DEPARTMENT OF MECHANICAL AND AEROSPACE ENGINEERING (DIMEAS)

MASTER OF SCIENCE IN AUTOMOTIVE ENGINEERING

Development of a Knowledge Management System Through PLM-MES Integration

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Abstract and Keywords

Development of Knowledge Management System Through PLM-MES Integration

Along the stages of industrial evolution and approaching Industry 4.0 in the past decade, competitiveness increased with a high rate in the industrial environment where companies compete in order to supply current highly customized markets through the most efficient technologies possible.

To remain as a main competitor in this environment, companies need to stay updated to the latest technologies and tools that can improve the production process as well as the relationship with the customers, vendors, suppliers etc.

The tools that represent a main support in the Industry 4.0 era are information systems in manufacturing. These systems ensure an efficient information flow between different departments in the industry besides information flow between different levels in the same department. The corresponding information flow manage the data required to produce the product and allows to store it in a digitize way which results in a more effective design and production process. Its benefits are mostly recognized in storing past experience thus creating a digitized knowledge to avoid repeating the same errors which reduces production time in the future and hence increasing competitivity.

Information systems mostly adopted in daily industrial data are Product Lifecycle Management (PLM) and Manufacturing Execution System (MES). The information flow between these two information systems through a central Knowledge Based System (KBS) will ensure the industrial goals in achieving a more efficient and competitive system. PLM captures, manages, and share the data regarding the product through its whole lifecycle from design until recycle or disposal. Whereas, MES manages and shares information regarding shop floor data and manufacturing status.

The objective of this thesis work is to study the feasibility of obtaining a central KBS that is able to exchange information between PLM and MES through Odoo software in order to reduce cycle errors, production time, and increase production effectiveness and thus obtaining the desired industrial competitiveness. Besides that, hopefully this paper would be a useful guide for any future studies regarding Odoo software because it will support information regarding the main functionalities of Odoo and the application method.

Keywords: Product Lifecycle Management (PLM), Manufacturing Execution System (MES), Information Systems, Odoo, Knowledge Management

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Chapter 1
Introduction

In the 21st century, and with the deployment of Industry 4.0, the customization of the customers' needs became the main focus. Thus, the companies' goal is to satisfy the customers' need by continuous innovation of new products and technologies which makes the introduction of new products to the market be led by the customer himself. The continuous change in the market demand based on the dynamic customers' needs focused on cost and quality of the product, requires a flexible manufacturing system able to respond to market changes on the design and production level. Therefore, this heavy goal can be achieved by the deployment of manufacturing information systems (IS) which will succeed in realizing a flexible manufacturing system by its integration throughout the manufacturing process. On the other hand, the attained flexibility plays the role in continuous innovation in addition to the improved quality, reduced cost, and reduced delivery time. Hence, the high global competitivity to gain customers' satisfaction, led business process to be focused on quality and innovation content of product besides production cost. In this paper, the studied IT platforms that will be discussed and further integrated are PLM and MES systems.

The PLM system is a business strategic approach that integrates the corresponding creation, management, dissemination, and the use of product definition information across the extended enterprise from concept to end-of-life where it integrates people, processes, business systems and information together. Thus, PLM manages and pursue information throughout the product life cycle. On the other hand, the MES system captures the shop floor data and represents a connection between the organizational level and the shop floor thus aims at performing the manufacturing plans. Besides that, the organizational level is supported by the ERP system which is a software program that is applied by the company management and represents a database that includes operations related to finance, sales, marketing, purchasing and human resources where they are traced and managed[1,2].

The integration between PLM and MES improves products' quality where the integration between these two systems allows designers and engineers to obtain a feedback information mechanism regarding the manufacturing process criticalities captured from the shopfloor. This data collected in an efficient way can be reused in future product design and development stages improving the performance of the production process and the quality of the manufactured parts. Moreover, this integration can be deployed to exchange information and experience between several companies or between a company and its suppliers. Thus, PLM-MES integration create a repository system where all data registered during preceding operations and processes is stored and this knowledge can be used whenever it is useful as for example suggesting convenient scenarios to an operator and help him in making aware decisions [2].

Hence, based on the advantages due to the integration between the two information systems and due to the fact that this integration is scarcely applied in the manufacturing industry, the paper's aim is to propose a framework to integrate the two information systems thus capture the advantages obtained by the PLM-MES integration.

The paper's sections are divided as follows; Sec.2 imposes literature related to the topic and the suggested framework, Sec.3 discusses the implementation of the framework for the PLM-MES integration related to the practical case study using Odoo software and corresponding modules, while Sec.4 draws conclusions related to the implementation and states possible future works.

Chapter 2

State of Art

1 Industry 4.0:

The term Industry 4.0 represents the fourth industrial revolution which exploits a step towards modern approach of organization and control through all the stages of the product's lifecycle. The main goal of industry 4.0 is focusing on customized customer need and satisfying it which brings various advantages in several sectors in the concerned manufacturing industry. Industry 4.0 enhance the integration of sensors, monitoring devices, firms' assets, and the internet.

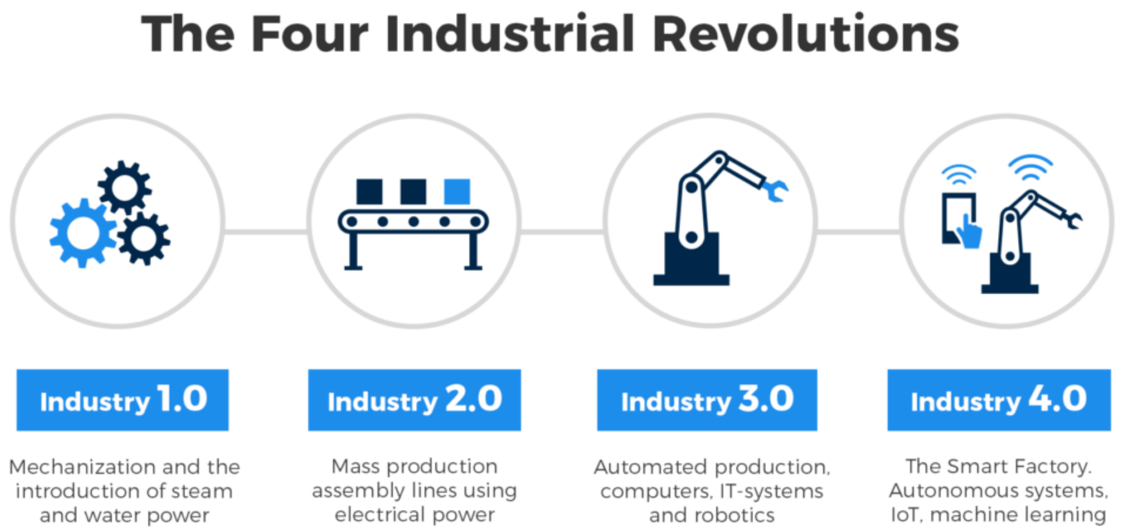


Figure 2.1: Industry 4.0 evolution

The deployment of industry 4.0 has a goal of achieving a self-aware and self-learning machines in order to boost habitual machines' efficiency and accomplish a better interaction with their working environment. Therefore, Industry 4.0 seeks to achieve unfastened, intelligent manufacturing site in which a network of integrated information systems is exploited. This innovative approach presented, trace in real time the production process status in addition to products' manufacturing quality. Hence, in Industry 4.0 the manufacturing and logistics systems take advantage of the accessible knowledge and applies efficiently a systemized automated exchange of information in order to improve the process performance and enhance the manufacturing industry. Therefore, Industry 4.0 will convert faraway manufacturing sectors into an integrated, automated manufacturing environment which will boost relationships between several suppliers, producers, and customers in addition to an effective interaction between the machine and the operator [10].

- The four main drivers of Industry 4.0 that accomplishes an automated smart manufacturing process are the following [10]:

1. Internet of Things
2. Industrial Internet of Things
3. Cloud based manufacturing
4. smart manufacturing

- Integrated system is one of the main principles of the Industry 4.0, however industrial integration can be summed up in several types [14]:

1. Horizontal integration over the business value networks
2. Vertical integration through the integration of different companies' systems
3. End-to-End integration across the products chain

2 Product Lifecycle Management (PLM):

PLM system models, captures, manipulates, exchanges, and uses the information through the entire products' life cycle in which this life cycle consists of three main phases. First, beginning of life (BOL) covering design, industrialization, and production. Second of all, middle of life (MOL) covering logistics, use, service, and maintenance and finally end of life (EOL) covering reverse logistics, remanufacturing, recycle, and disposal. Moreover, PLM work on developing the virtual product and its corresponding process before proceeding to operate on producing the actual product that will be displayed in market [1]. Therefore, the goal of PLM is to ensure the rapid, convenient, clarified, well distributed and reutilized data that is required in daily manufacturing, design, or maintenance operations [2]. Hence, due to the preceding aims of PLM system, it integrates a set of strategies, representations, and IT tools for managing product information, engineering processes and applications. An efficient PLM system thus focuses on achieving a smooth workflow for product development encourage innovation in the manufacturing process [4].

Nowadays most manufacturing companies install PLM systems to cover processes starting from product planning until reaching product disposal in order to ensure efficient product development and service [6]. PLM plays a role in optimizing the process of the development of new product through sharing the product data among the company's different information systems and sectors, in order to reach an additional goal of automating the products' development by the application of up-to-date PLM software intelligent agents [8]. Thus lately, PLM gained its place in being one of the main players in the technological and organizational strategies and a necessity for an efficient management development and creation of a product in a manufacturing process [9].

Figure 2.2: Definition of PLM

Manufacturing industry is capturing several technological advantages due to PLM application. Since PLM is considered a main player in the technological evolution of the manufacturing process and industry in general, thus the analysis of the product information evolution became as much as important. Product information is created at its first level when the product is originated at the beginning, then it is evolved with the introduction of Computer Aided Design (CAD) models and drawings, and further corresponding manufacturing processes, maintenance and recycling guidance [9].

3 Manufacturing Execution System (MES):

MES system goal is to perform manufacturing plans in which it creates a connection between management level and the shop floor. Thus, it keeps operators and administrators updated regarding the real-time state of the plan's execution and all corresponding resources such as, operators, equipment, material, and customer demand. MES has the ability to play the role of optimizing the manufacturing management through the whole process from the creation of the production order until product’s realization. When real-time events occur in the factory, MES can dynamically respond to real-time events in the plant, then analyse them with current accurate data to arrive to an aware. Appropriate decision [1].

MES has eleven functions defined by Manufacturing Execution System Association (MESA) [1]:

1. Resource Allocation and Status
2. Operations/Detail Scheduling
3. Dispatching Production Units
4. Document Control
5. Data Collection/Acquisition
6. Labour Management
7. Quality Management
8. Process Management
9. Maintenance Management
10. Product Tracking & Genealogy
11. Performance Analysis.

Figure 2.3: Definition of MES

Practically, the MES exchange information with ERP in order to keep the ERP updated about production information and status [1]. As mentioned before, MES is a system to ensure efficient communication thus data exchange organizational level represented by ERP, and the shop-floor control systems. Based on what mentioned above, the aim of MES can subdivided into two main categories. First, the system must assess the optimal sequence planning considering the main characteristics of the process, such as processing and setup times, and workstations capacity, and above all note the fundamentals stated by the organizational level of the company. Besides that, the system has a role in managing and assigning resources needed for the manufacturing process and producing the product. On the other hand, the second aim of a MES is to control the data flow of shop floor information to be exchanged with higher organizational level seeking higher product quality and process performance [2]. In addition to that the application of a MES thus the collecting information from the shop-floor data and exchanging it efficiently in the manufacturing system allows the detection of anomalies, criticalities, or the analysis of structured trends [4].

4 Knowledge Management System:

The framework proposed for the PLM-MES integration is an open source architecture based on a Knowledge Based System (KBS) that is considered as a connection for data flow between PLM and MES systems thus receiving and sending data from and to the corresponding systems respectively. Thus, the following literature section is dedicated to defining Knowledge Management, and Knowledge Management System in the manufacturing industry and covering its main characteristics and domain before going into discussing literature related to the information systems integration.

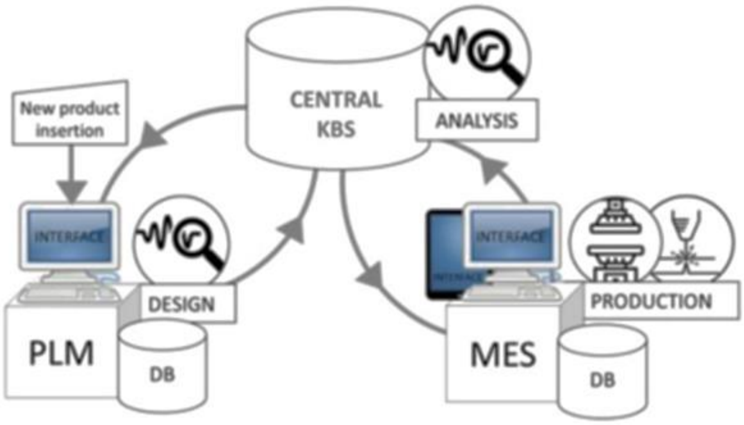


Figure 2.4: Central Knowledge Based System

4.1 Knowledge Management:

Knowledge management can be defined as executing the operations related to discovering, capturing, sharing, and applying knowledge with the aim to improve, in a cost-driven strategy, the effect of knowledge on the industry accomplishments [11]. Knowledge management consists of four principal kinds of KM processes as shown in the Figure 2.5 below. This figure summarizes the KM processes in which knowledge is captured, discovered, shared, and applied. These four KM processes are subdivided into seven different KM sub-processes:

combination, socialization, externalization, internalization, exchange, direction, and routines [11].

