided, since this model should already be known to many Magna employees. Additionally some basics which are needed to understand the different aspects of the guideline should be explained at the beginning. An introduction, explaining the project was included as well. With the inclusion of Health and Safety standards and the currently used logistics tools a total of six chapters were developed:

- Basics and introduction
- Standards and tools
- Health and safety
- Information flow
- Transportation and customs
- Material flow

This breakdown of chapters also allows an easy adaption of any section that might be added in the future.

Secondly, a general proceeding according the 6R of logistics was decided. To let the reader of the guideline know which logistics challenge a specific section of the guideline pursues, symbols representing the 6R were developed. For the development of these symbols, roughly 15 persons were questioned on their understanding of the 6R, and different symbols were showed to them. The symbols with the highest recognition value were then given to the marketing department, to redraw the designs, so they fit to the Magna standards. The result can be seen in Figure 16.

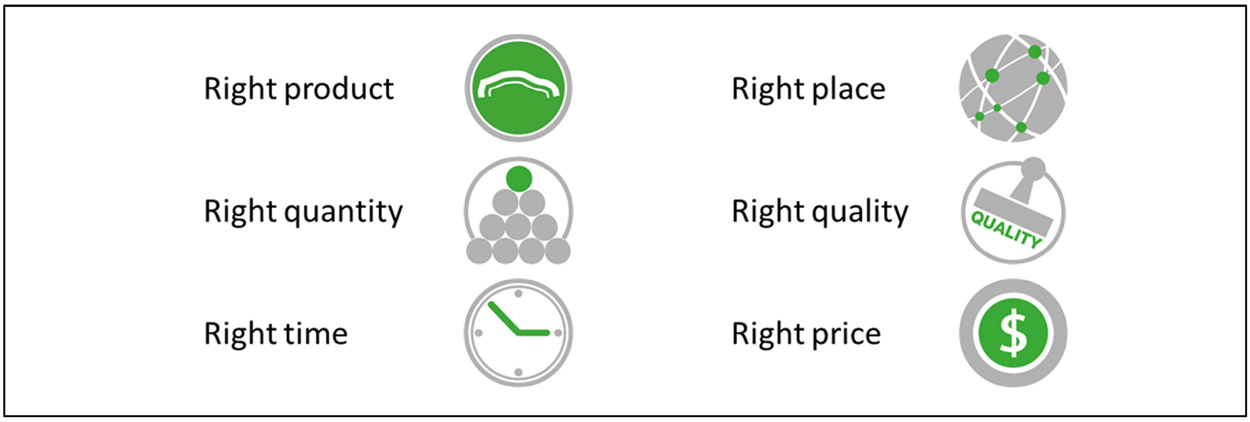

Figure 16: Symbols for the 6R of World Class Logistics[169]

5.2 Goods Receiving and Warehousing

The first point that was addressed in the creation of the WCL-Guideline was the goods receiving and warehousing process of the Magna SCR-M. To create some first concepts for this part of the WCL-guideline a workshop was held at Magna Slovteca in Slovakia. Building on the results of this workshop, a first draft of the guideline was created and coordinated with the participants of the Material Flow Expert Team.

In the following, the results for this process are described.

5.2.1 Logistics Absolutes

The first step for the creation of a guideline which' goal is to be applicable for all Magna plants, was the definition of Logistics Absolutes. These Logistics Absolutes describe requirements, which should be fulfilled by all Magna plants to achieve World Class Logistics.

For the goods receiving and warehousing process, these absolutes are:

- 100% scheduled time slots for shipping and receiving

[169] Own Illustration, based on the MFeT and Arndt (2006), p. 36

- Materials received have to be booked max. 1 hour after unloading into the ERP system
- Time and frequency for booking of materials has to be defined (as many as needed, as less as possible)
- Leveled shipping and receiving operations
- High delivery frequency for A- parts (requires definition of an ABC structure for received goods)
- Paperless goods receiving (no reprinting of labels)
- Usage of standardized labels throughout the plant
- Packaging control process during receiving
- Use of first in first out principle
- Receiving and storage of parts close to the point of use
- Defined and monitored min/ max inventory level
- No double handling

While many of these absolutes are self-explaining or can’t be addressed directly in the short term of a master thesis, and again others are already lived by many Magna plants, it was tried to include concepts for as many absolutes as possible.

In the following, some of the recommend actions and best practice examples for these absolutes are described.

5.2.2 Definition of a Process Flow

To have a common understanding about the Goods Receiving and Warehousing processes, a flow chart was developed, which should be applicable to all Magna plants (compare Figure 17).

This process model marks the start for inbound processes with the information of arriving trucks. All process steps that have to be done before the truck arrives, like the handling of freight documents, are marked red. These processes are later described as “preparation for unloading”. Once the truck arrives, the “unloading process”, which is marked blue, begins. Depending on whether deviations were found during the visual check, different process steps have to be performed, before the materials can be taken into the warehouse or to the line. This last part of the flow chart, which is called warehousing, is marked green.

The work of the workshop oriented itself directly on this flow chart, and systematically proceeded step by step to include all important parts of the goods receiving and warehousing procedures.

In the following, the results of the workshop, conference calls and expert interviews should be described, following this process model.

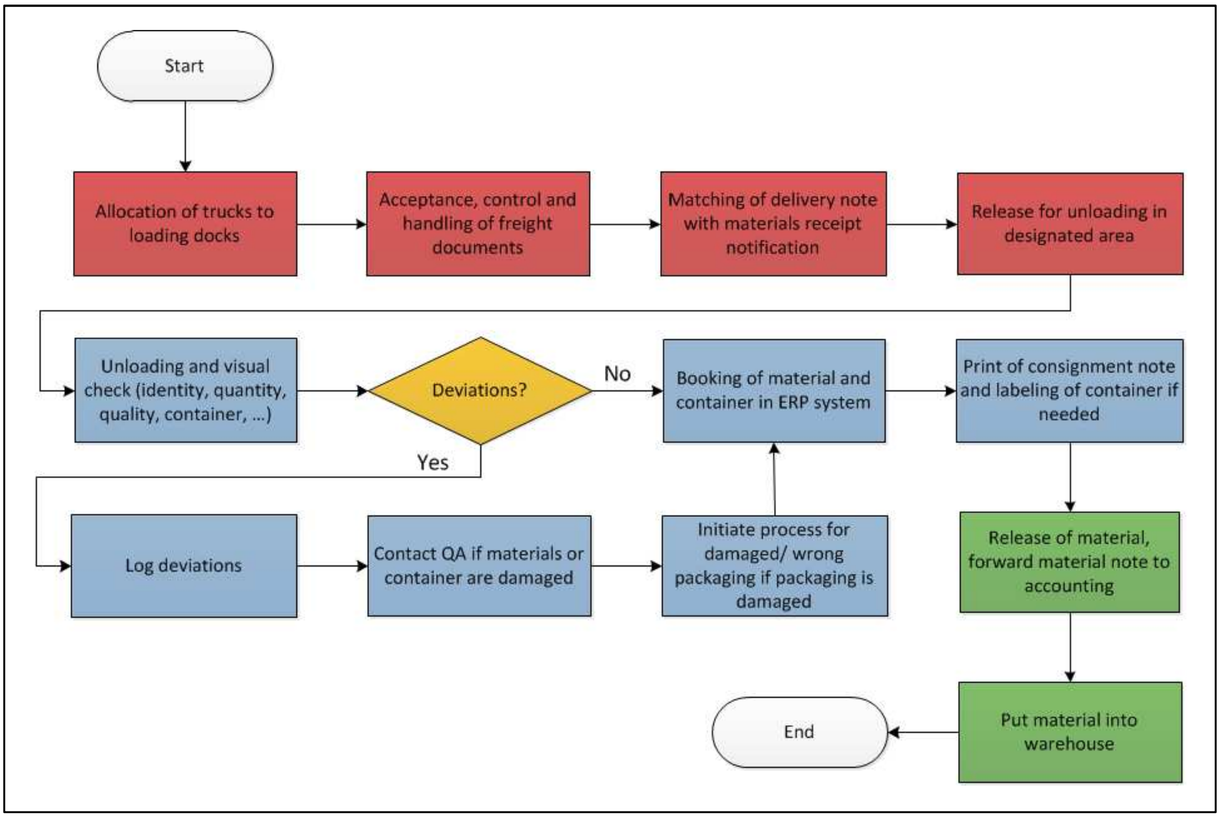

Figure 17: Uniform goods receiving and warehousing process[170]

5.2.3 Preparations for Unloading

This process can be broken down in four sub-processes. The first sub-process, when receiving goods from a supplier, is the allocation of trucks to the loading docks. This is followed by the acceptance, control and handling of the freight documents, the matching of the delivery note with the materials receipt notification and the release of the trucks to the designated area for unloading.

The optimization of the first process step, allocation of trucks to the loading docks, can already be seen as crucial, due to its high influence of downstream processes.

[170] Own Illustration, based on the MFeT

Therefore the target was an optimization of the delivery time and place, to distribute the workload throughout the whole day.

The first strategy, which addresses this problem and was developed during this project, is the visualization of time slots and the unloading plan.

Visualization of Time Slots and Unloading Plan

Visualization, often under the name Andon, is a very important topic in Lean Management. Usually used to signal problems at the production line, visualization can also be used to find a solution for a balanced work distribution in the Goods Receiving area.

In its easiest form, a whiteboard, indicating the different loading docks and time slots for delivery is deployed in the goods receiving area. On this whiteboard, incoming trucks are registered with the planned time of arrival and the loading dock they should deliver to. If trucks are registered for the same time slot, a change of the delivery time should still be possible by simply conferring with the supplier.

As simple as the visualization with a whiteboard is, it also has its limitations, especially in larger plants with multiple loading docks and a high delivery frequency, the use of one or maybe more whiteboards can become confusing.

To be capable to manage multiple loading docks and deliveries, the use of a computer program was suggested. Such a program should be online accessible for employees as well as for suppliers and carriers. Suppliers and carriers get the possibility to choose from a number of given timeslots for their delivery, in accordance to the concerning purchase order. The timeslots selected by the suppliers and carriers, are visualized on screens in the goods receiving area, so all employees are able to see which truck is arriving at what time and at which loading bay.

Software that fulfills all these criteria was introduced by Magna Powertrain Lannach, shortly after the first MFeT workshop.