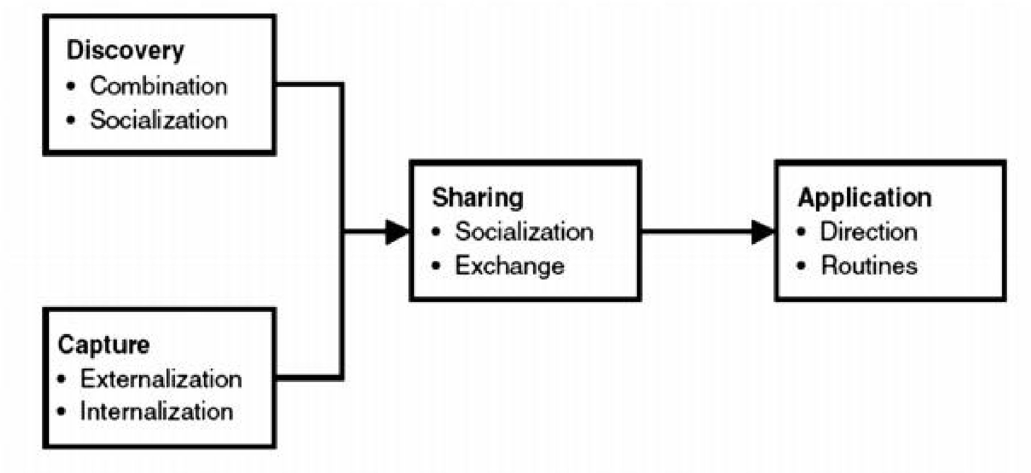


Figure 2.5: Knowledge Management Processes and Subprocesses

After new knowledge is captured, KM mechanisms goal is to make this knowledge ready to enter the organization's memory through a methodology that maximizes the knowledge's influence and reusability in the future. Then, knowledge refinement would take place which covers the processes and mechanisms that are used to set, treat, purify and optimize knowledge so they are included in the corresponding storage medium. However, the most beneficial impact of knowledge can be captured when it is shared or transferred. Knowledge transfer is an aimful knowledge communication from a sender to a known receiver, while knowledge sharing is less targeted, and knowledge goes from a sender to an unknown receiver [11]. Knowledge management is a competitive methodology to seek several advantages in the manufacturing industry. Main advantage of KM in manufacturing is training people working in the firm where training advantages can be visible in the short- and long-term improving the overall performance. Knowledge turns to be accessible to all levels of the organization thus becomes an efficient way to improve employees and production process in which it encourages the fact of people's self-learning and realizing aware decisions in addition to minimizing resources required [13].

Knowledge management recollect and analyse the required and available knowledge, and then proceeded by the setup and organization of actions to attain the knowledge assets seeking the achievement of the organizational goals. Knowledge assets are the knowledge that are owned by an organization causing its business to give rise to profits such as markets, products, technologies, and organizations. Thus, it is important to note the four kinds of knowledge management [13]:

1. Creating knowledge repositories to reclaim knowledge effortlessly.
2. Enhancing knowledge accessibility to improve its transfer between different levels.
3. Boosting a knowledge environment to encourage more efficient knowledge creation, application, and transfer.
4. Managing knowledge as an asset and work on a strategy to augment the effective application of knowledge assets.

In addition to that, there are five steps to ensure an efficient Knowledge Management process [13]:

1. Point out the organizational conflicts and explicit of goals and aims for knowledge activities.
2. Assign a knowledge team.
3. Work on conforming all organizational levels to the process.
4. Prepare companies to be familiar with the new culture of implementing knowledge activities.
5. Make knowledge accessible by applying corresponding technologies.

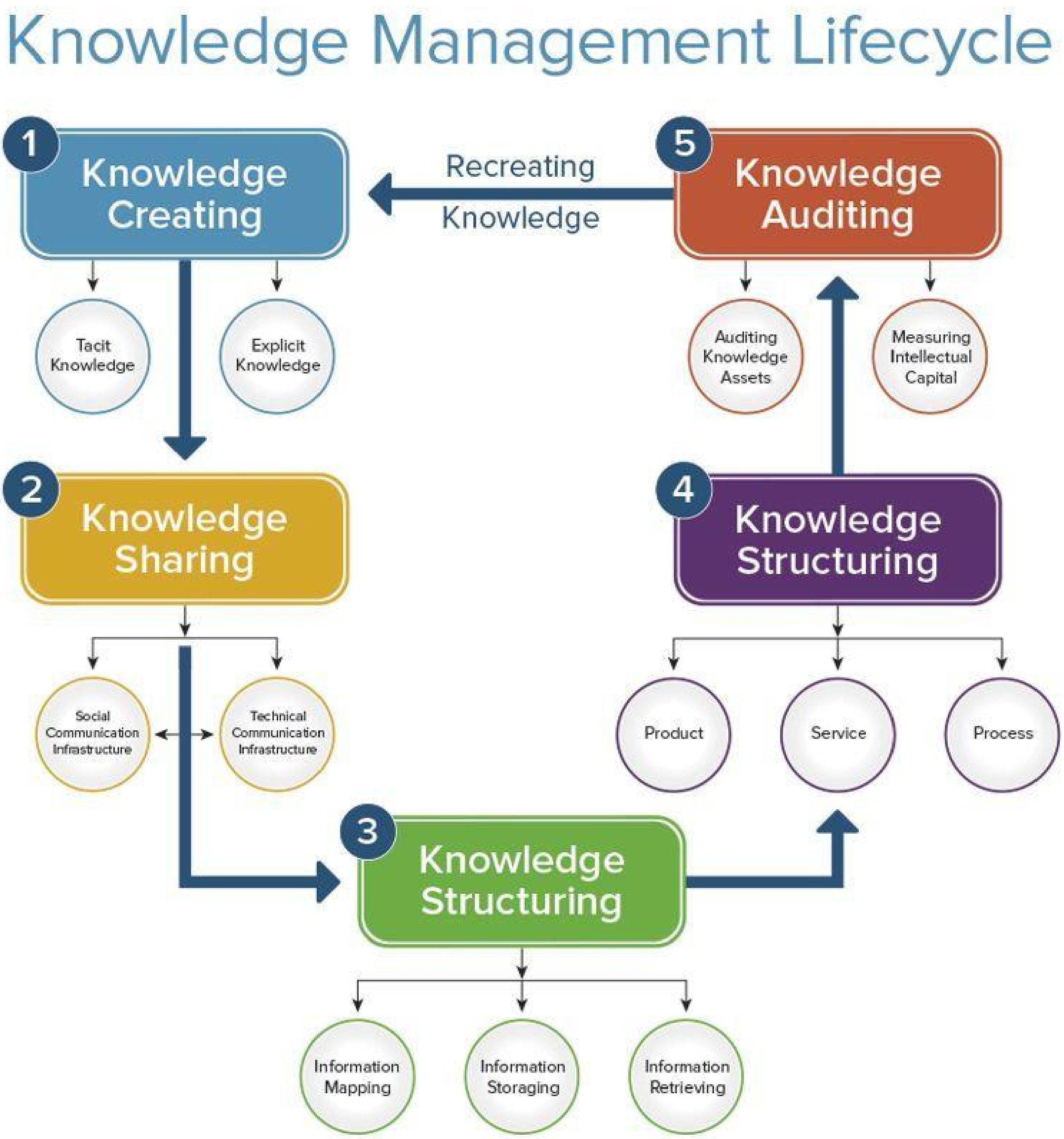


Figure 2.6: Knowledge Management Lifecycle

4.2 Manufacturing Knowledge Management:

Industries are rescheming their internal and external architecture and relations flow, where knowledge networks are created to allow the exchange of data, information, and knowledge, in addition to enhancing the organization environment and encouraging more aware decision making and planning habits. Types of knowledge flow can be investigated in a cooperative supply chain, and suggests knowledge management architecture to enable the corresponding knowledge management .Different proposed architecture will result in different e-business models and different supply chain network type thus resulting in different knowledge flows and methods applied attaining different knowledge management system. Due to what mentioned above, knowledge management and application and reuse will be the main key to provide competitiveness in the manufacturing industry in the present and the future, thus creating a knowledge management system appropriate for manufacturing and production process is an important factor towards an organizational successfulness. However, manufacturing industries are worried about their technological and process exclusiveness and privacy thus they are cautious about the open platform IT/IS for KM which may keep a boundary between automated knowledge management and manufacturing industries for a certain extent. Although, this boundary could be found, traditional manufacturing aims at physical assets, but present manufacturing organizations focus on knowledge assets [13].

The change in the manufacturing and management mentality, led to a change in the culture of the industries, from a closed protected environment to a sharing inter-connected networks within the same organization and with other firms and organizations. Hence, this resulted in highly flexible, active, and competent in meeting the highly customized customers' demands with higher quality. Information systems enable easier communication in order to create knowledge networks thus, acquire and share knowledge which will result in innovation boost which will be the main key for creating manufacturing competitiveness. However, communication and knowledge networks result in a huge amount of data and information which demands an appropriate data warehousing and data mining system for KM in manufacturing. Therefore, it is essential to store the data in the appropriate storage media and assign the data to the appropriate organizational level to improve manufacturing productivity through knowledge sharing and transfer [13].

Manufacturing Knowledge Management can be defined and thus applied along the main core functions in manufacturing , and the classification is done in general literature to define the cause for the use of KM in each domain and the key behind the success of the implementation of KM in each corresponding domain[13]:

1. Design and engineering
2. Production
3. Distribution
4. Information systems

4.3 Manufacturing Knowledge Management Systems:

The Knowledge Management System is the main block for acquiring and sharing knowledge among different organizational levels. Knowledge sharing is the key factor for a non-stop improvement activities and processes thus it is one of the main methodologies that adapt quickly to dynamic environments related to change in customer and market demands or change in the manufacturing process. Implementation of KMS in a manufacturing industry is crucial and the success of this implementation is connected to the ability of reusing knowledge due to the ease of access to the knowledge and its availability when needed. According to the key factors that assure the KMS implementation success, frameworks have been proposed and put on trial to examine if the proposed models are sufficient to achieve the key factors necessary for the KMS implementation [12].

An important issue regarding introducing KMS in the manufacturing industry is the impact of these systems on the manufacturing working force. Industrial firms aim to shorten production thus works on innovating tools and methods to shorten the time needed by a worker to take an aware decision thus launching systems that take the aware decision automatically. The application of the corresponding models and simulations related to a KMS solved problem-solving conflicts easier and in a shorter time, but on the other hand they replaced the workers by an automated repeated process which makes employees less eager to work or learn. Besides that, this is accompanied by less communication of knowledge between experienced and new workers due to the fact that knowledge owned by experienced workers couldn't be explained or shared by the presence a process model.

On the other hand, manufacturing workers being adapted to use a system that frames, transfer and exchange knowledge emphasizes the process of noting their experiences and transferring them into knowledge references that could be shared with the other workers through KMS. Hence, this is advantageous for the company as for the workers who found an environment to show and share their abilities and to expose their potentials and in addition to helping other less experienced workers in need thus creating a motivational environment as well. Therefore, the introduction of a social software based KMS makes workers more confident in the decision-making process due their peers knowledge support. The main step for the introducing a KMS in a manufacturing industry is acquiring and organizing the human knowledge through proper methodology. The four essential factors of knowledge creation to design an efficient KMS are the following [12]:

1. Culture: New culture is introduced to the company that will encourage share of knowledge between workers.
2. Technology: New technologies will be introduced contributing to the adaptation to the workers to the new environment.
3. Infrastructure: New organizational roles and responsibilities are defined.
4. Measurement: Data acquired by real-time sensors will be defined by measures read and analysed by the shop floor workers.

5 Product Life Cycle Management (PLM)-Manufacturing Execution System (MES) Integration:

There is a necessity nowadays to apply the PLM-MES integration in the manufacturing industry however there is a scarcity in researches regarding this topic. The following points would summarize the main needs behind the corresponding PLM-MES integration:

1. Effective information exchange between the information systems.
2. Engineering accessibility to production data to validate product design to proceed to manufacturing.
3. Exchange of product information between different stages of a product life cycle.
4. Reduce the variability between the actual production process and simulations outcome.

In practice, not applying PLM-MES integration can result in a system that prevents organization between engineering and production thus preventing development and enhancement. Therefore, this absence of integration can become an obstacle Infront of manufacturing industries to obtain. After PLM receives information from MES, it must study how the information received could modify its data structure and thus apply the corresponding changes to inform engineering about the modified data thus enhancing the overall process [1].

- PLM-MES integration can be applied based on the firm type [1]:

  1. One product is produced on one production site: The integration is a necessity when a modification of product or production takes place thus, PLM is responsible for the data from the production lines until machine programs.
  2. One product is produced on several production sites: The integration is a necessity when a modification of a product takes place thus, PLM is responsible for data related to production lines only.

- PLM-MES integration can be applied based on the product type [1]:

  1. The firm initiate a new product and a corresponding production system: PLM is already applied, then defining and creating appropriate MES for the corresponding production system.
  2. The firm adjusts an existing product and the corresponding production system: PLM and MES are already applied. Hence, recorded information is exploited to enhance the adjusted product quality and the corresponding manufacturing system efficiency.

- It's visible that the PLM-MES integration results in advantages that spread on production and engineering sectors [1]:

1. Complete tracking of the product life cycle and thus enhance products' quality and reduce errors and anomalies.
2. The information exchange between manufacturing and engineering accelerates data accessibility and problem solving thus, this allows to have available the products', tools', and processes' definitions.

3. MES manages Bill of Processes (BofPs) thus it should be shared with the engineering to enhance their knowledge regarding BofPs to enhance performance.
4. PLM-MES integration provides records for the firm including previous experiences, processes and products with the corresponding designs and information.
5. Decreases product develop times.
6. Accelerates Ramping up production of new products.
7. Reduce production errors based on the acquired design and process records.

Hence, PLM-MES integration defines the interoperability between engineering information and production information which makes dynamic real time shop floor activities provided by MES accessible by the PLM system. After that, it's important to note what is the information exchanged between PLM and MES. The engineering data in PLM includes the product information provided by CAD tools, including attributes of the parts, product drawing, structure relationship, and EBOM in addition to manufacturing process information provided by Digital Manufacturing (DM) tools, including manufacturing proceeding, 3D models, MBOM, work instructions, man-hour, and materials. These data are defined as the as-designed and as-planned records that constitutes the PLM data in an industry and will be transferred from the PLM to the MES system to produce a certain product. On the other hand, as-built record is the data regarding the transformation from a virtual product concept toa physical product that is presented in the market thus can be defined as the manufacturing data that is acquired by the MES system. As-built records consists of parts, equipment, labour and production status thus it is divided into records of products' parts and process information in addition to monitoring and quality control information and MES will transfer as-built records back to PLM. In the next step, PLM will analyse and store the received data. Therefore the two way data exchange between the two information systems mirrors the built in monitor and feedback relation between them.

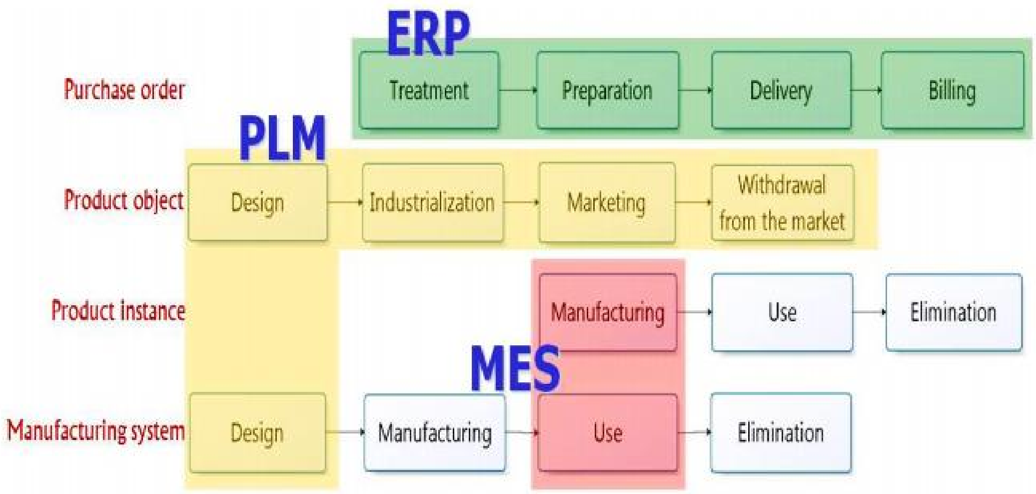


Figure 2.7: PLM, MES, and ERP Information Systems

The PLM-MES integration ensures a continuous workflow between several organizational levels. Hence, the suggested Architecture for PLM, MES integration is based on a central Intelligence system called Knowledge Base System (KBS) that includes data from both PLM and MES information systems in addition to its own database. According to this definition, information systems can send and receive information from and to the KBS thus two ways flow of information exchange. The information related to a new product will be stored in the KBS in which study of this data will be applied. This study would assist in defining a classification of products possessing similar characteristics which will decrease production time and improve the performance control. Therefore, the suggested architecture will have a goal in gathering data related to weak points regarding the new product and store this knowledge and then share it for further users and future production to improve product quality and process performance specially concerning reducing trial and error cycles in new product development.

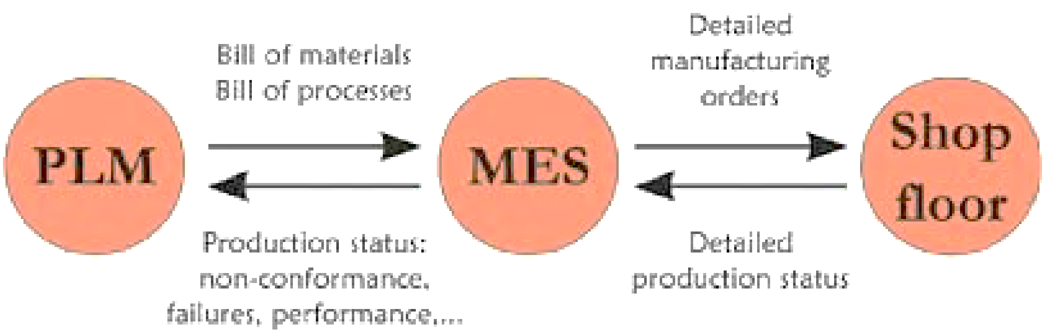


Figure 2.8: Information Flow between PLM, MES and Shop Floor

When an order of a new product takes place, KBS database is checked to see if there is a previous product data stored in the KBS that has similar characteristics with the new one thus with the least possible modification needed, to be then fitted to the new order and eventually to the shop floor. The selected product data from the KBS database is communicated with the PLM in which needed modifications are done. After that, the data related to the new product passes through the KBS to be transferred afterward to the MES. Hence, MES organize the manufacturing process and send back information regarding the production status to the KBS in real time and reports the results corresponding to the production or disposal of the considered new product. According the obtained results modifications are suggested to improve process performance and thus product quality.

Chapter 3
Use Case: Sliding Door Trolley

1 Manufacturing Process

The finished parts produced in the following manufacturing process should be ready for assembly with other purchased parts to obtain the sliding door trolley final product. The finished manufactured products are **Wheel, Internal Ring, and Short Internal Ring** which start as purchased metal bars then undergoing 4 manufacturing operations.

The first step in the production process is buying metal bars from which will be produced the finished products ready for final product assembly. For the production of each finished product 0,5 kg of purchased bar material will be reserved to be then consumed in the manufacturing line.

The manufacturing process of each finished product starts with lathe cutting of the bar into two pieces to obtain the lathe cutted bars and followed by lathe turning of the pieces. After that, the next operation would be carbon case hardening to be then passed to the following machine where zinc coating operation takes place and the finished product is produced.

While Wheel, Internal Ring and Short Internal Ring parts are produced, **Nut 12 mm, Pin, Ball Bearings and White Galvanized Bracket** are purchased so then corresponding produced and purchased parts are assembled together through an assembling machine to obtain the final Sliding Door Trolley product. Finally, the assembled product is packaged to obtain the final product ready for sale and to be then consumed.

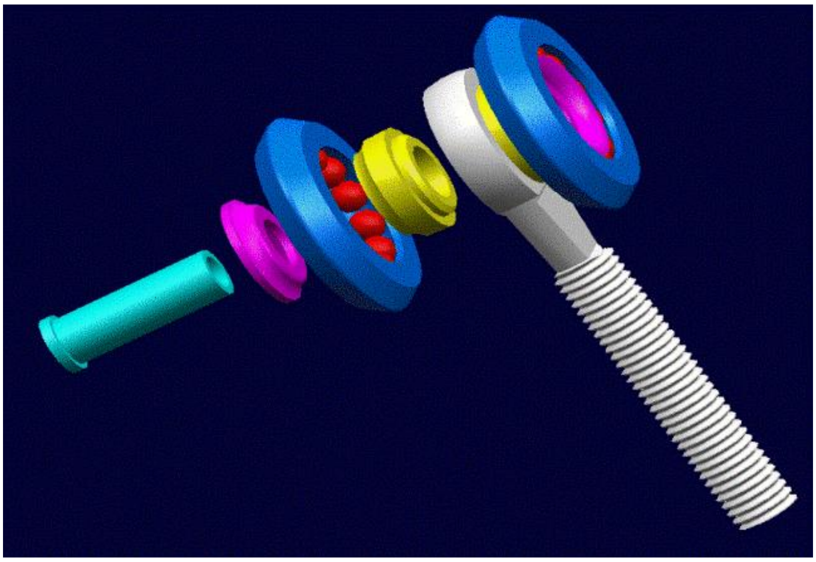


Figure 3.1: Sliding Door Trolley Configuration

2 Bills of Materials

Each finished product is composed of a set of components and they are indicated in a hierarchical form and will be presented in a tree form divided into levels. This definition of finished products and the corresponding components results in obtaining the Bill of Materials (BOM).The finished product (at the highest level) is the Level 0 of the BOM tree and consists of the components of level 1 and in a similar manner the Level 1 components are made up of the components of Level 2. Therefore, Level N components are made of Level N+1 components.

SLIDING DOOR TROLLEY BILL OF MATERIALS (BOM)

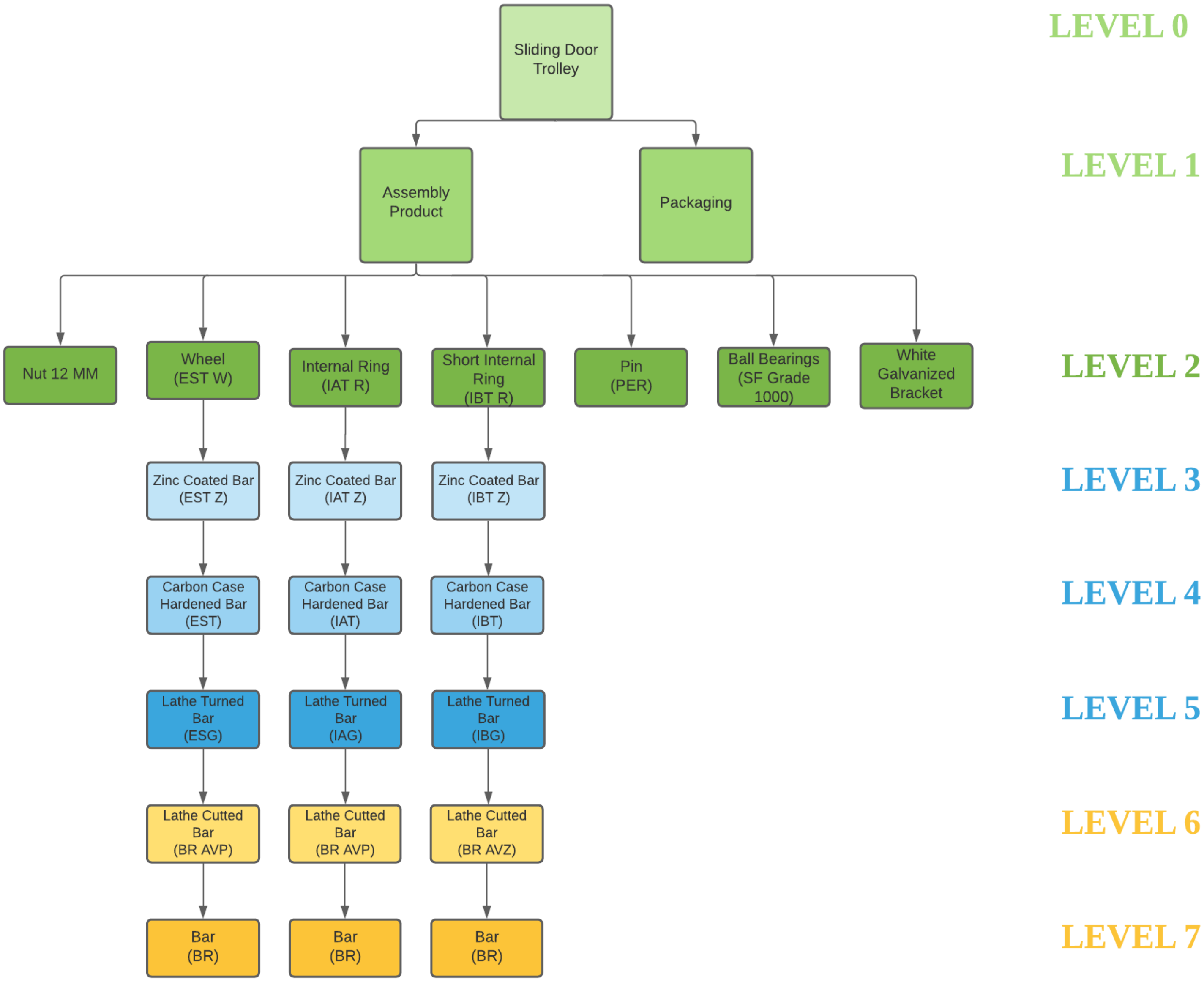


Figure 3.2: Sliding Door Trolley Bill of Materials

3 Parts Count for the 2 Wheels Sliding Door Trolley Configuration

Part Name	COUNT
Nut 12 mm	2
Wheel	2
Lathe Cutted bar	*2*
Lathe Turned Bar	*2*
Carbon Case Hardened Bar	*2*
Zinc Coated Bar	*2*
Bar	*0,5 kg*
Internal Ring	2
Lathe Cutted bar	*2*
Lathe Turned Bar	*2*
Carbon Case Hardened Bar	*2*
Zinc Coated Bar	*2*
Bar	*0,5 Kg*
Short Internal Ring	2
Lathe Cutted bar	*2*
Lathe Turned Bar	*2*
Carbon Case Hardened Bar	*2*
Zinc Coated Bar	*2*
Bar	*0,5 Kg*
Pin	1
Ball Bearings	24
White Galvanized Bracket	1
Packaging	1

Figure 3.3: Parts Count for 2 Wheels Sliding Trolley Configuration

4 Workcenters and Routings:

According to the proposed manufacturing process each machine is dedicated to a specific process in its specific path and each workcenter is dedicated to a certain machine. Thus, to produce each of the wheel, internal ring and short internal ring, a separate lathe cutting, lathe turning, carbon case hardening and zinc coating machine is needed hence obtaining 3 lathe cutting machines, 3 lathe turning machines, 3 carbon case hardening machines and 3 zinc coating machines. Hence, to produce each of the wheel, internal ring and short internal ring 4 machines with 4 dedicated workcenters are defined to reach 12 workcenters in total. Besides that, when obtaining all Level 2 products, assembly is performed by the assembly machine in its dedicated assembly workcenter and then packaging is done by the packaging machine in its dedicated wokcenter to obtain the sliding door trolley. Therefore, to obtain the final product sliding door trolley, **14 machines with 14 dedicated 14 workcenters are defined**.

Regarding the routings, a single routing is assumed for each transformation from certain level to another starting from the bar obtaining wheel, internal and short internal ring then assembly and final packaging to produce the sliding door trolley. Thus, with such strategy 14 routings are obtained.

4.1 Workcenters:

- <u>Wheel:</u>

  1. Lathe Cutting Machine
  2. Lathe Turning Machine
  3. Carbon Case Hardening Machine
  4. Zinc Coating Machine

- <u>Internal Ring:</u>

  1. Lathe Cutting Machine
  2. Lathe Turning Machine
  3. Carbon Case Hardening Machine
  4. Zinc Coating Machine

- <u>Short Internal Ring:</u>

    1. Lathe Cutting Machine
    2. Lathe Turning Machine
    3. Carbon Case Hardening Machine
    4. Zinc Coating Machine

- <u>Assembly Product:</u>

    1. Assembly Machine

- <u>Sliding Door Trolley:</u>

    1. Packaging Machine

4.2 Routings

- <u>Wheel:</u>

    1. Lathe Cutting
    2. Lathe Turning
    3. Carbon Case Hardening
    4. Zinc Coating

- <u>Internal Ring:</u>

    1. Lathe Cutting
    2. Lathe Turning
    3. Carbon Case Hardening
    4. Zinc Coating

- Short Internal Ring:
    1. Lathe Cutting
    2. Lathe Turning
    3. Carbon Case Hardening
    4. Zinc Coating
- Assembly Product:
    1. Assembly Product
- Sliding Door Trolley:
    1. Sliding Door Trolley

Chapter 4

Implementation of The Integration Model in Odoo Software

1 Odoo Software

Figure 4.1: Odoo Logo

The production in the 21st century and the industry 4.0 era is accompanied by new challenges and high competition in the shop floor and the market. Thus, within this highly challenging and competitive environment, software tools are introduced where information technologies are installed to make machines, operators and corresponding resources interact among each other and collect then store useful data. Hence, the next step towards information technologies in manufacturing industry was the integration between different information systems installed in order to achieve an efficient company of the fourth industrial revolution.