With this program, suppliers have to register online for the timeslot they want to deliver in. They can choose any available timeslot, according to the delivery order they are fulfilling.
Analyzes of the delivery times of supplier before and after the introduction of this software showed a drastic improvement in the distribution of receiving operations. Before the introduction, 65 percent of all supplies were delivered in the morning, one

month after the introduction this figure was already reduced to 56 percent. The detailed changes in work distribution over one day can be found in Figure 18.[171]

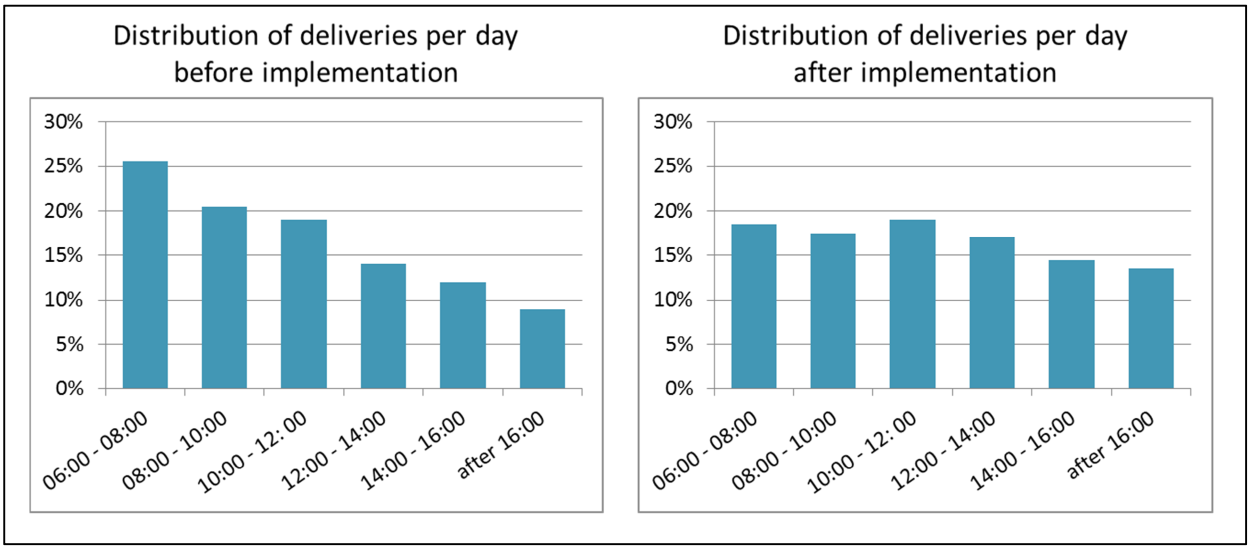

Figure 18: Change of distribution before and after implementation of software solution[172]

Advantages of the visualization and leveling of the time slots are:

- Reduction of waiting and unloading times and therefore reduction of costs for carrier, supplier and customer
- Reduction of delivery peaks
- Reduction of congestion at loading docks
- Improvement of transparency
- Improved transport planning and control
- Distribution of workload for employees

The second strategy, that can be classified into the preparations for unloading is the leveling of the reception of goods.

Reduction of Stock through Leveled Receiving Operations

The reduction of stocks is a major strategy of companies these days. Reasons for the reduction are:

[171] Cf. Magna Powertrain Lannach (2014)
[172] Own Illustration, revised from Magna Powertrain Lannach (2014)

- Reduction of tied up capital and therefore an increase of liquidity (this liquidity is usually used in cash back models and an interest rate of 10%[173])
- Reduction of needed areas for warehousing, reducing investment costs and increasing availability of areas for different projects
- High inventories are a type of waste of Lean Management, hiding other problems of a plant like quality issues or unevenness in the production line (compare section 2.3.1)

To achieve this, order placement and the consumption of materials have to be aligned. Stock levels are to be defined with a minimum and maximum level (min-max level), whereby the min-level is defined as safety stock. The safety stock is required to cover unforeseeable issues in the internal and external supply chain (e.g. scrap, bad weather, etc.). Thus it should be calculated by parts usage and volatility, the supply chain reliability, the part volume, the importance of the part for the assembly (has the line to stop if the part is missing?) and the part value.

The max-level is defined by the min-level plus the material needed for production until the next planned transport delivers new material and therefore directly dependent on the replenishment lead time. This time should be calculated separately for every part and is dependent on:

- Parts used per day
- Distance to supplier
- Transport costs
- Costs per part
- Part size and room available for warehousing
- Packaging type and costs

Evidently the average stock level is reduced with the number of deliveries in a time period, as it can easily be seen in Figure 19. Parts delivered only once or twice a month have a higher average stock level and therefore cause higher inventory costs (depending on the price per part) than parts with a more frequent delivery rate. Depending on the boundary condition of the company and the warehouse, different goals may want to be achieved. E.g. if the company only has a tiny warehouse and don’t want to expand, a reduction of inventory space may be more desirable that a reduction in total warehousing costs.

[173] Cf. Drobnitsch (2014), pp. 93

The total costs for this model have to be calculated according the previously mentioned aspects separately for every part and may also involve strategic decisions.

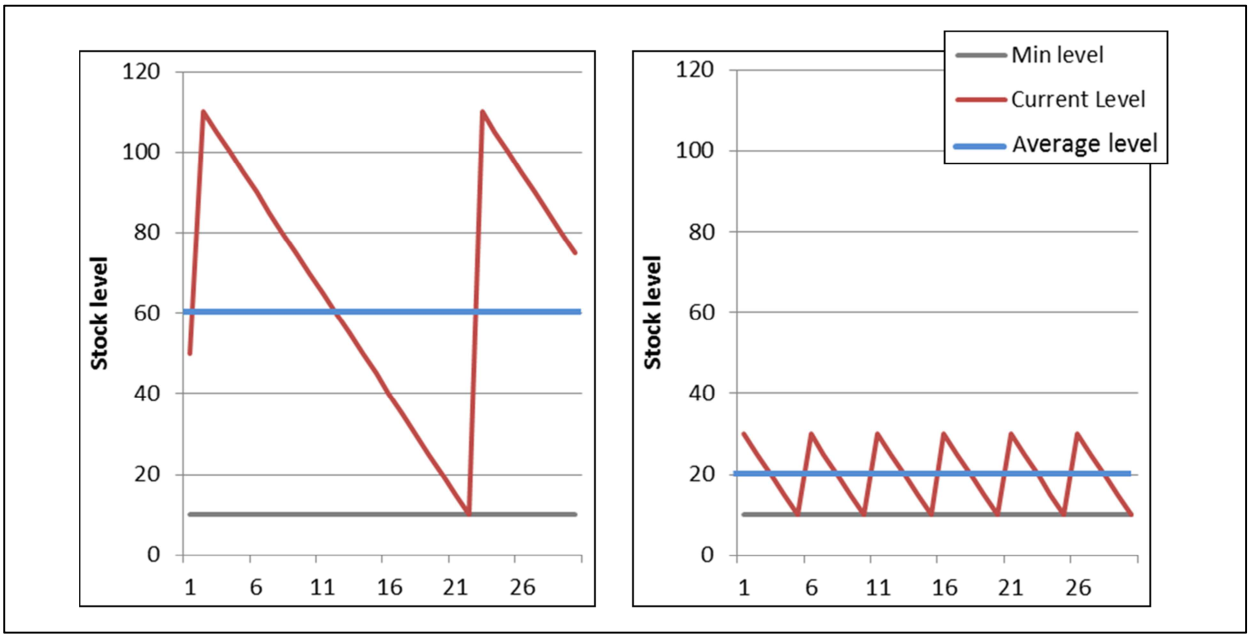

Figure 19: Stock level for low (left) and high (right) delivery frequency[174]

Decentralization of Loading Docks

An approach of Lean Management is the reduction of unnecessary movement of materials and the reduction of double handling. No double handling is also one of the Logistics Absolutes for goods receiving and warehousing.

A decentralization of the unloading docks is one strategy to reduce double handling and to have materials always as close to the point of use as possible.

This system finds it application in larger plants with more than one production line or unloading dock. Incoming trucks are allocated as close as possible to the point of use of their loaded goods, to avoid unnecessary in-house transportations of materials. This helps to enable a short time and short way material provision that leads to an information and material flow acceleration and improves the transparency of in-house logistics.[175]

[174] Own Illustration, based on expert interviews
[175] Cf. Klug (2010), pp. 204

5.2.4 Unloading

The unloading process includes the physical removal of goods from any means of transports and at least a visual check of the received goods. Depending of the QA a more detailed quality check may be performed. According to the results of the visual or detailed quality check, materials may be tagged as good, booked in the ERP system to release the invoice for accounting, and the be taken to the warehouse or to the line. If any deviations were found, the process for Not OK (NOK) materials must be started.

The first major potential for improvement that was determined by the expert team for this process was a clear definition how the unloading area should look like.

Unloading Area

The first action for a standardization of the unloading process was the definition of a uniform unloading area. The target was the development of an unloading area, which prevents errors through clear visualization, explaining the current status of the received goods.

The standard, as it is described in Figure 20 was created in continuous iteration with the MFeT, and including insights from visits at the Magna Steyr Cross Docking in Graz and Neovia Logistics in Budapest.

The allocation of areas, as shown in the graphic are applicable to all goods receiving areas of Magna, the size of the respective area has to be determined by the operational procedures of each plant. This includes the need for all areas (e.g. an area for material waiting for customs clearance is only needed in very few plants).

Independent of the true size of the goods receiving area, floor markings are used to indicate, in coordination with info boards, where newly delivered materials have to be deposited. It also indicates which materials in the receiving area can be taken directly into the warehouse or to the line and which materials are not to be used at the moment (e.g. because of damage of packaging, needed quality inspection, etc.).

The floor markings used should be done in accordance with the Magna internal color standards.

Using this standard unloading area, received goods are unloaded into blue framed areas, close to the truck. In this area, a visual check and the booking of materials is done. If all materials are OK, they should be taken immediately into the warehouse, or directly to the line. Materials, which failed the visual check or have a quality tag, indicating a needed quality check, have to be put into the designated QA area. The same proceedings apply for materials waiting for customs clearance, if custom clearance is done at plant site (compare Figure 20).