Odoo was founded by Fabien Pinckaers in 2005 where the word Odoo is the acronym of On-Demand Open Object and it is an efficient framework with various modules to apply in different types of business. Odoo is a large collection of business-related applications and modules like CRM, Sales management, Warehouse management, Purchase management, Accounting suit, Manufacturing management, Product Lifecycle Management, etc. where all these basic modules collectively called Enterprise Resource Planning software. Apart from its basic modules, Odoo has more than 14,000 third party Apps/Plugins available in its app store where each of them is custom-built for different user needs. Today, Odoo is one of the widely used open-source ERP solutions in the market for many reasons some of it mentioned below:

1. Open source
2. Flexible
3. Scalable
4. Custom Readymade Apps
5. Global Support
6. Proven Product
7. User-Friendly
8. Up to date with Technology
9. Highly Modular
10. Easily Integrate with Third-party services
11. Less Implementation Cost
12. Less implementation Time Frame#

In this thesis work Odoo 13 software is used through a free version to apply the use case proposed, where different modules contain its corresponding industrial data that is digitized and stored in an efficient mode. Odoo free version is obtained by downloading Odoo Community Version from the Odoo official website;

https://www.odoo.com/it_IT/page/download and then typing in **localhost:8069** in the search engine of the internet browser to get access to the Odoo page where the needed modules are found.

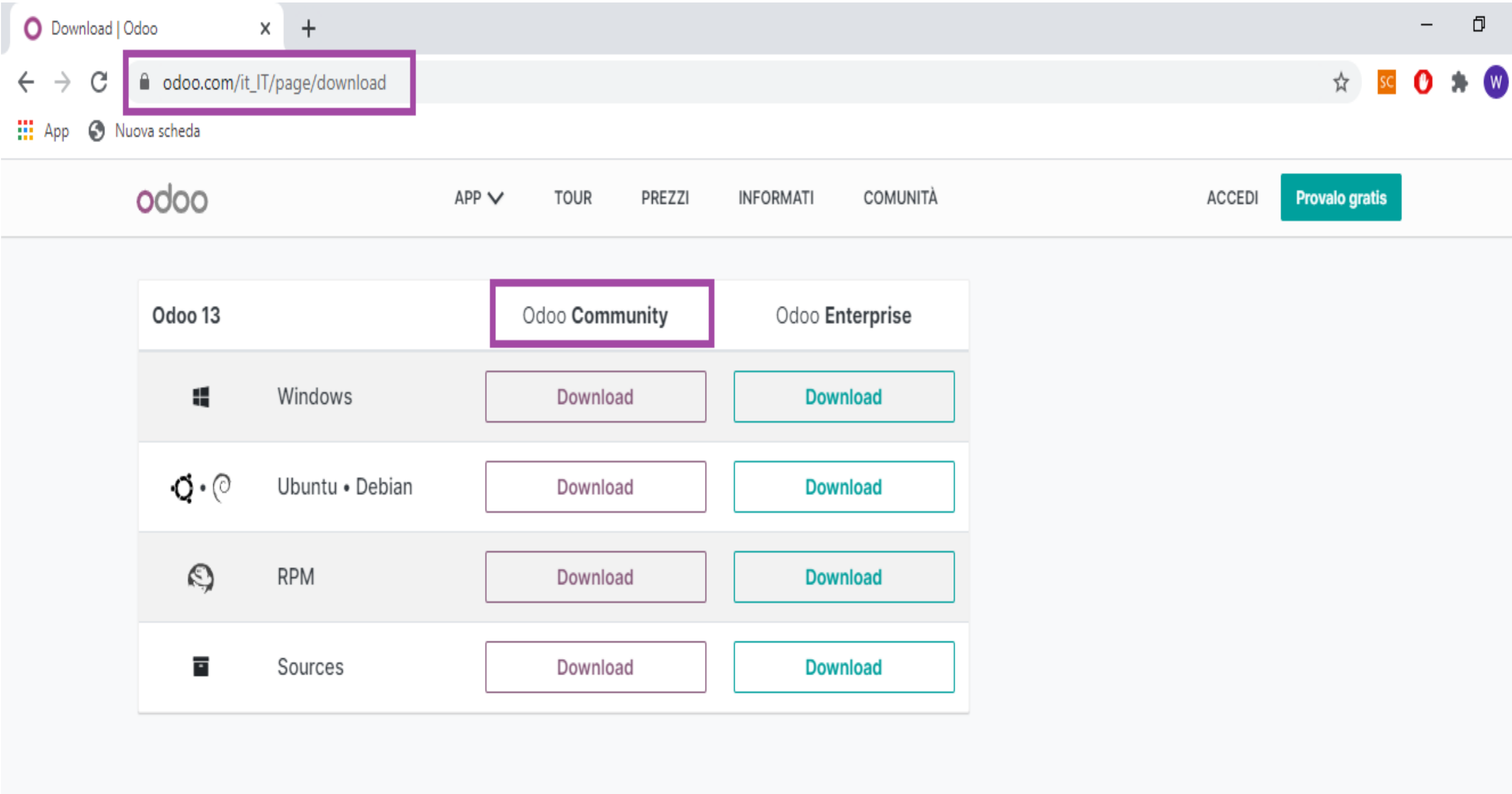


Figure 4.2: Odoo Download page

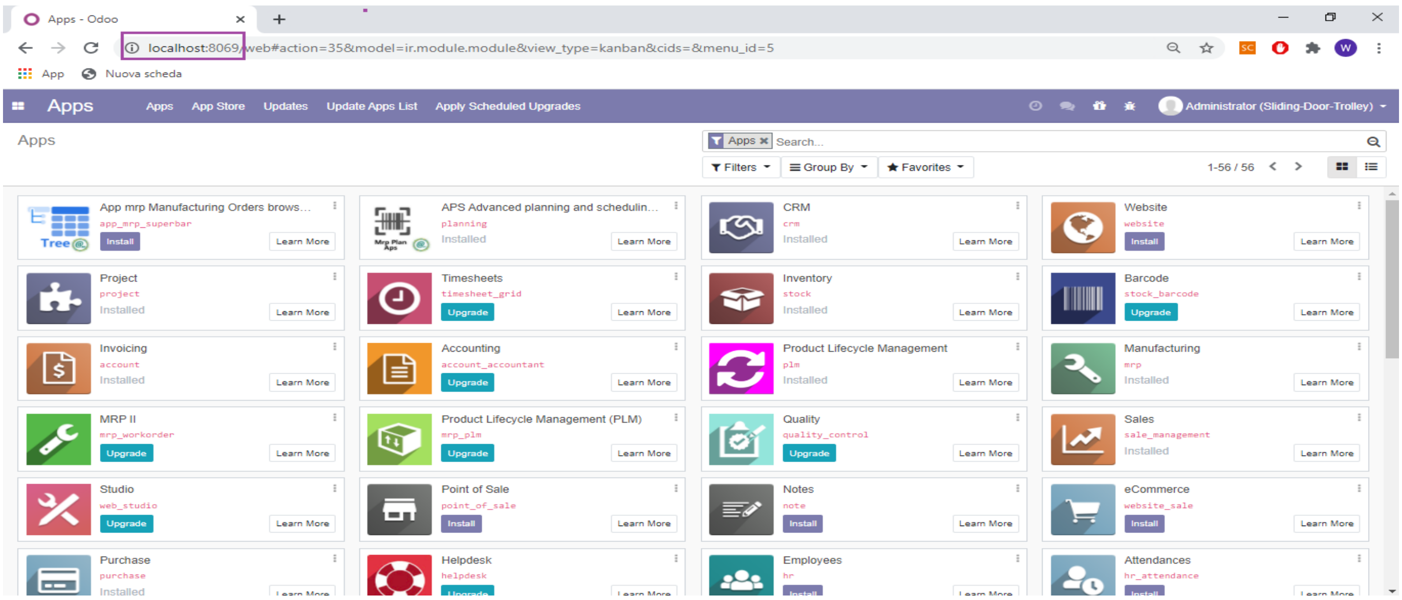


Figure 4.3: Odoo Local Host Page

2 Flow Diagram of Odoo Information Flow

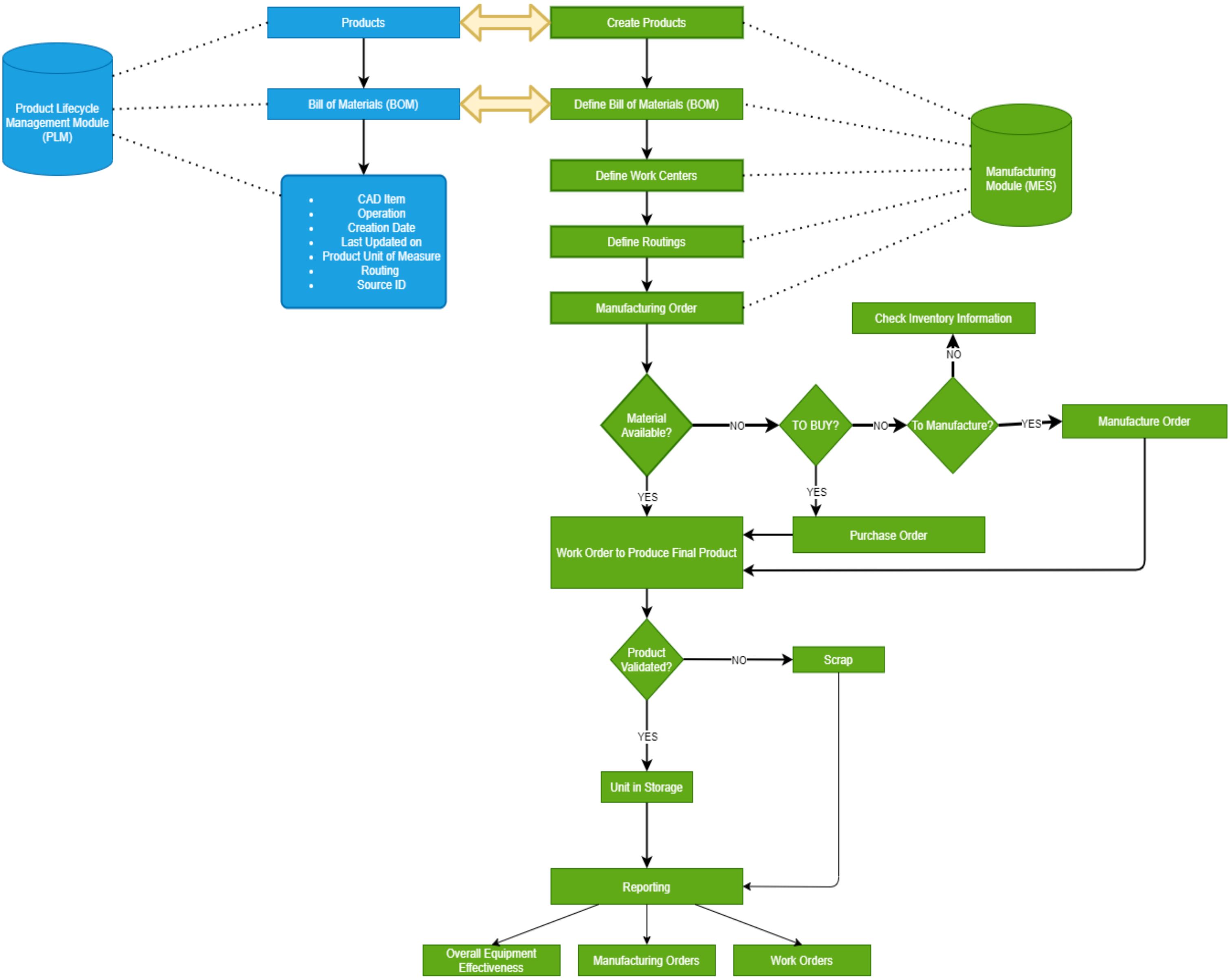


Figure 4.4: Flow Diagram of Odoo Information Flow

MES ENTITIES

PLM ENTITIES

The process in Odoo starts from the **Manufacturing Module (MES)** with creating the products consumed for the manufacturing process by defining each product attributes mentioned above. After creating the products, the bill of materials is created where the BOM tree data mentioned above is inserted in Odoo to obtain products at different levels each with its corresponding BOM starting from Level 0 containing the Sliding Door Trolley reaching Level 7 containing the Bar. However, it is important to mention that the products which are purchased doesn't have a corresponding BOM. Hence, after creating the products and the corresponding BOM, this data through Odoo management system is transferred automatically from the MES module to the **Product Lifecycle Management (PLM)** module where the **importance of Odoo for PLM and MES integration is exploited.** After that the products and BOM data is inserted in the PLM, data related to design such as CAD item, product unit of measure, creation date, source ID etc... is inserted through the PLM module for each product in the BOM tree*(path: PLM Module- Component Relations-Search on Normal BOM Lines-Product-Related BOM Lines).*

On the other hand, in the MES module, workcenters then the corresponding routings are defined with the corresponding attributes mentioned above. In each workcenter a certain machine is defined to do a certain operation and although the same operations are done to manufacture the wheel, internal ring and short internal ring (thus same type of machine) however each has its own workcenters thus its own machines differentiated in Odoo by different codes. Regarding the routings, for each operation leading to the transformation of material from one step to another in each workcenter reaching the final product, a specific routing is defined with a specific reference defined by Odoo.

After defining products, bill of materials, workcenters and routings, we assume that a customer order is placed for certain quantity of sliding door trolleys. Through Odoo, a customer order is exploited and triggered through the manufacturing order operation in the manufacturing (MES) module. When a new manufacturing order is created the material availability of the directly related bill of materials of the is checked and If they are available then work order to produce the product is generated. However, if the materials are not available, the missing materials are purchased or manufactured according to the specific material concerned.

Hence, considering our use case the strategy used to manage manufacturing and work orders for producing the sliding door trolley through Odoo will be discussed further. The first step is to create a manufacturing order and mark it as to do for the *final product* sliding door trolley, and then check the availability of the directly related BOM which are the *final packaging and the assembly product*. If these parts are available, then Plan tab is selected before a work order to produce sliding door trolley is directly generated. Regarding work order, the responsible employee manages production through Odoo where manufacturing process accompanied by a time tracker is done noting productivity and duration as well as validating the product to specify if good thus ready for storage or scrap thus wasted. On the other hand, if the material is not available to produce the sliding door trolley, when creating a manufacturing order and after selecting mark as to-do , the plan tab order will automatically generate manufacturing /work orders for the missing materials all through the BOM tree so the responsible employee can produce level by level all missing materials reaching the final product. Work orders for missing materials are generated automatically since the user can insert an option called Replenish on Order (MTO) when creating and defining each part. However, regarding missing materials that should be purchased, a purchase order should take place through the purchase module in Odoo.