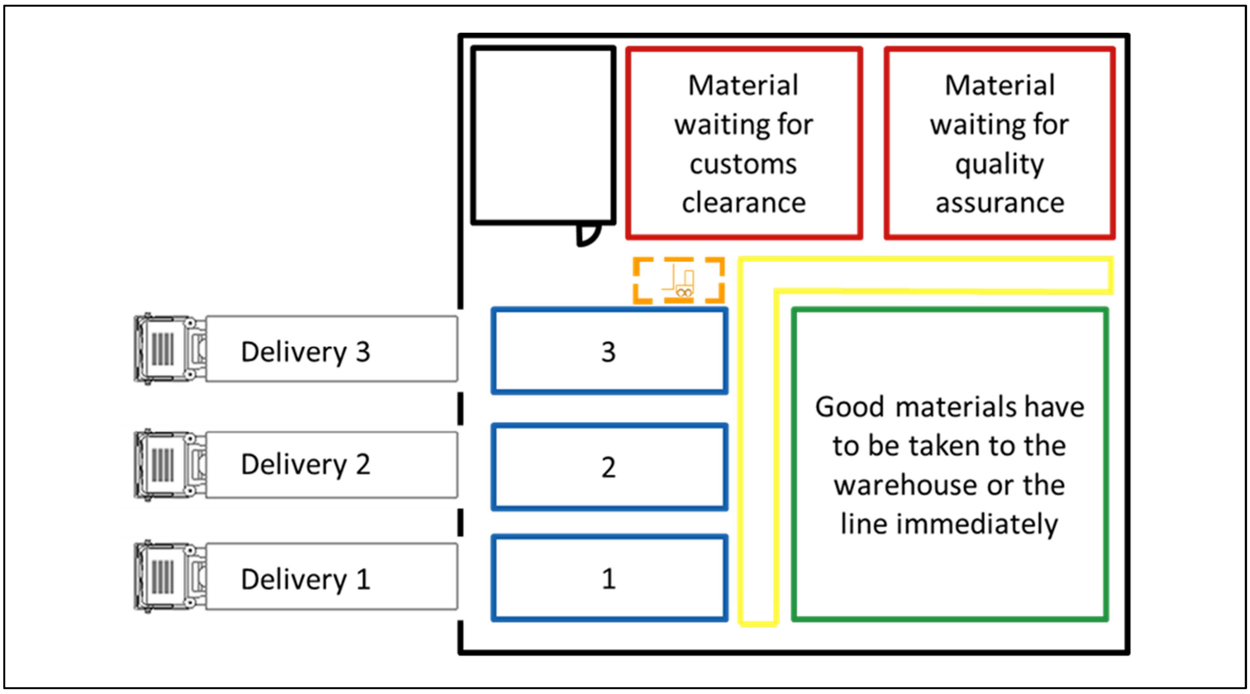

Figure 20: Standardized goods receiving area[176]

The QA area should be segmented as illustrated in Figure 21, having an area where suspect materials can be put by any employees. Next to this area is the workplace for employees of the QA, which are the only ones, allowed removing goods from the left, red marked area. Dependent of the analysis of QA employees, goods are put into the green area, indicating that these parts are OK and ready to be used; or into the red area, indicating that these parts have to be scrapped, claimed or rejected to the customer.

[176] Own Illustration, based on expert interviews

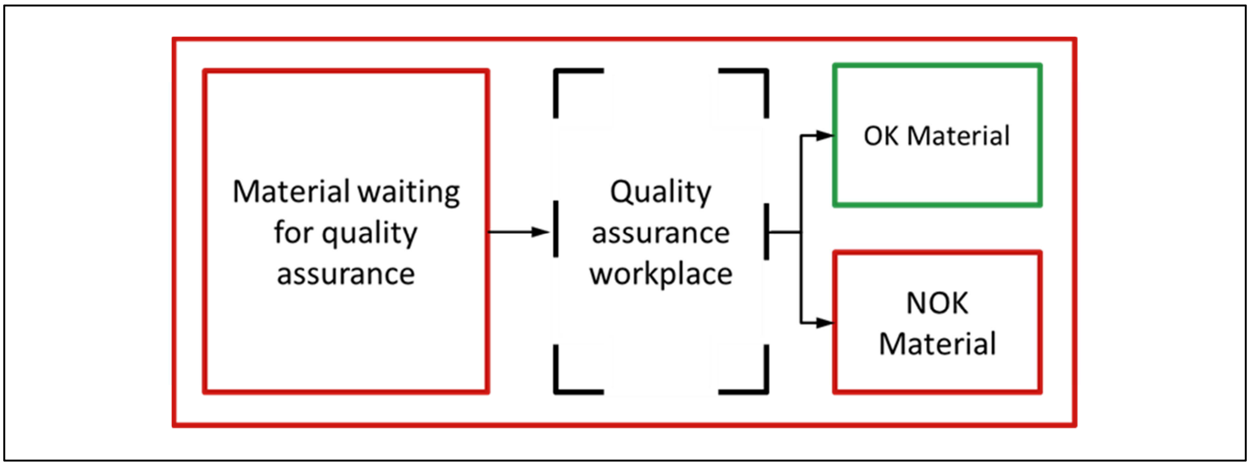

Figure 21: Standardized quality assurance area[177]

Receiving Control

Besides of a standardized goods receiving area, a defined process for the receiving control was developed.

In this process, all materials received have to undergo a swift visual control during the logging of the received goods. Obvious deviations in quantity should be handled via the Magna claim management system QPF. If the received materials have any obvious deviations in the quality (materials delivered in damaged containers or any other obvious visual damages), they have to undergo a quality check before further processing (accordingly these materials have to be taken into the QA area).

During takeover of goods, the part numbers on the packaging units have to be compared to those on the delivery note. Simultaneously it has to be examined if the goods were delivered in the right packaging. For materials delivered in the wrong packaging, a claim has to be formulated, as it would be done for wrong parts, quantity or quality.

Due to the high and increasing importance of packaging (costs of returnable packaging, stackability for warehousing, compatibility to racks at the line, etc.) it has to be controlled during the goods receiving operations. If the packaging of materials is damaged but the containing materials are still in the right quality, it has to be verified if the packaging is still safe for use (e.g. statics during warehousing, etc.). Unsafe packaging has to be repaired or scrapped, and the containing materials have to be repacked for further processing.

[177] Own Illustration, based on expert interviews

Packaging which is damaged but still safe for use have to be marked yellow, to inform employees that this packaging has to be handled with care and, and that it will not return into the packaging cycle once it is empty.

5.2.5 Warehousing

The warehousing operations involve the physical movement of good materials from the Goods Receiving area into the warehouse, to store them there for later usage as well as the storage process itself.

Because of the high product variety in different Magna plants, it is impossible to standardize the used warehousing type or storage facilities.

The most important question that came up in the context of warehousing was, how operations inside the warehouse could be improved, especially the storing and retrieval operations.

Allocation of Materials in the Warehouse

The used strategy for warehousing operations has a high effect on the efficiency and therefore on the costs of a warehouse. While several different strategies exist, the strategies which are most common should be described in the following:[178]

- **Concentration on fast runners**
  Fast moving items are stored in storage locations close to the entrance and exits of the warehouse, to reduce the average driveway
- **Chaotic warehouse**
  Empty storage locations are used for waiting parts, irrespective of their part number. Depending on the boundary conditions (e.g. type of packaging, etc.), many different part numbers can be stored in the same type of storage locations within one warehouse.
- **Fixed location warehouse**
  For every part number, a fixed storing location with the capacity for the maximum expected inventory is reserved.
  This strategy usually needs more space compared to a chaotic warehouse. For this reason it is particularly suitable for picking locations in a staging area.

[178] Cf. Gudehus (2010), pp. 598

- **Zoning of warehouse**
  The warehouse is separated in different zones, one zone for each group of commodities. The separation in groups can be done following different criteria (e.g. type of packaging, part size, special requirements like cool environment, etc.). In the respective zones, only one sort of goods may be stored.
- **Equal distribution strategy**
  To ensure a high access security, the stocks of a single commodity are distributed on several different rack aisles. By distributing the goods on several different aisles it is guaranteed, that fast access to the part is possible, even if one aisle is blocked by a different picking operation. Cycling of aisle assignment results in an automatic distribution of the parts.

In general, it is not possible to recommend one specific strategy for warehousing, since the best strategy is strongly depending on the demands on the warehouse. However, if a reduction of the total needed warehousing space should be achieved, while the number of parts in the warehouse and the layout of the warehouse cannot be changed, the utilization of the warehouse has to be increased.

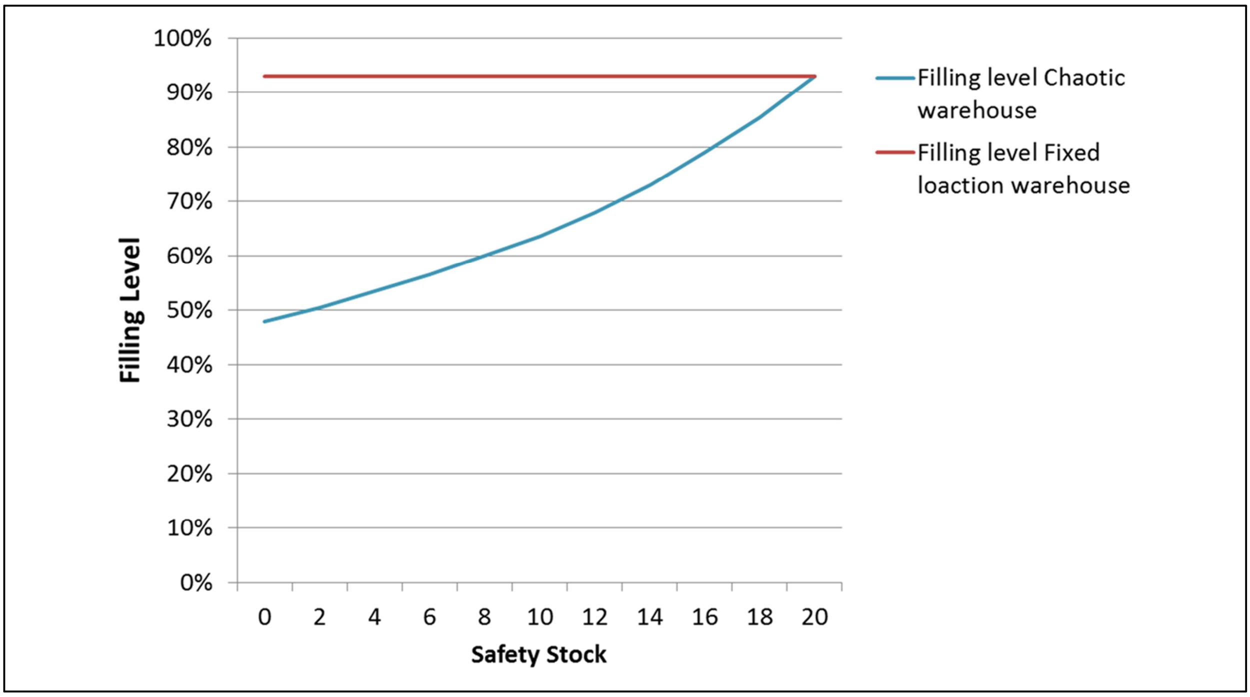

Figure 22: Filling level of storage locations in dependence on safety stock[179]

[179] Own Illustration, revised from Gudehus (2010), p. 604

To achieve such a high utilization, a chaotic warehousing strategy should be chosen. According to Gudehus, a chaotic warehousing system needs up to 50% less warehousing space, compared to a fixed location warehouse, depending on the safety stock. This behavior can easily be recognized in Figure 22, which explains the behavior of a chaotic warehouse compared to a fixed location warehouse.[180]

Even if this behavior can't be observed with the same significance as described by Gudehus in the Magna plants, a chaotic warehouse is highly suited to improve the utilization and therefore reduce the needed space for warehousing.

To improve the speed of storage and retrieval operations, the warehouse can be separated in different zones for normal, fast and slow moving items (NFS-parts). Therefore an analysis has to be done, defining the throughput of different commodities in the warehouse. The items are then stored according this distribution, whereby F-parts (parts with a high throughput) will be stored in a fixed location with short transport routes. M- and S-parts which aren't used as often as F- parts are assigned with storage locations further away (compare Figure 23).

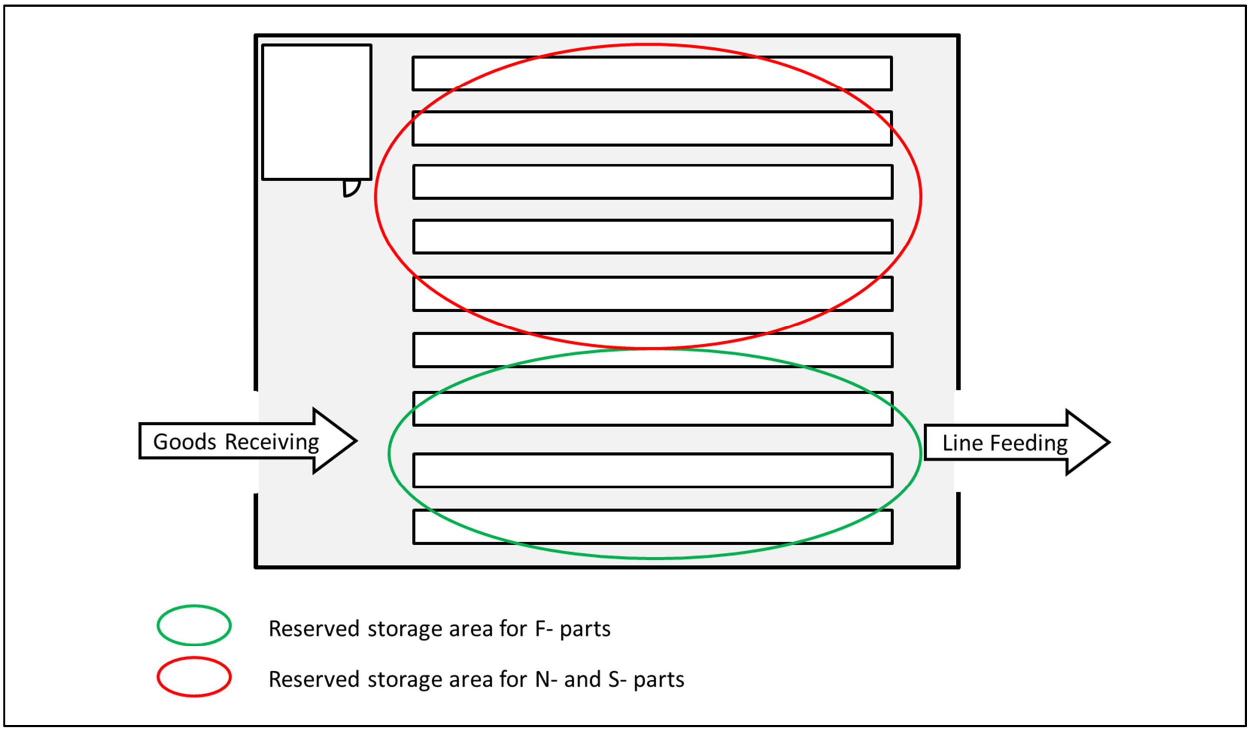

Figure 23: NFS distribution in a warehouse[181]

[180] Cf. Gudehus (2010), pp. 600; E-Mail correspondence with Timm Gudehus, Oct-02, 2014
[181] Own Illustration, based on expert interviews

For further improvement of warehousing speed, different warehouse guidance systems can be used, which help employees to find a storage location or to reduce walking times.

However, this warehousing system has some restrictions. Depending on the number of lift trucks in use it is not recommended to make such an allocation according NFS parts. Although this systems has shorter transport routes compared to conventional warehouses, it would result in mutual obstruction of the lift trucks since they have to use similar routes most of the time. In most cases, the effect of an allocation according NFS parts has an effect of less than 10%, while the maximum improvement of the handling capacity may not exceed 15%.[182] Even in warehouses with long routes and a significant NFS characteristic. Therefore an equal distribution strategy might be more reasonable for warehouses with a high throughput, since this strategy reduces congestions in the warehouse and therefore guarantees a permanent high access speed to all parts.

Labeling

Relabeling of containers can be seen as one of the most unnecessary works for several reasons:

- Reprinting of labels
- Double handling of containers
- Possible source for errors

For these reasons, the avoidance of reprinting of labels was defined as one of the Logistics Absolutes for the goods receiving and warehousing process.

However, every container or loading unit still has to be labelled clearly. Labels are used to explicitly identify all goods and to track them in case of complaints. Therefore every label has to contain the following information:

- Product (article number and name)
- Quantity
- Supplier
- Receiving date & time
- Packaging (loading unit)

[182] Cf. Scheid (2011), pp. 62; Gudehus (2010), pp. 598

Additionally all labels used during the intra-logistics process have to be suitable for barcode scanning.

To reduce or eliminate the need for relabeling of containers as far as possible, it was agreed that the use of labels according to the VDA 4902 should be implemented in all plants (compare Figure 24) and with all suppliers.

This label was developed by the "Verband der Automobilindustrie e.V." (VDA) in a cooperation of different automotive OEMs and suppliers to create an economical handling of the accompanying documents of the material flow.[183]

Using the same type of label with every supplier leads to a standardization in the receiving process and eliminates the need for relabeling. This reduces unnecessary work and double handling, as well as the use of paper in the goods receiving area.

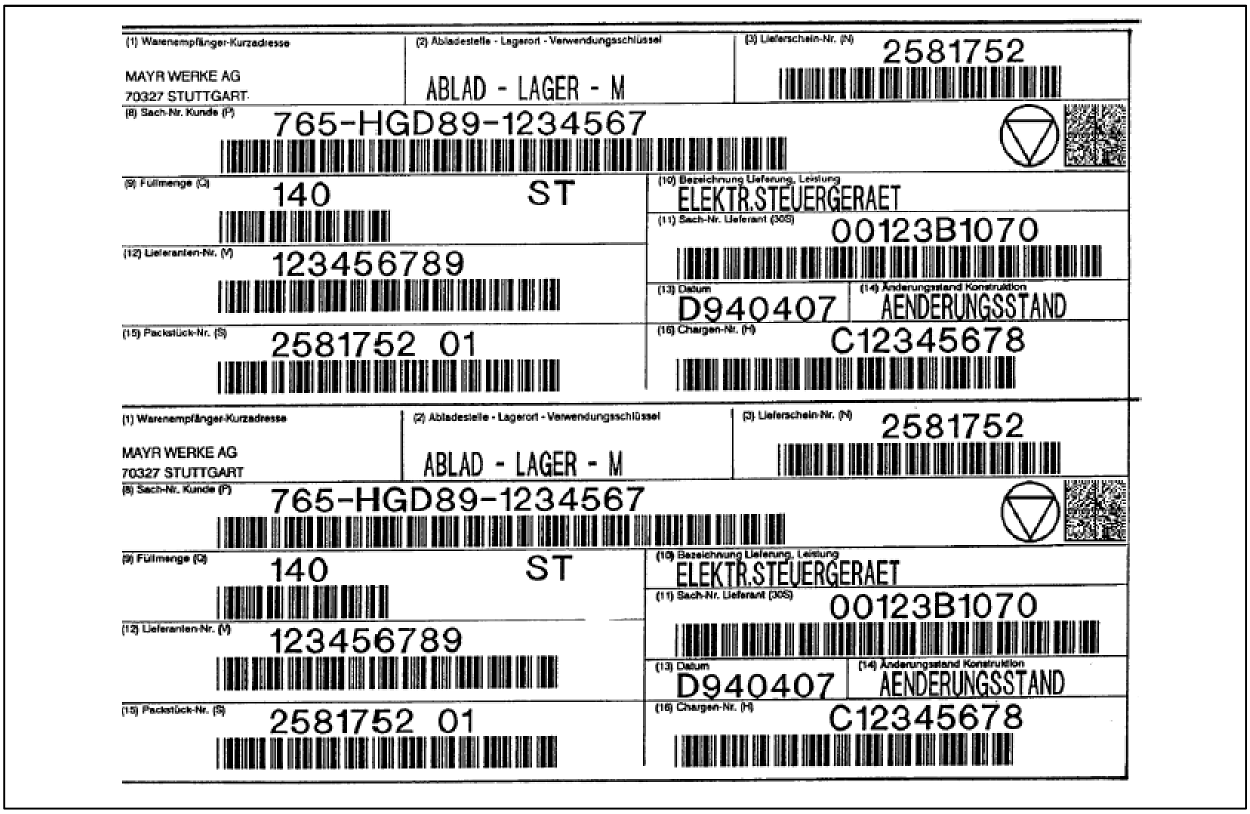

Figure 24: Example of a label for a small load carrier according VDA 4902[184]

[183] Cf. Verband der Automobilindustrie e.V. (1992), p.3
[184] Verband der Automobilindustrie e.V. (2012), p.6

5.3 Line Feeding

Line feeding was the second section that was addressed in this thesis. It was planned to use the same approach as for the goods receiving and warehousing processes and start with a workshop, to define the Logistics Absolutes, find a first mutual understating for line feeding processes and to create the first concepts. This workshop would have been planned for the end of June or beginning of July. But due to the holiday season no common date for a workshop was to be found. For this reason a conference call with the MFeT was conducted (compare section 4.3.2).

To get some additional insights on the topic of line feeding, a visit at the logistics service provider Neovia in Budapest was done (compare section 4.3.3).

In the following the results of these conference call and workshop are described.