3 Manufacturing -MES Module

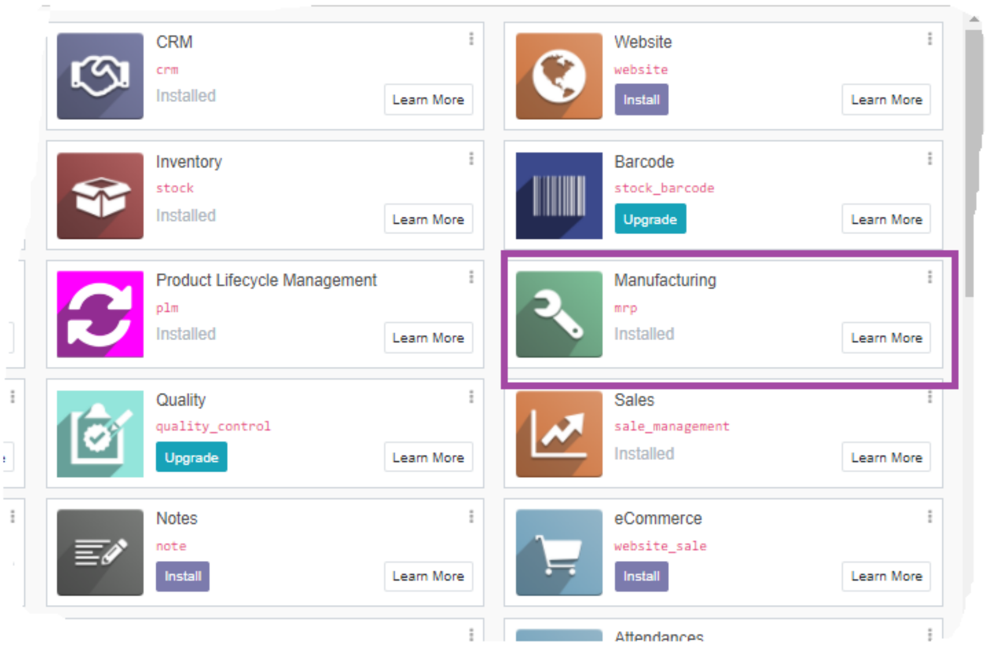


Figure 4.5: MES Module in Odoo

Manufacturing Module in Odoo is responsible for managing the data in the shop floor regarding the machines, workcenters, routing, manufacturing orders and work orders thus the complete production line to obtain the final product. The ***Master Data*** that should be defined in the manufacturing module are:

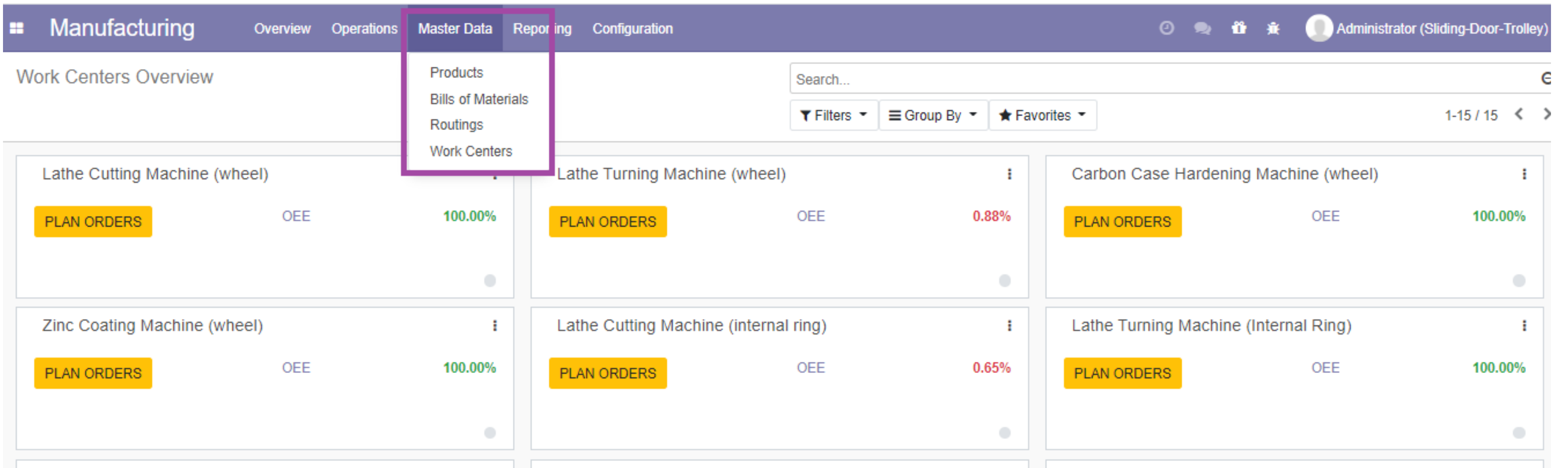
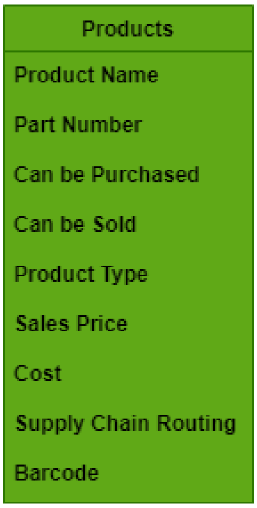


Figure 4.6: MES Module Master Data in Odoo

3.1 Products



- In this master data the information regarding each product used during the manufacturing process at each level of the bill of materials should be inserted with the required details.
- Regarding **Supply Chain Routing or Routes**, the user in Odoo can select Manufacture, Buy, and Replenish on Order(MTO) which serves that when an order for the final product is received, a work order to manufacture the MTO needed bill of materials is automatically generated.

Figure 4.7: Products' Group Entities in Odoo

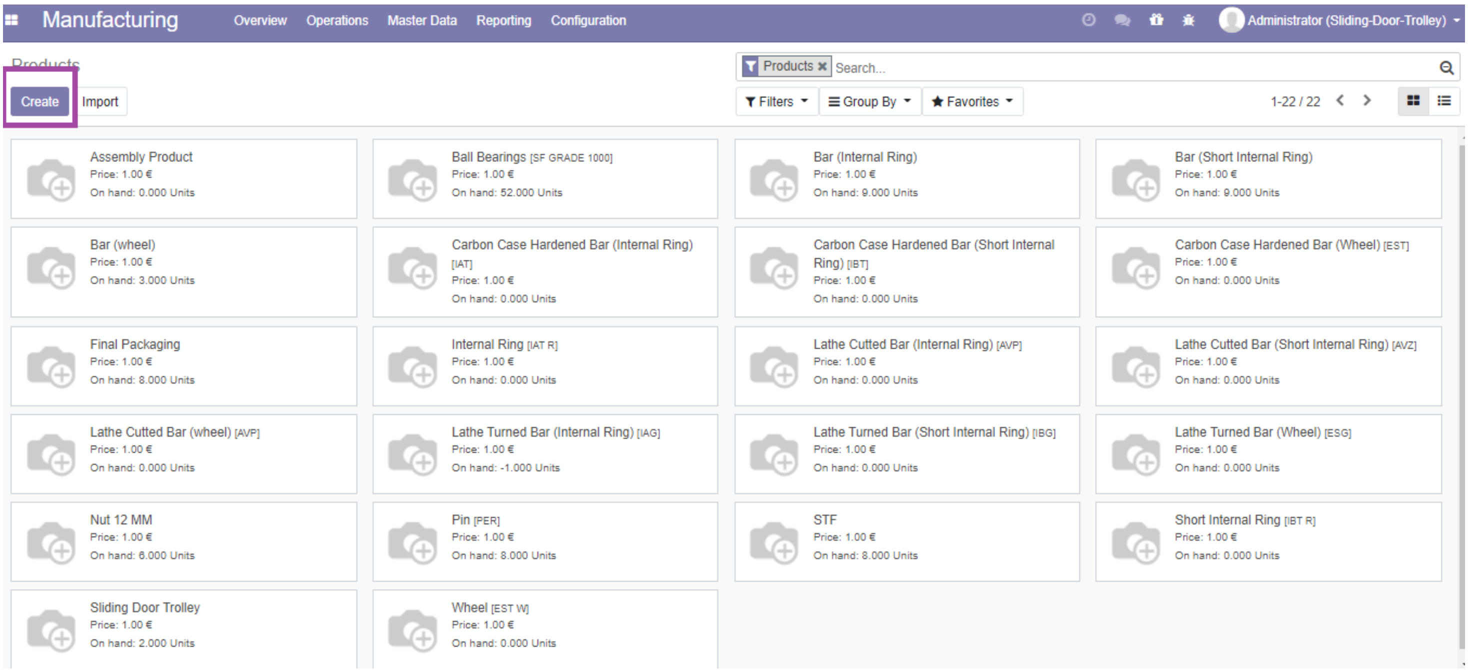


Figure4.8: Products in Odoo

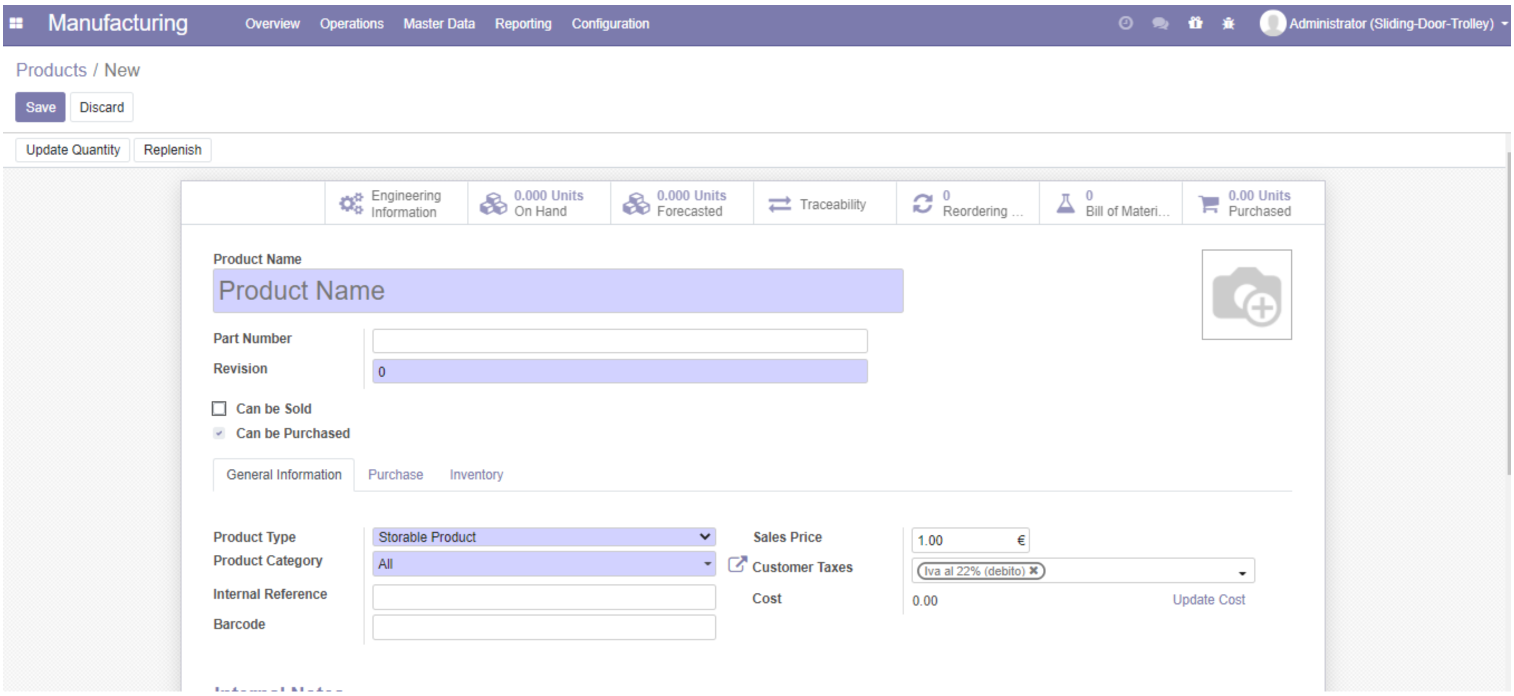
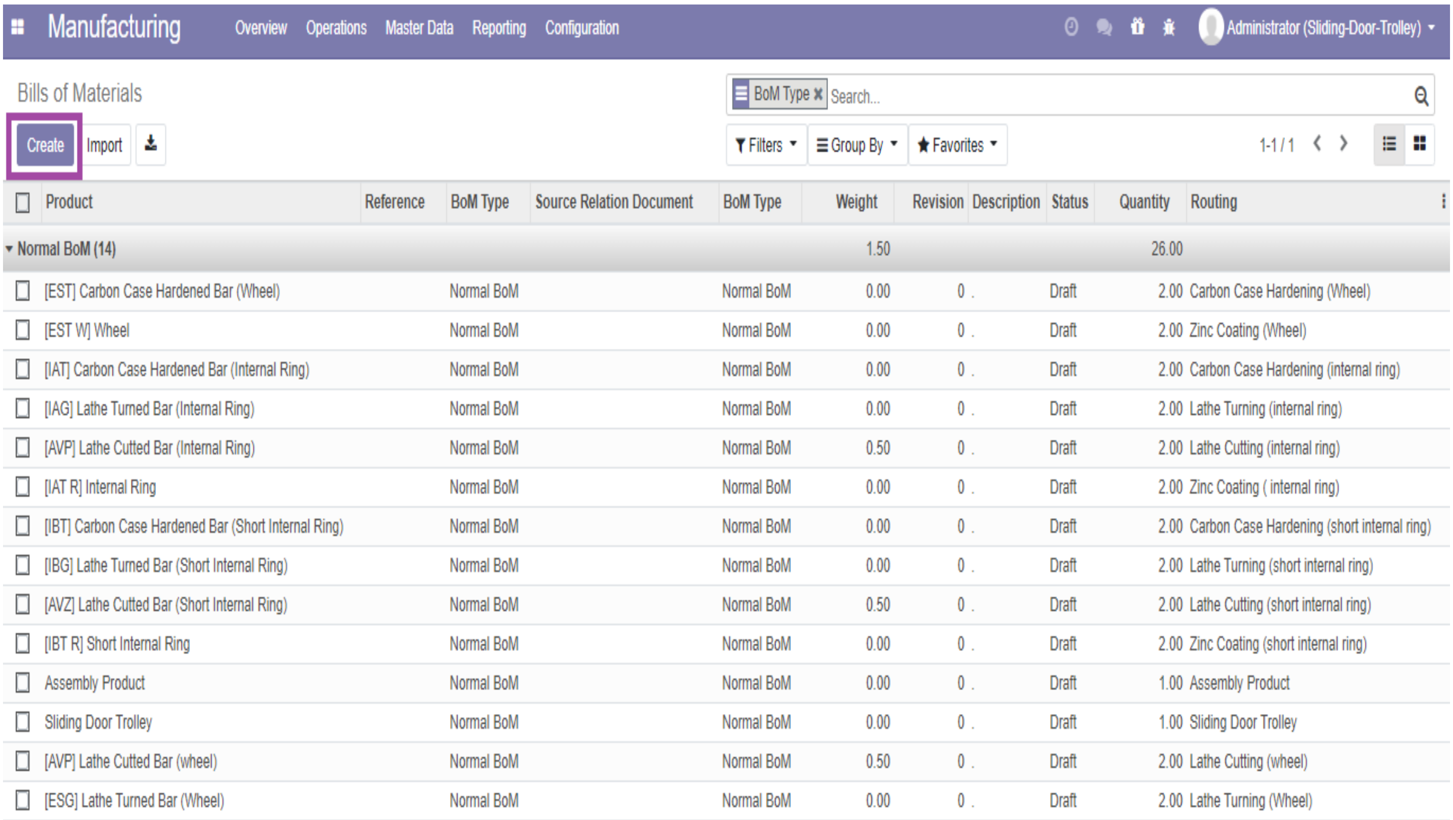


Figure 4.9: Product’s Entities in Odoo

3.2 Bills of Materials

- For each product you create the corresponding Bills of Materials where it is composed of products, defined as BOM components in Odoo, from the next level as mentioned in the BOM tree diagram.
- Regarding **BOM type** there are normal BOM and kit BOM, where kit BOM split the product into its components, at the creation of the manufacturing order and at the creation of a stock transfer. However, in our use case only normal BOM was applied.