5.3.1 Logistics Absolutes for Line Feeding

As for the goods receiving and warehousing process, the Logistics Absolutes for line feeding were defined in coordination with the MFeT as a first step and basis for the standards and tools of the line feeding process.

The Logistics Absolutes for line feeding are:

- Low inventory at line site; calculation of max inventory depending on the replenishment time (max. double replenishment time or two boxes at the line)
- Smallest possible lot packaging (to support above), manually handled or on wheels
- Fork lift free delivery
- Leveled and balanced routings
- High delivery frequency
- Delivery directly to the point of use
- No repacking
- 100% pull delivery to point of use
- Material presentation at station according 5S principles
- No double handling

The below described concepts try to address these absolutes as far as possible.

5.3.2 Line Delivery

Line delivery is the provision of materials from the unloading area or the warehouse to the point of use. This process has major impact on almost all of the defined Logistics Absolutes. The design of the used systems for material provision affects the inventory at the line and therefore the delivery frequency.

Since in the Logistics Absolutes a use of forklifts is already excluded, sole system recommended is the use of tugger trains.

Use of Tugger Trains for Line Delivery

Tugger trains consist of a tractor unit and one or several trailers, on which commodities are transported from a warehouse to their point of use, usually the production line. Most commonly tugger trains are used in round trips, always providing the same stations with materials in defined time intervals. For this the tugger train starts at a loading station, where the employee loads the goods which are needed at the line. Then the tugger train drives to the different points at the line, providing materials in the right time and in the right sequence (if necessary). Simultaneously the driver of the tugger train can pick up empties from each workstation and collect Kanban cards. At the end of his route, it enters the loading station and gets prepared for a new route (compare Figure 25).

Depending on the requirements of the plant, one or more tugger trains will drive on single or multiple routes in short or long timed intervals. Also the type of tugger train may vary, depending on the requirements. For indoor deliveries of a high number of small load carriers, and an electric traction engine with several small carts will be chosen; for outside deliveries of heavier parts or large load carriers a forklift may be chosen as traction engine and also the trailers will be adjusted on the specific needs.

The reasons for the use of tugger trains are versatile, but the number one reason is safety. In 2012, about 29,000 accidents happened in Germany with floor conveyors, whereby in more than 10,000 of them, forklifts were involved. Eight of these accidents with forklifts were fatal, while accidents with other floor conveyor systems usually resulted in only minor injuries (compare Table 3). Therefore, floor conveyor systems form the largest groups of accidents in the section of in-house transportations with 13.7%. In more than 50% of all accidents with forklifts the casualty was hit, jammed or run over by a forklift.[185]

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[185] Cf. Standke (2014), pp. 67

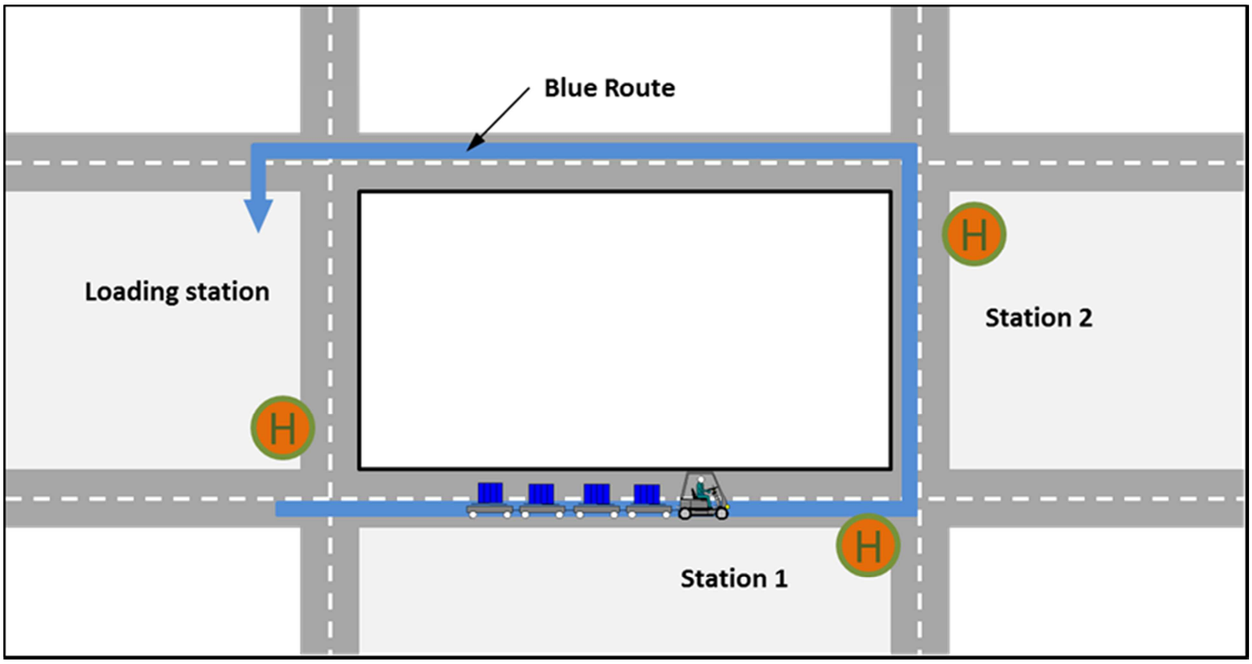

Figure 25: Tugger train round trip[186]

Secondly forklifts are less economical compared to tugger train concepts. This is mainly to the fact that forklifts have a high need for manpower (driver, maintenance, etc.) and can usually only handle one transport order simultaneously. Calculations in the course of different projects within Magna showed that a solution with tugger trains only needs approximately 60% of the resources compared to a solution with forklifts.

	Notifable Accidents		Accident Annuities		Fatal Accidents	
Means of Accident	Number	%	Number	%	Number	%
Transport- and Handling Equipment without Lifting device	**14,618**	**50.3%**	**107**	**20.5%**	**1**	**10.0%**
Wheelbarrow	427	1.5%	8	1.5%	0	0.0%
Handcart, Sack Barrow	588	2.0%	5	1.0%	0	0.0%
Trolley, Baggage Wagon, Dollies	7,924	27.3%	30	5.8%	1	10.0%
Hand Pallet Truck	5,088	17.5%	53	10.2%	0	0.0%
remaining Transport- and Handling Equipment without Lifting device	590	2.0%	11	2.1%	0	0.0%
Forklifts	**10,470**	**36.0%**	**345**	**66.2%**	**8**	**80.0%**
with driving seat	2,204	7.6%	115	22.1%	3	30.0%
without driving seat	1,608	5.5%	30	5.8%	0	0.0%
no allegations on driver seat	6,658	22.9%	200	38.4%	5	50.0%
remaining Floor Conveyor Systems	**3,966**	**13.7%**	**69**	**13.2%**	**1**	**10.0%**
Total	**29,054**	**100.0%**	**521**	**100.0%**	**10**	**100.0%**

Table 3: Number of accidents with floor conveyor systems[187]

[186] Own Illustration, based on expert interviews

The use of tugger trains can reduce in-house traffic drastically. Tugger trains can carry a high diversity of parts to multiple different stations in one run. In a study with 16 enterprises on the topic of tugger trains, 80% said that their number of in-house transports was reduced after implementing tugger train systems.[188]

In aspects of Lean Management, tugger trains help to reduce the amount of material at the line and improve the replenishment time, while increasing the security of supply. Additionally the replenishment process is standardized, which helps to reduce errors.

A disadvantage of tugger train systems is the loss of flexibility with this system. Since forklifts can be used for single runs throughout the whole plant in the same way, they are much more flexible to use. When using tugger trains the routes have to be planned and timed in advance to assure the needed material is always at the right place in the right time.

This minor disadvantage faces several advantages for line delivery processes why the tugger train concept can be recommended generally to all Magna plants.

Choosing the Right Delivery Frequency

For an optimal use of tugger trains for line delivery, the ideal delivery frequency has to be found. An optimal replenishment rate for workstations can decrease labor costs and inventory costs. The reduction of labor costs is possible if the replenishment routes and rates are optimized for the workload of the logistics operator. Inventory costs can be reduced by higher replenishment rates, reducing the needed space at each workstation.

Obviously a high delivery rate leads to lower stocks at the workstations, while a low deliver frequency increases it. For the calculation of the optimal delivery frequency, following parameters should be considered:

- Route length for replenishment
- Available space at each workplace/ size of parts
- Workload for logistics operator

This calculation can also be compared to the levelling of incoming trucks (compare pp. 65).

[187] Revised from Standke (2014), p. 70
[188] Cf. Günthner, Galka, Klenk, Knössl, & Dewitz (2012), pp. 26

5.3.3 Picking

The picking process can be seen as a preparation for line feeding that compiles different parts that have to be delivered to the line for further processing.

Picking can also influence the ergonomics at the production line. This is the case if during picking operations a kit is assembled, where different parts are put in one container for easier access.

In the following different concepts for picking are explained.

Zoning of Picking Locations

The visit at the Neovia Logistics plant in Budapest showed that the zoning of picking location can help to improve the time needed for picking operations.

As already mentioned in 5.2.5, the zoning of a warehouse does not necessarily improve the performance of the warehouse, particularly if large floor conveyor systems are used, since they are likely to block each other and therefore reduce the overall performance.