Figure 4.10: Bills of Materials' Group Entities in Odoo



Product	Reference	BoM Type	Source Relation Document	BoM Type	Weight	Revision	Description	Status	Quantity	Routing
Normal BoM (14)					1.50				26.00	
[EST] Carbon Case Hardened Bar (Wheel)		Normal BoM		Normal BoM	0.00	0	.	Draft	2.00	Carbon Case Hardening (Wheel)
[EST W] Wheel		Normal BoM		Normal BoM	0.00	0	.	Draft	2.00	Zinc Coating (Wheel)
[IAT] Carbon Case Hardened Bar (Internal Ring)		Normal BoM		Normal BoM	0.00	0	.	Draft	2.00	Carbon Case Hardening (internal ring)
[IAG] Lathe Turned Bar (Internal Ring)		Normal BoM		Normal BoM	0.00	0	.	Draft	2.00	Lathe Turning (internal ring)
[AVP] Lathe Cutted Bar (Internal Ring)		Normal BoM		Normal BoM	0.50	0	.	Draft	2.00	Lathe Cutting (internal ring)
[IAT R] Internal Ring		Normal BoM		Normal BoM	0.00	0	.	Draft	2.00	Zinc Coating (internal ring)
[IBT] Carbon Case Hardened Bar (Short Internal Ring)		Normal BoM		Normal BoM	0.00	0	.	Draft	2.00	Carbon Case Hardening (short internal ring)
[IBG] Lathe Turned Bar (Short Internal Ring)		Normal BoM		Normal BoM	0.00	0	.	Draft	2.00	Lathe Turning (short internal ring)
[AVZ] Lathe Cutted Bar (Short Internal Ring)		Normal BoM		Normal BoM	0.50	0	.	Draft	2.00	Lathe Cutting (short internal ring)
[IBT R] Short Internal Ring		Normal BoM		Normal BoM	0.00	0	.	Draft	2.00	Zinc Coating (short internal ring)
Assembly Product		Normal BoM		Normal BoM	0.00	0	.	Draft	1.00	Assembly Product
Sliding Door Trolley		Normal BoM		Normal BoM	0.00	0	.	Draft	1.00	Sliding Door Trolley
[AVP] Lathe Cutted Bar (wheel)		Normal BoM		Normal BoM	0.50	0	.	Draft	2.00	Lathe Cutting (wheel)
[ESG] Lathe Turned Bar (Wheel)		Normal BoM		Normal BoM	0.00	0	.	Draft	2.00	Lathe Turning (Wheel)

Figure 4.11: Bills of Materials in Odoo

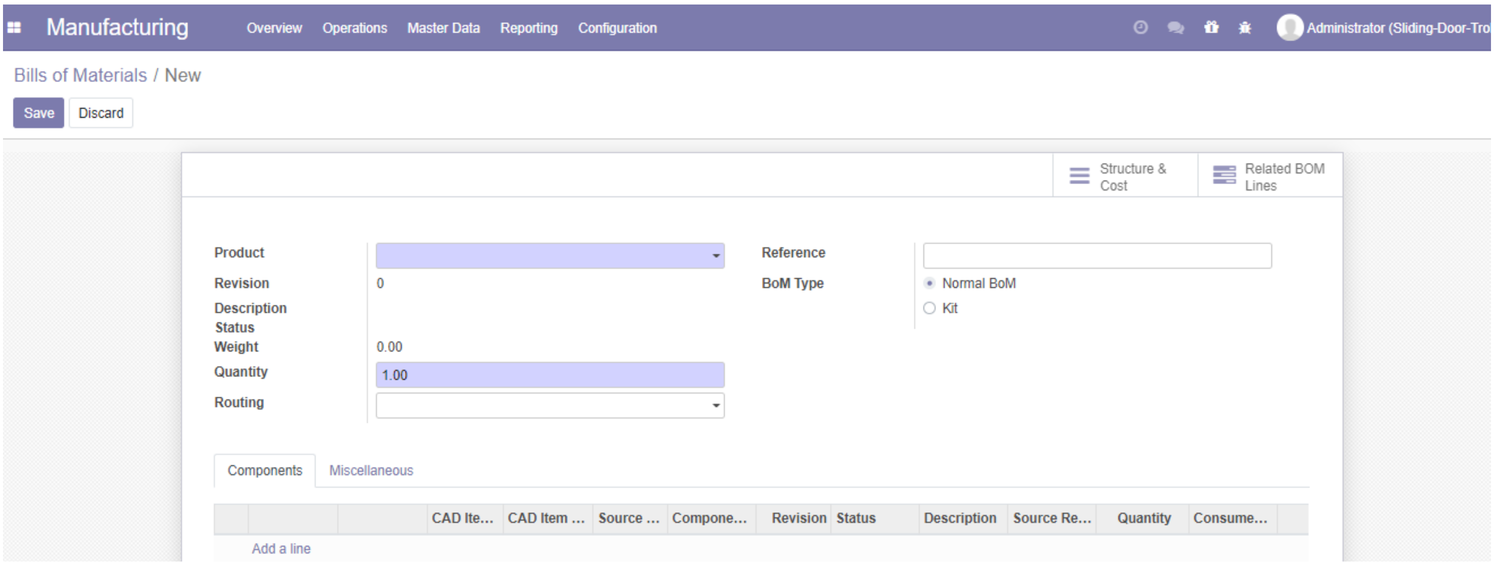
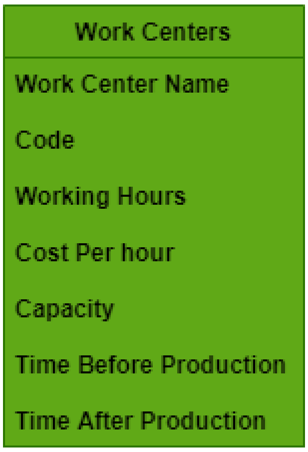


Figure 4.12: Bills of Materials' Entities in Odoo

3.3 Work Centers



- In Work Centers master data, data regarding the machine used for each operation and the functioning of each machine is inserted.
- Regarding **Capacity,** it is the number of units that can be produced in parallel in the defined workcenter.

Figure 4.13: Workcenters' Group Entities in Odoo

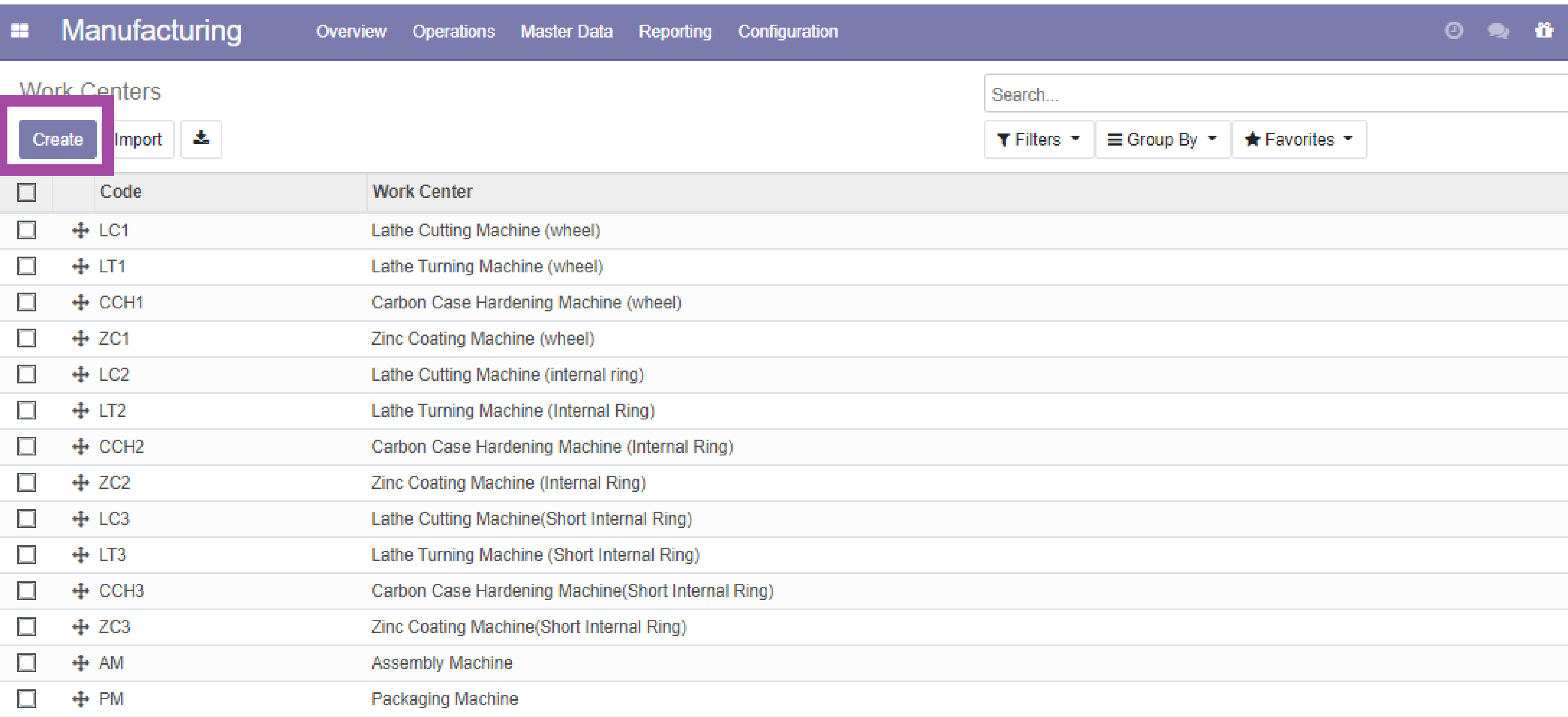


Figure 4.14: Workcenters in Odoo

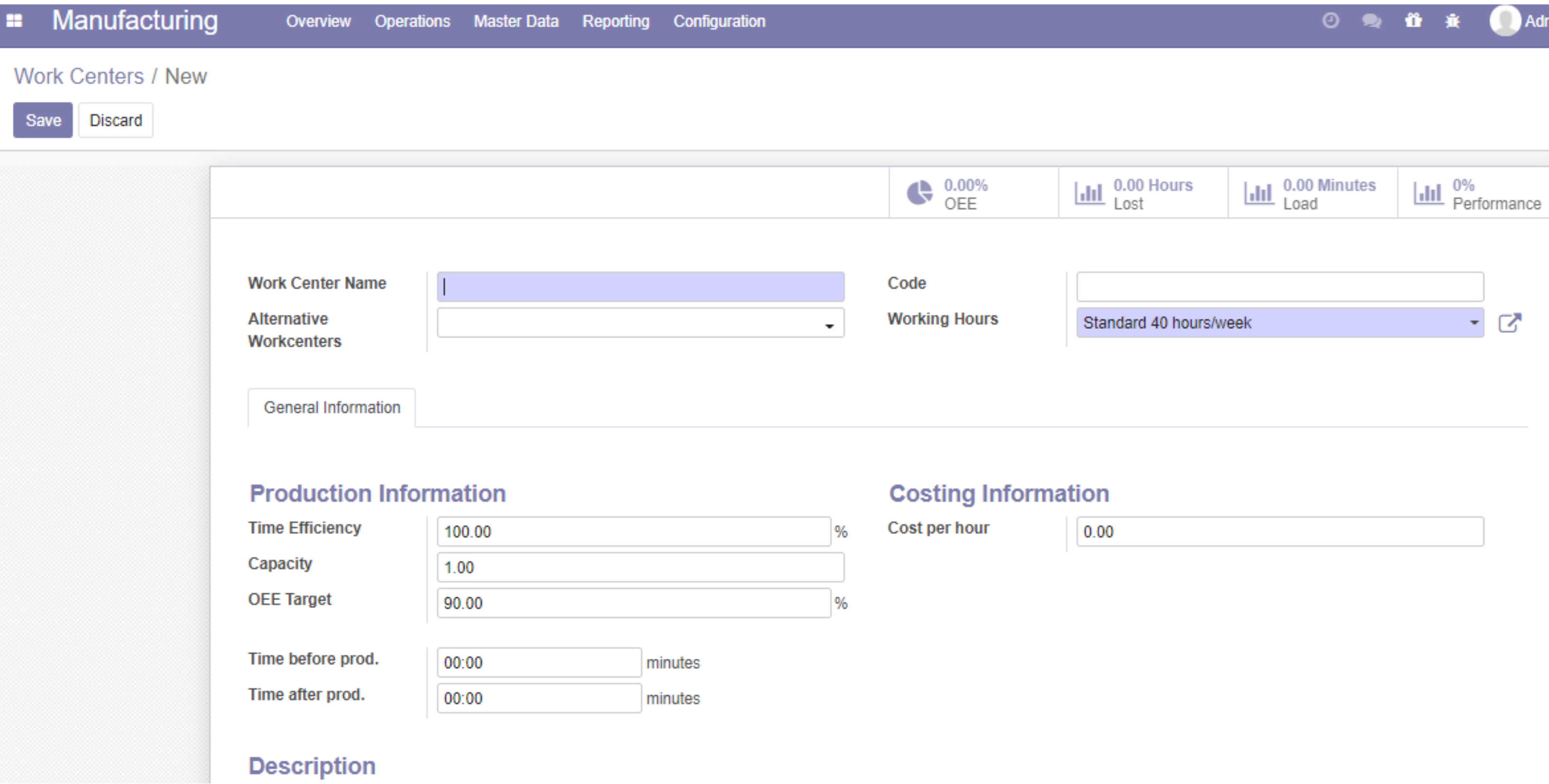
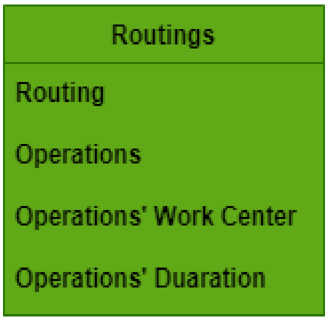


Figure 4.15: Work Centers' Entities in Odoo

3.4 Routings



- In Routings master data, for each transformation undergone by materials, the workcenters thus the machines involved with the corresponding duration are defined.
- In our use case every transformation is achieved with only one processing thus with only one machine and each processing requires one cycle.

Figure 4.16: Routings' Group Entities in Odoo

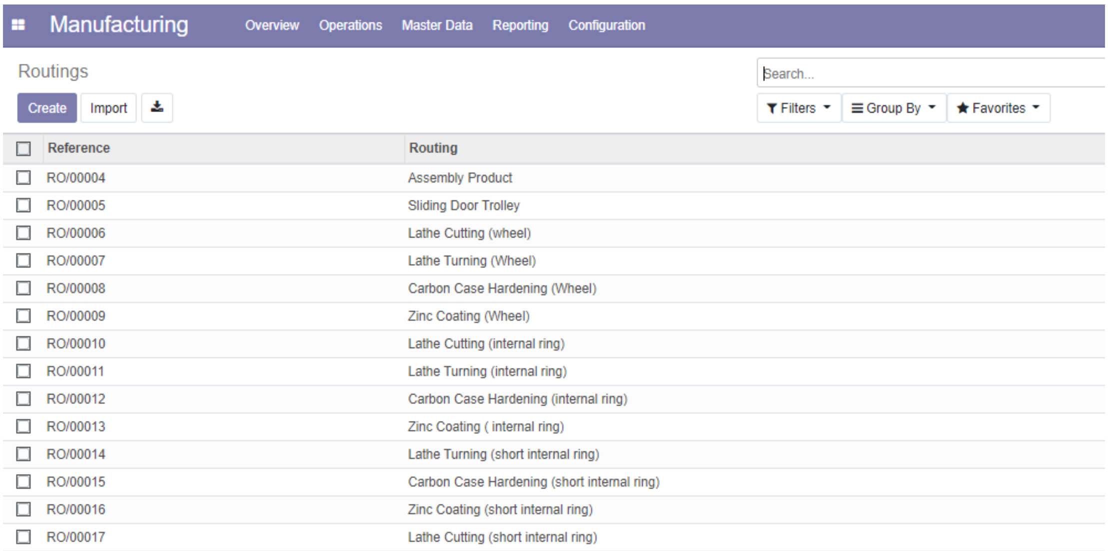


Figure 4.17: Routings in Odoo

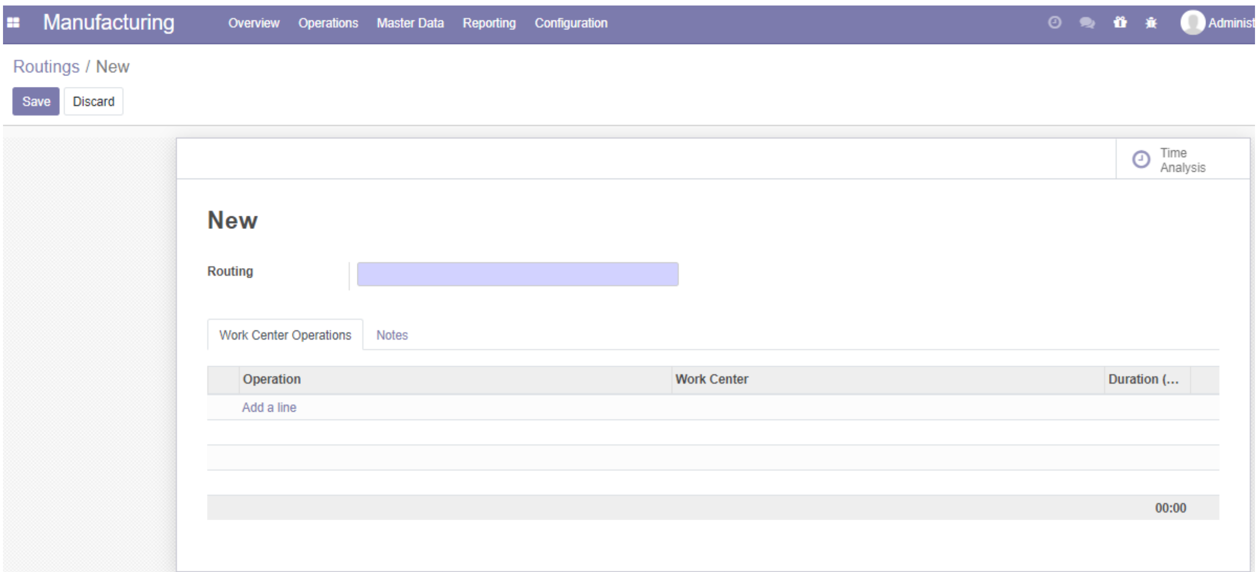


Figure 4.18: Routings' Entities in Odoo

Besides the Master Data tab in the Manufacturing module, there is the ***Operations*** tab where the following data is included:

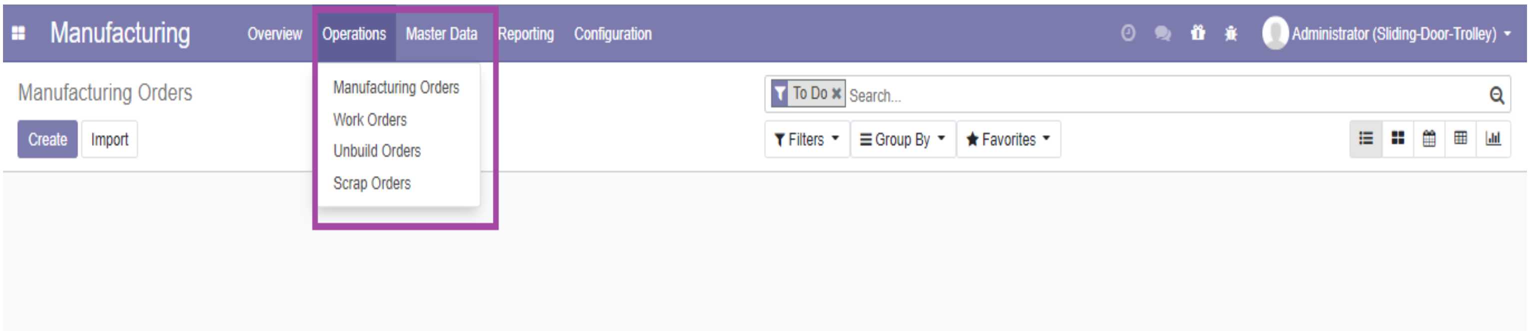
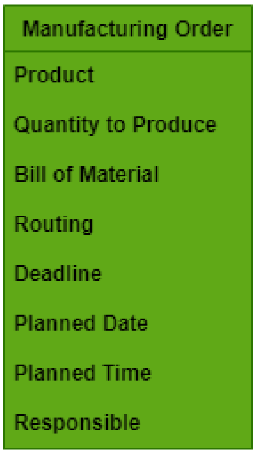


Figure 4.19: Operations Tab in MES Module in Odoo

3.5 Manufacturing Order



▪The manufacturing order is the trigger for the start of production of the needed product.

Figure 4.20: Manufacturing Order Entities in Odoo

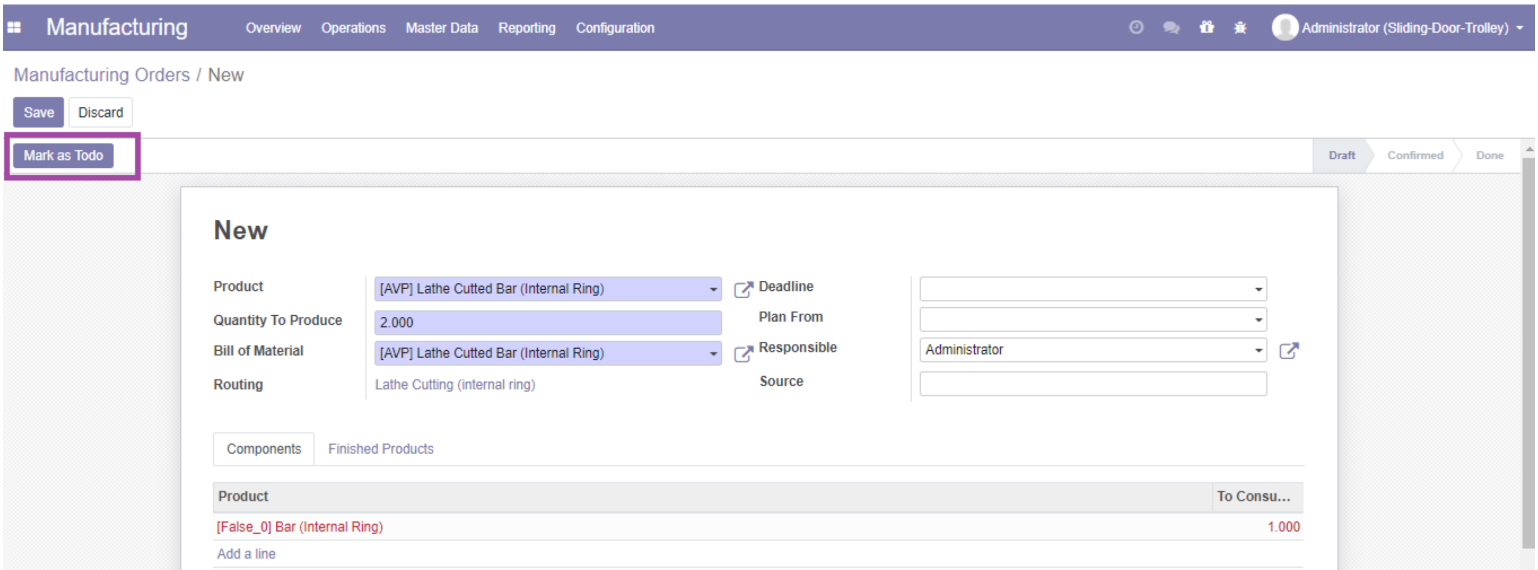


Figure 4.21: Manufacturing Order Entities in Odoo

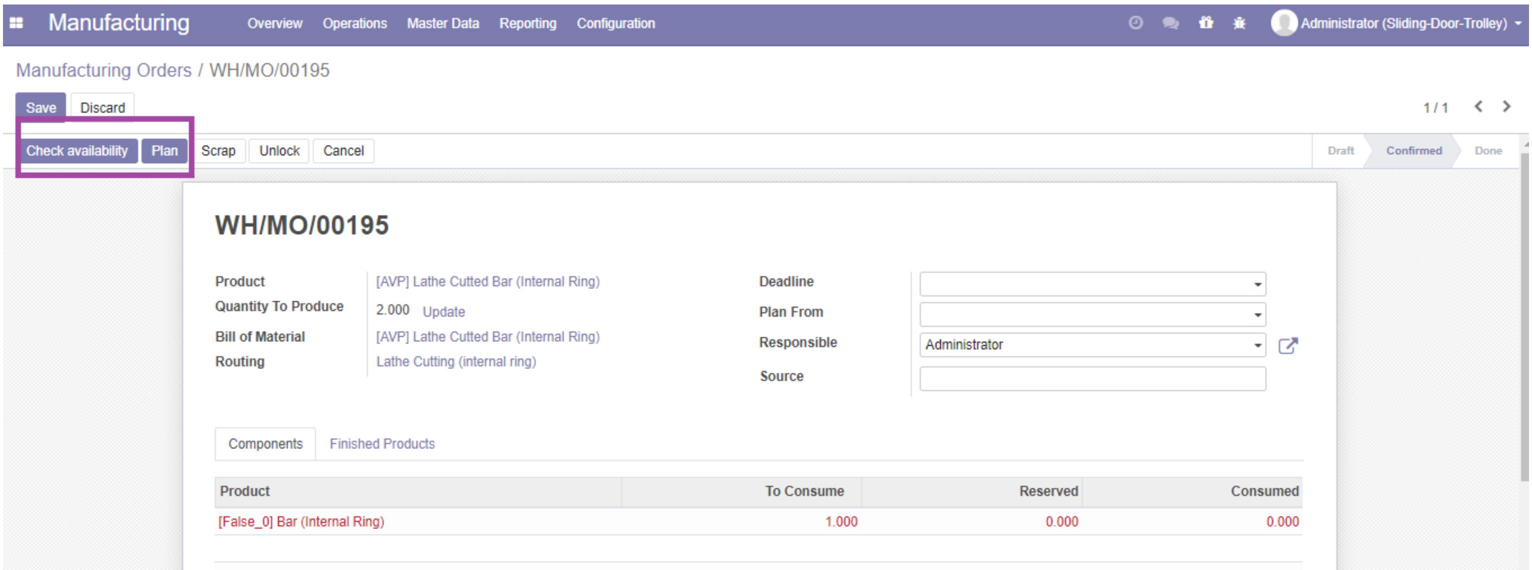


Figure 4.22: Plan a Manufacturing Order in Odoo

3.6 Work Order

- After confirming the needed manufacturing order, the corresponding work order should start to begin production and track production time from the beginning till the finishing of the manufactured product.
- **Productivity** indicates the percentage of the tracked time in which efficient production took place.