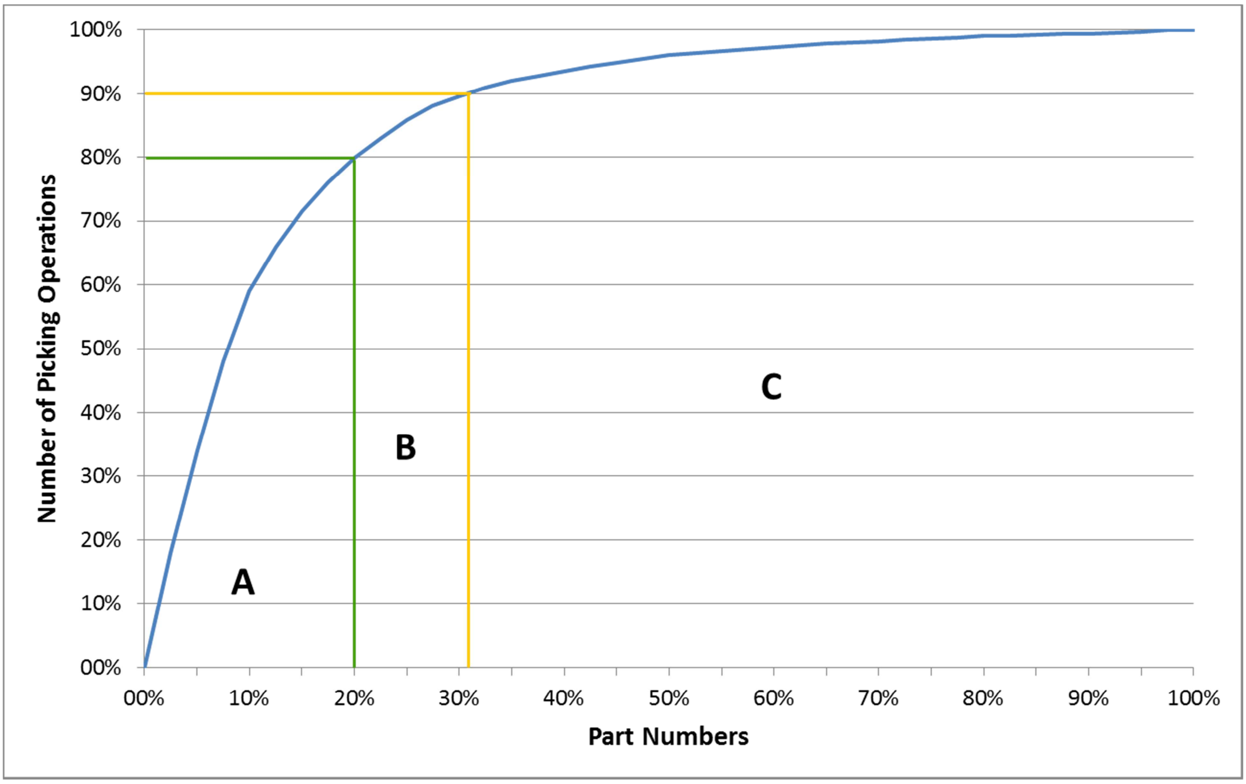

Figure 26: Classical ABC segmentation for picking operations[189]

[189] Own Illustration, revised from Andler (2011), pp. 153

The situation is slightly different in a small parts warehouse for commissioning. Here, the employee usually only uses small trolleys which are easier to maneuver and where even two fit into one aisle side-by-side.

These types of operations are very labor intensive, since single parts or small load carriers are withdrawn one by one to create patches of just-in-sequence items. To reduce the workload for the employees, an ABC distribution on picking locations should be done, analyzing the number of picking operations per part number. This usually results in an 80/20 distribution, where 20% of the parts cause 80% of all picking operations (compare Figure 26).

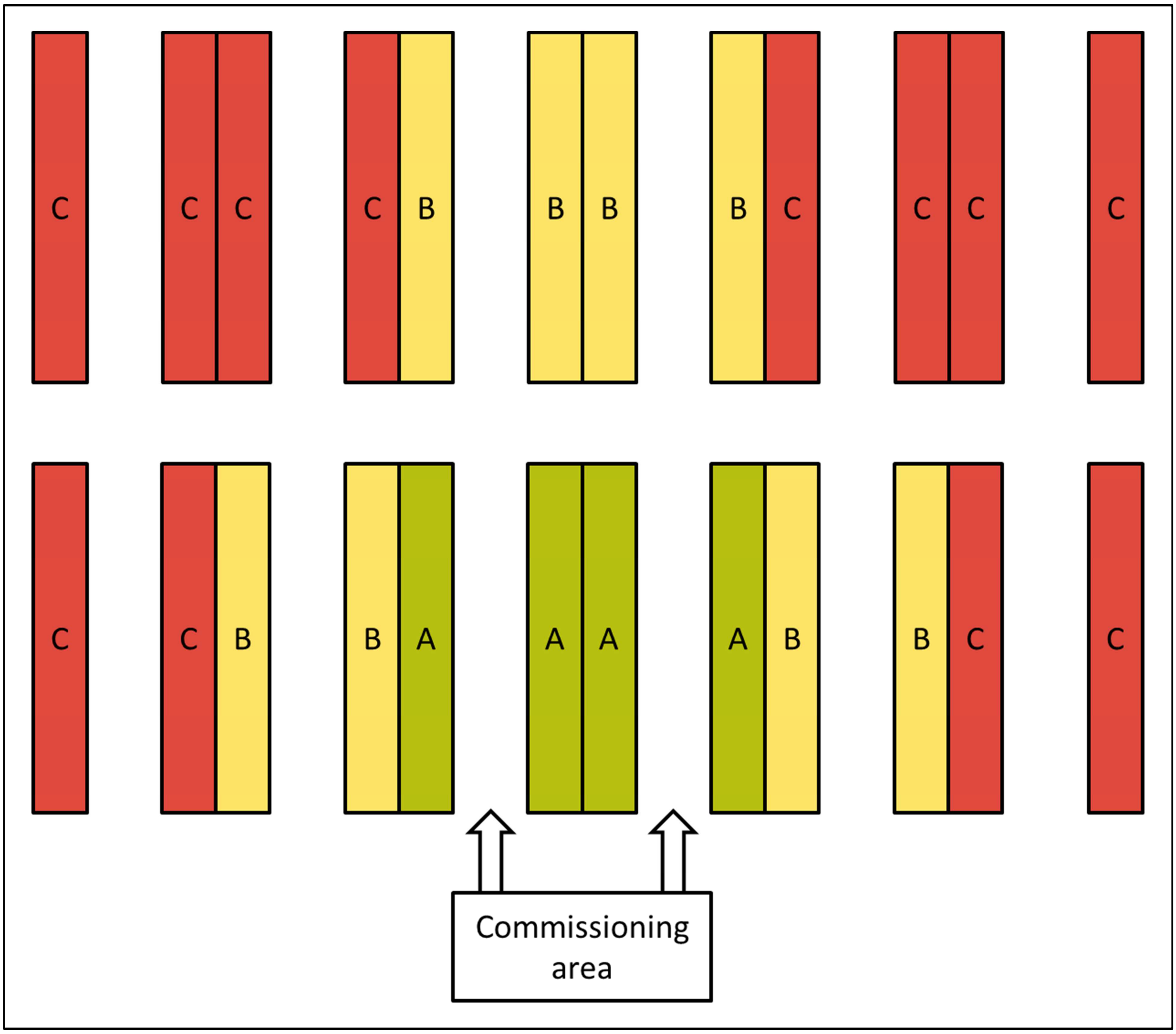

Figure 27: ABC distribution on warehouse level[190]

[190] Own Illustration, based on expert interviews

The picking locations inside the warehouse should then be fragmented according to the results of the ABC analysis. Fast and often moved parts (A-parts) should be stored in easy and fast accessible areas, while slow moving parts (C-parts) can be stored far away from the commissioning area. From these demands a first layout for parts in the warehouse can be derived (compare Figure 27).

To get the best results from this strategy, the results from the ABC analysis also have to be applied on every picking location. Fast moving parts, or A-parts, have to be stored on a level between the hip and the eyes to assure fast picking for the employee since it is faster to take one more step to the side than bending down. This also improves the ergonomics for employees, improving their endurance and reducing disorders, especially in the spine area.

Parts below the hip, for which employees have to bend down to reach them, are defined as B-parts and parts next to the floor or so high that employees have to stretch or even need a ladder to reach them are considered as C-parts (compare Figure 28).

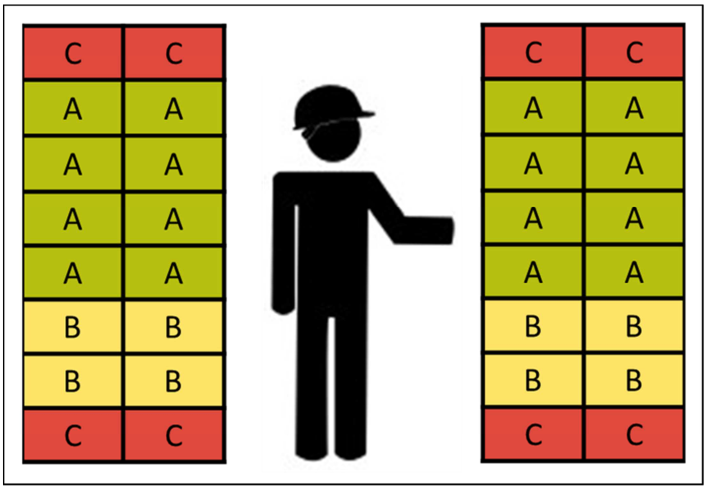

Figure 28: ABC distribution on picking level[191]

Since the results of the ABC analysis may change with the production of different parts or products, a regular repetition of the analysis has to be done, e.g. on a monthly basis. The warehouse has then to be rearranged according the new results.

[191] Own Illustration, based on expert interviews

Auxiliary Systems for Picking

To further increase the performance of the picker, and to reduce the likelihood of errors, the use of picking assistance systems can be recommended for some cases.

These systems can drastically reduce the error rate during picking and simultaneously improve the productivity of the employee. Therefore they are especially worthwhile in JIS productions with high product diversity. Here a part that is delivered in the wrong sequence to the line is likely to cause high efforts or costs for rework or compensation (if items are sent to customer).

The most important and mature picking systems are pick by light and pick by voice, which should be explained here briefly:

- **Pick by light system**
  A pick by light system consists of a network of lights and displays which are located above or below each picking location, and a database which administrates the locations together with the part numbers. When an employee scans a picking order, the picking locations are marked with lights and at each location a display indicates the quantity required for this order. By pushing a button next to the light/ display the employee signifies that the pick is complete.[192] Modern pick by light systems show the employee the nearest way to the next picking location with an optical signal after confirming the pick.
  Pick by light systems drastically reduce the picking error rate to less than 1%.[193] To minimize errors during the picking, employees have to pick material first and push the button to confirm the pick afterwards. Additionally two similar parts (e.g. screws of different length) should not be placed in adjacent boxes.[194]
- **Pick by voice system**
  The transmission and confirmation of the picking list is done via voice. A wearable terminal connected with the central computing systems receives radio frequency signals and converts them into acoustic signals for the employee. The use of wrist-mounted displays and ring scanners can improve the efficiency of pickers even further by letting the picker have both hands free.[195]
  Advantages of pick to voice systems:[196]
    - Hands free technology lets employees use both hands for product handling

[192] Cf. ten Hompel & Heidenblut (2011), p. 227
[193] Cf. Forte Industrial Equipment Systems Inc. (2014), p.5
[194] Cf. Expert interview with Hans-Soenke Hartmann, conducted on Aug.-13, 2014
[195] Cf. ten Hompel & Heidenblut (2011), p. 158; Forte Industrial Equipment Systems Inc. (2014), p.5
[196] Cf. Forte Industrial Equipment Systems Inc. (2014), p.5

- Picker can wear safety equipment (gloves, helmet, etc.)
- Higher safety through eyes free operation
- High order accuracy of more than 99%
- Productivity increase of up to 20%

Provision of Parts to the Line in Assembled Kits

The provision of picked items to the point of use can be done in a continuous supply, bringing single parts in patches, just-in-time or just-in-sequence to the point of use. In this case a specified amount of each part is stored at the assembly line, where they are used. When different variants of the same part are delivered to one assembly station, the operator has to pick the right parts for the assembly of each variant, what can easily lead to errors, particularly in complex assemblies with high variances. Another option is to deliver the parts just-in-sequence in pre-prepared kits.[197]

A kit consists of different parts or component families and should be used sequential or parallel, directly at the point of use. Kits contain exactly the parts needed to complete one assembly object. A kit doesn't have to look the same all the time, in a mixed-model assembly, every one delivered to the line might vary from the previous one. Therefore kitting is a method that has a good applicability in JIS productions.

Even if the use of kits is more labor-intensive than a classic JIT or JIS delivery of single parts, kitting has some advantages that are suited to reduce overall costs:[198]

- Improve of productivity of employees at the line by reducing time for searching or fetching of parts
- Reduction of needed space in production or final assembly (e.g. by reducing the number of flow racks needed to present all needed materials)
- Reduction of errors in terms of using wrong parts in production or assembly
- Increase of flexibility

A reduction of errors is always a crucial point in a JIS-production line and the use of kits with shadow boxes is particularly suited to address this issue. Using shadow boxes, it can be guaranteed that only complete sets containing the right materials are delivered to the line (Poke-Yoke) (compare Figure 29). If, in spite of the Poka-Yoke characteristics of this system, a wrong or incomplete box is brought to the line the

[197] Cf. Hanson (2012), p. 3
[198] Cf. Balakirsky et al. (2013), pp. 1206

correction of this error may result in high efforts (e.g. installment of wrong parts may only be detected by the customer).

Figure 29: Kit for outside mirrors at MSF[199]

The most common way of presenting kits is also in flow racks, but the kitted boxes might even travel with the production line to provide all materials needed at a certain time.

Since the used principle of delivery can significantly influence the performance of the assembly and the in-house materials supply, a detailed analysis determining the advantages, performance and ideal configuration of each system should be done.

Performance criteria to be considered are:[200]

- **Man-hour consumption**
  Kitting will result in less man-hour consumption at the workstation, but will increase the consumption within the material supply operations.
- **Product quality**
  Since employees don't have to consider which parts have to be assembly, they can focus completely on the assembly process what leads to a higher assembly quality. To assure this, the kits also have to be of a high quality and parts presentation within kits should be done to assist the assembly process.
- **Flexibility**
  In a continuous supply system the available space sets a limitation to the amount of part numbers that can be presented within one workstation.

[199] Own Illustration, picture taken at MSF
[200] Cf. Hanson (2012), pp. 21

- **Inventory levels and space consumption**
  Kitting is related with less space requirements at the workplace, since multiple part numbers are presented within one kit. On the other hand the assembly of kits usually requires more space upstream. Therefore kits can be advantageous if the available space at the workstation is limited.
- **Control and visibility**
  When using kits, the assembly specific presentation offers a better visibility of the material flow to the workstation. On the other hand, when performing the kit preparation downstream the main plant storage, additional control of the material flow may be needed.
- **Product throughput time**
  Kitting can reduce the non-value-added time by reducing search time for parts and presenting parts closer to the point of use.
- **Ergonomics**
  For small and lightweight parts, good ergonomic solutions exist for both continuous supply and kitting. If kits are used the preparation of kits has also be included in ergonomic considerations.
- **Investment costs**
  Since neither of these systems needs any automation, the investment cost for both systems are negligible compared to the labor costs. Anyway, kitting systems can decrease investment costs due to decreased space requirements at the line but on the other hand increase investment costs when a pick-by-light or pick-by-voice system is used to support the picking process.

5.4 Packaging Management

For the topic of packaging management, a slightly different method than the ones described before for the goods receiving and warehousing, and line feeding processes was applied. The first results were not discussed and decided within an expert team meeting, but during a mini workshop with Ronald Beck, the head of the Packaging Management Expert Team. The results of this workshop were then presented during the next expert team meeting at Magna Slovteca, to discuss the results and to get additional input (compare section 4.3.4).

In the following, the results of the workshop with Ronald Beck are described, starting with the Logistics Absolutes for packaging management. Then the explanation on how to achieve the Logistics Absolutes is given.

5.4.1 Logistics Absolutes for Packaging Management

As for all other chapters, the Logistics Absolutes for packaging management were defined first:

- Definition of plant internal packaging standards
- One-way or returnable packaging decision for every part
- Consideration of the Magna Global Packaging and Shipping Manual

The Global Packaging and Shipping Manual is a handbook that specifies the packaging and shipping standards for goods being shipped to Magna or its customers. Since the requirements that are listed in this manual have to be applied on all parts shipped to Magna, it is one of the first documents that have to be reviewed when designing a supply chain.[201]

5.4.2 Definition of Plant Internal Packaging Standards

Because of the high diversity of products in the different Magna groups and plants, a high variety of different packaging exists. This high variety of packaging is uneconomical due to several reasons:

- **Disadvantages in warehousing of empties**
  Since different packaging types can't be put on the same storage location, a lower utilization of the warehouse is probable
- **Higher propensity to errors**
  The more diversity exists in packaging, the more likely it is to deliver wrong empties to the customer, or use the wrong packaging for a specific part.
- **Compensation of volume changes**
  Since production volumes change regularly, a high diverse packaging portfolio is unlikely to be able to absorb variations. This is definitely applicable to large-scale changes in the production volume (e.g. on a yearly basis), and in a small scale also on short-term fluctuations in the production.
- **No synergy effects**
  Purchasing larger amounts of the same product at the same supplier will result in better terms than the purchase of many different products at different suppliers

[201] Cf. Magna International Inc. (2014e), p. 5

(product in terms of packaging type). Having a high packaging variety, these synergy effects cannot be used.

For these reasons, a standard container portfolio, describing used packaging types, should be defined by each plant. This portfolio will help to find the right packaging for every application while simultaneously reducing the number of different types of packaging.

The different packaging that are taken into this portfolio have to be chosen in accordance to existing Magna Container Menus, a listing of existing and recommended packaging for each class. Thus an improvement of the compatibility between plants should be reached, creating advantages for bulk purchasing and making it possible to interchange containers within different plants.

Experiences from various plants show that such a portfolio is likely to cover up to 90% of a plant's packaging needs. The remaining 10%, which are not represented in the portfolio are usually special cases, which need a special designed packaging and are therefore not suited for synergy effects anyway.

Besides the definition of standard load carriers and loading devices, following specifications should be recorded for every type of loading unit:

- Packaging number and description
- Packaging dimensions
- Packaging material
- Packaging source
- Packaging type and classification

Classification of Packaging

The classification of different types of packaging supports the definition of standard packaging. Therefore six standard packaging classes were defined:

- **A-Item**
  Part specific load carriers with or without attached or loose returnable dunnage
- **B-Item**
  Vacuum formed or injection molded custom (part specific) trays
- **C-Item**
  "Off the shelf" produced small load totes or bulk containers

- **D-Item**
  Permanently attached or loose returnable/expendable customized dunnage used with a "C-Item"
- **E-Item**
  Expendable packaging material for part protection used with a "C-Item"
- **F-Item**
  Expendable or returnable small load container for loose material

5.4.3 One-Way or Returnable Packaging Decision for Every Part

The decision if a one way or returnable packaging is used in a project can have major influences on the costs of a project.

As mentioned before, Magna has several classifications for packaging. For each of these classifications one-way or returnable packaging may exist and according to the "plan for every part" principle, for each part the same calculation has to be done.

In general, a one-way packaging can be discarded after it was used and is therefore also called expendable packaging. It is usually used, if the return shipment of the returnable packaging is more expensive than buying new disposables.

When considering the use of expendable packaging, some major points have to be respected:

- **Packaging type**
  Depending on the purpose of the part, a different packaging may be chosen. Despite the packaging types that were already described in 3.4.3, three packaging types which are used within the supply chain of Magna were defined:
  - Packaging for serial parts (free-flow, SKD, CKD, …)
  - Substitute packaging (In case of serial packaging bottlenecks,)
  - Spare parts packaging (Usually one-way packaging, since it is also used as sales packaging)
- **Plant restrictions**
  Are there any restrictions (environmental, safety or process related) which exclude a specific type of container or material?
- **Container recycling**
  Usually recycling companies pay to further process one-way packaging. Therefore considerations about storage, in-house recycling and sales of the one-way packaging should be done.

On the other hand, returnable packaging can be reused after transporting items with it. Therefore it represents a value. To improve the lifetime of returnable packaging it should be managed within a material flow system similar to standard parts.

To put the decision, which type of packaging to choose, on a profound basis, several points have to be considered:

- Cycle time
- Investment costs per pallet
- Expandable costs
- Return costs of packaging
- Project time and volume

While most of these points are based on project data or need a quotation from a logistics service provider, the cycle time can be calculated. At Magna, the cycle time is also called system days and therefore the calculation of the cycle time is called system days calculation.

System Days Calculation

System days calculation defines how many days a load carrier runs in the process until it reaches its starting location. A complete packaging cycle can be long and complex (compare Figure 30), the following steps are included (starting from the outgoing goods at the supplier):

- Transport of full load carriers to the plant by a logistics service provider
- Storage of the full load carriers at the plant until they are needed at the production line
- Storage of full packaging at the line until parts are used and packaging is emptied
- Storage of the empties at the plant until they are collected and sent back to the supplier
- Transportation from the plant to the supplier
- Storage of empties at supplier, including possible special treatment like cleaning, repair, etc.
- Filling of empties at suppliers production line
- Storage of full containers at suppliers outgoing goods department.

Since this value is multiplied with the average part consumption per day (take rate), the result influences the costs for a specific packaging type significantly. For this reason an accurate calculation is very important.

To make this calculation as accurate as possible, a tool was created by Ronald Beck, which includes several parameters to get to a value that is very precise.

These parameters include:[202]

- Number of parts per unit [pieces]
- Density per primary container [pieces]
- Units per day [pieces]
- Shifts per day
- Hours per shift [h]
- Shipping frequency inbound [days]
- Transport time inbound [days]
- Shipping frequency outbound [days]
- Safety inventory at supplier [days]
- Safety inventory at plant [days]
- Plant internal transport [days]
- Time for maintenance/ cleaning of container [days]

By using these parameters it is possible to calculate the exact time a container needs for one full cycle, including all the steps in between and the exact number of containers that are needed for a specific part number.

Combining these values for cycle times and needed amount of packaging with the above mentioned points, it is easy to make a break-even calculation, which should show the point from where the use of a returnable packaging solution causes less costs than a one-way packaging solution. Despite of these points, the decision must also be based on plant internal requirements and quality requirements.

[202] Cf. Expert interview with Ronald Beck, conducted on Oct.-10, 2014

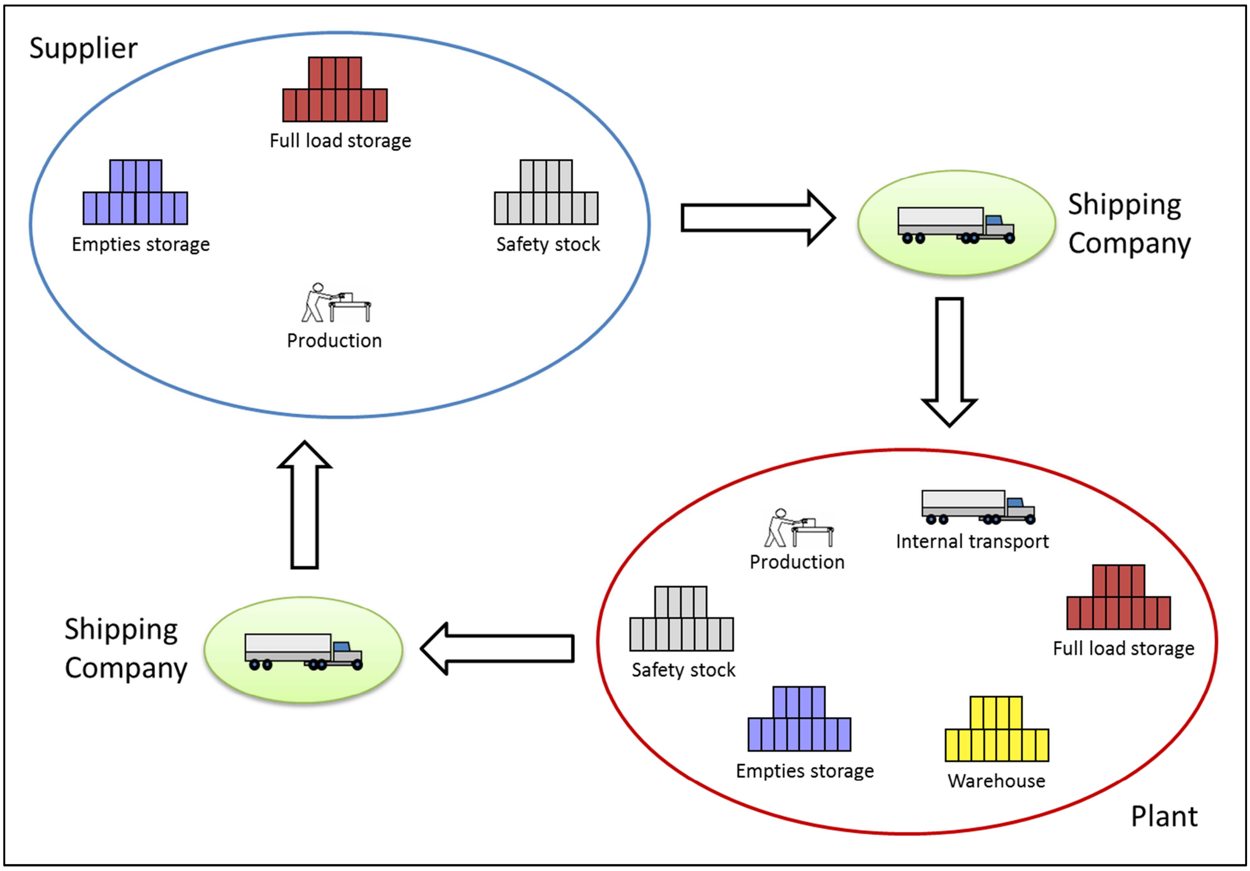

Figure 30: Packaging process cycle[203]

[203] Own Illustration, based on expert interview with Ronald Beck, conducted on Oct.-10, 2014

6 Conclusion

In the following section a summary of the findings that were made during the work on this thesis is done.

Afterwards, a conclusion, which contains an outlook on the World Class Logistics project, including the use of the results and the most important next steps for implementing World Class Logistics at Magna, is given.

6.1 Summary

The idea for this thesis was the creation of a guideline, which can be used as a manual for all Magna plants on their way to World Class Logistics. It was created out of the need for a higher standardization of processes and for more transparency of the complete supply chain to support the World Class Manufacturing initiative of Magna. The World Class Manufacturing initiative already combines standards for different Magna processes in one guideline and also puts a high focus on Lean Management. However, a definition of general logistics processes was not available at Magna until this time.

Therefore, the World Class Logistics project was created to define logistics concepts and best practice examples that are suited to be seamlessly integrated into the World Class Manufacturing initiative. During this thesis an in-depth contemplation of concepts that already exist in Magna, influences and ideas from external companies, and new findings from the university were used to cope with the claim to be World Class. All this was done while maintaining a high focus on Lean Management, as this is still one of the most influencing manufacturing concepts existing.

The work for this thesis resulted in a guideline, which makes the first strides towards a reference book for all logistics aspects. To do so, Logistics Absolutes were defined for the three main sections goods receiving and warehousing, line feeding, and packaging management. The Logistics Absolutes define the minimum requirements for plants to achieve the goal World Class Logistics. Besides them, different methods, tools and best practice examples were defined and described, which can be used to fulfill the Logistics Absolutes.

To reduce unnecessary work, throughout the complete material flow, the use of standardized VDA labels was recommended. This reduces the need for reprinting and changing of labels. Through implementation of a packaging control process during the goods receiving process, issues at the production line or in the warehouse due to wrong packaging are reduced.

By widely using visualization, the goods receiving process can be further optimized. Implementing large whiteboards or screens, displaying the next incoming trucks assists to level the workload of receiving operations throughout the day; using colored floor markings to define different areas in the goods receiving area supports the reduce tion of errors and accidents.

The focus at the line feeding operations was put on the reduction of inventory at the production line. To do so, the general use of tugger trains, if possible, is recommended. The application of tugger trains creates a defined process, helps to reduce stock levels at the production line, reduces in-house traffic and improves the safety at the production floor by eliminating the need for forklifts.

To prevent errors in the line feeding process (wrong materials, etc.), and to improve productivity of the assembly stations, different picking methods were considered, and different methods are proposed in the guideline. However, due to its labor intensity, it is only recommended to use a picking and kitting process, when there is only little space available at the line or a productivity increase is critical.

The target for packaging management was to optimize the needed number of packaging per plant. Therefore a calculation for the needed number of carriers per part was developed. This is done in combination with the definition of internal packaging standards for every plant, which helps to reduce the diversity of packaging. By providing a central database of already existing packaging in the Magna Europe group, the use of cross-divisional benefits can be achieved.

To optimize the overall packaging costs, the need for a one-way or returnable packaging decision for every part was defined. By applying the calculation method for the needed number of packaging per part, an estimation of the total costs for returnable packaging can be done, while costs for one-way packaging can be obtained at a possible supplier. An assessment of these values supports a profound decision process.

The validation of the results for this work was given by the members of the different expert teams involved in creating this thesis. Prior to this, several iteration steps with every member of the expert teams and meetings with the steering committee were made, to get approval for the implementation of the guideline.

The final step for this thesis was taken, when the results were presented at the Magna World Class Manufacturing Conference in Detroit, and the Magna Logistics Days at Schloss Seggau in Leibnitz. At these two events, the guideline was presented to several hundred managers of different Magna plants and top management, who are going to include the WCL-guideline in their future work.

6.2 Outlook

Although the presentation of the first results of this thesis to a large audience has been a great success, it can only be seen as the first step in this project.

The next important phase in this project will be the implementation of the results in different Magna plants. This represents a major challenge due to the already described highly decentralized structures of Magna and the high diversity of products Magna is producing. Furthermore, the level of realization for specific concepts as well as the need for these concepts will have to be elicited for every plant.

To assist the rollout, the development of a webpage, which is able to administrate all the knowledge created within the different expert teams, began already in summer of 2014. A webpage will presumably be best suited to handle all the available data.

The next step that must be done, besides the creation of a platform that simplifies the access to the guideline, is the extension of the guideline with the knowledge from the other expert teams.

Therefore Magna has already implemented or is currently implementing different expert teams for major topics of the supply chain.

The following topics will be adapted into the World Class Logistics guideline in near future:

- Implementation of information flow, describing the three major points customer order management, production planning and control, and materials planning and control
- Conclusion of the operational processes by implementing World Class requirements for transportation and customs
- Adoption of the section supply chain engineering

This brings it to the last and most important point that has to be mentioned. Even if this thesis is finished, the most important target for the WCL-guideline is that the continuous work on it will never end. Technological, economical, ecological and social border conditions develop at a high pace and to be world class means to develop in this high pace. For the guideline this means that it always has to be under review and that new findings will always have to be included, while no longer valid ones will have to be removed.

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8 List of Figures

9 List of Tables

10 List of Abbreviations

ASN: Advanced Shipping Note
CC: Concept Confirmation
EOP: End of Production
ERP: Enterprise Ressource Planning
FC: Functional Confirmation
FIFO: first-in, first-out
IFeT: Information Flow Expert Team
JIS: Just-in-Sequence
JIT: Just-in-Time
KPI: Key Performance Indicator
LDS: Leadership Development System
LIFO: Last In First Out
Max: Maximum
MFeT: Material Flow Expert Team
Min: Minimum
MIT: Massachusetts Institute of Technology
MLE: Magna Logistics Europe
MRD: Material Required Date
NOK: Not OK
OEM: Original Equipment Manufacturer
PMeT: Packaging Management Expert Team
PPS: Preliminary Program Specification
PS: Process Sign-off
PTO: Production Tryout
PV: Product Vision
R@R: Run at Rate
SCC: Supply Chain Coucil
SCE: Supply Chain Execution
SCEeT: Supply Chain Engineering Expert Team
SCM: Supply Chain Management
SCOR: Supply Chain Operations Reference Model
SCP: Supply Chain Planning
SCR-M: Supply Chain Reference Model
SOP: Start of Production
sq. ft.: square feet
TA: Target Agreement

TLeT: Transport & Logistics Expert Team
TTS: Transport, Transshipment and Storage
VDA: Verband der Automobilindustrie e.V.
WCL: World Class Logistics
WCM: World Class Manufacturing