Figure 4.23: Work Orders' Entities in Odoo

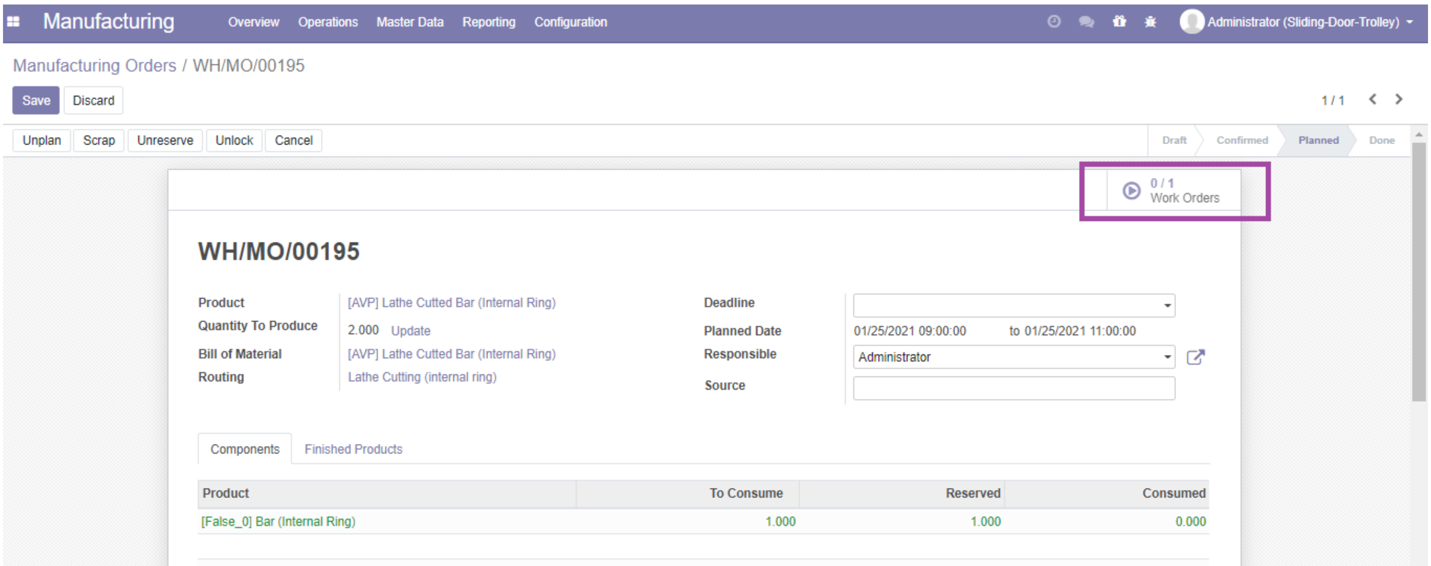


Figure 4.24: Initiating Work Order in Odoo

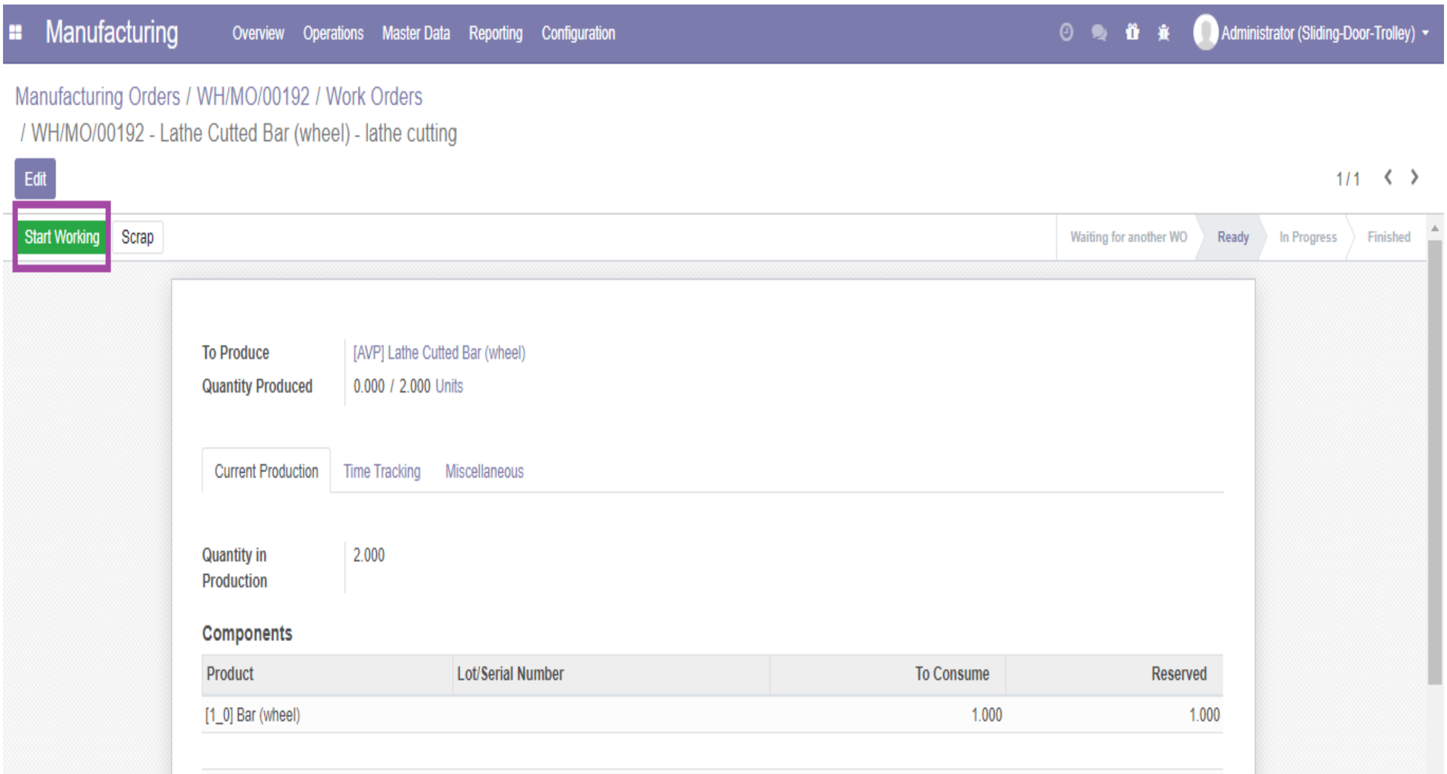


Figure 4.25: Start Working a Work Order in Odoo

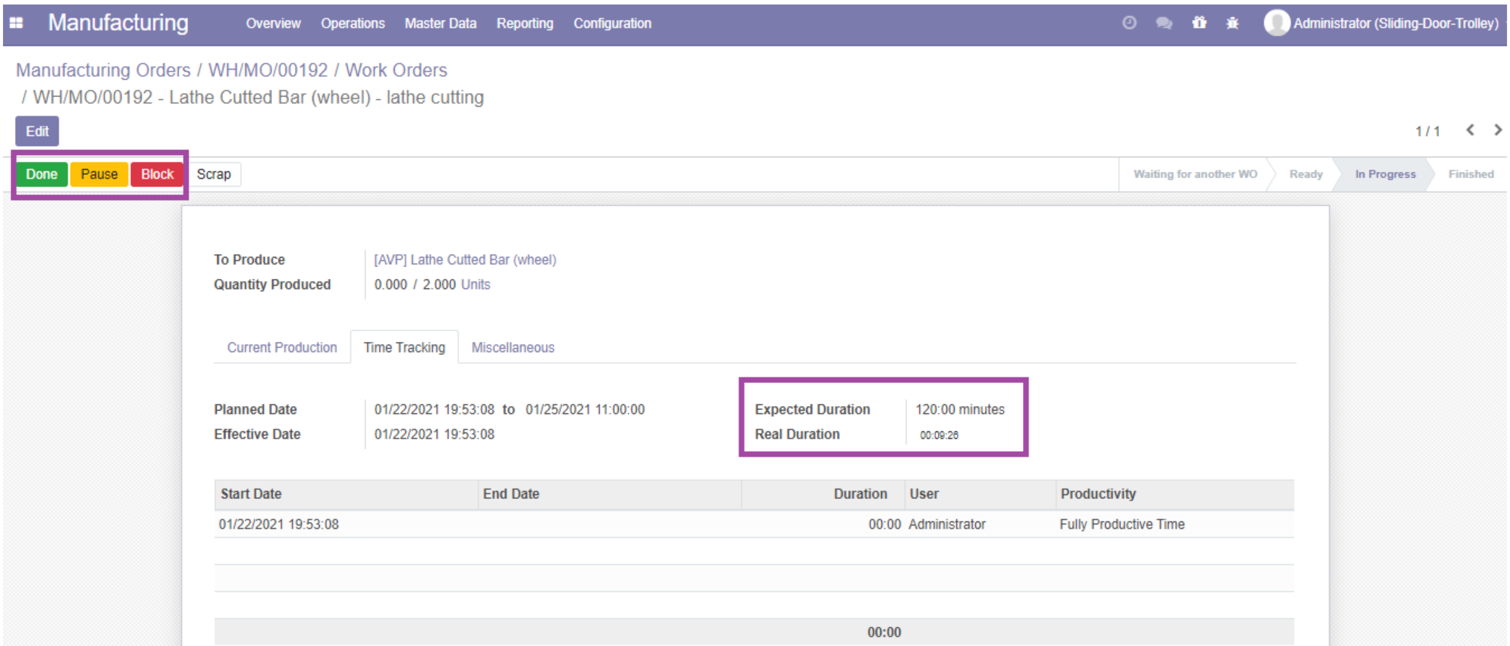


Figure 4.26: Work Order Time Tracking in Odoo

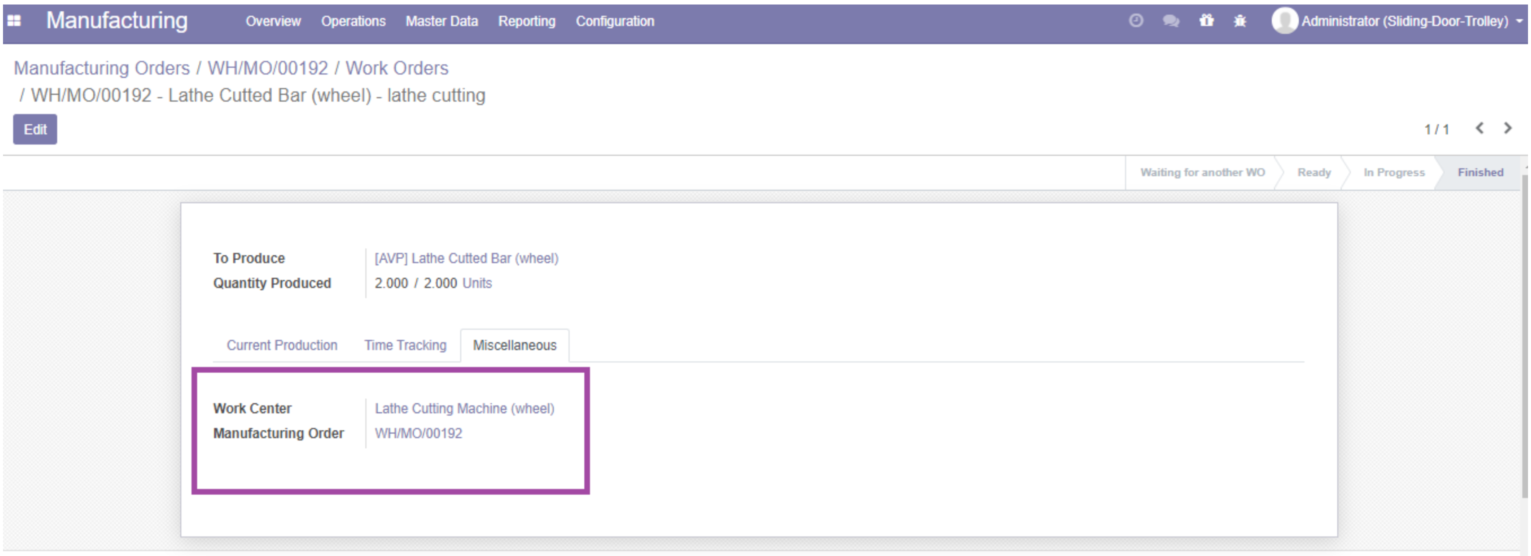
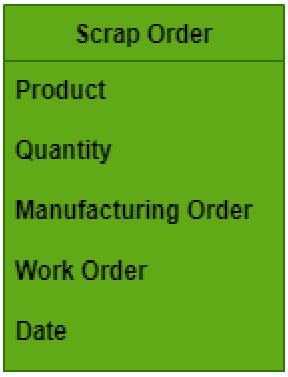


Figure 4.27: Work Order's Entities

3.7 Scrap Order



- In the case that there is a failure in producing the part at any step of the production process, the work of the machine is blocked, and the part is defined as scrap thus a scrap order is created.

- The manufacturing and work order is defined to specify at which step of the production process the failure occurred and the scrap order was created.

Figure 4.28: Scrap Order's Entities in Odoo

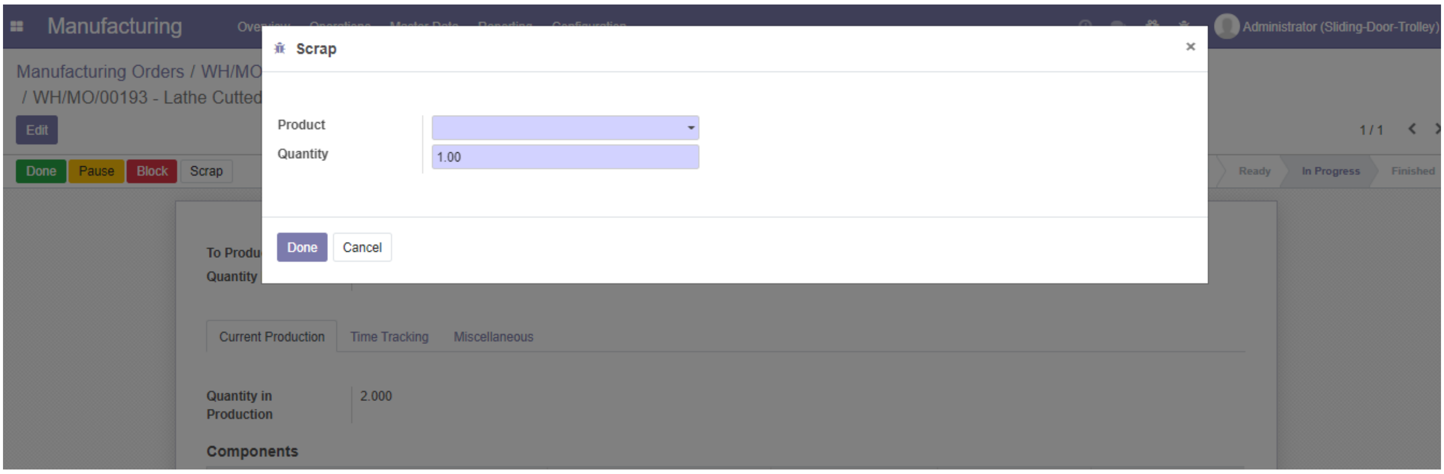


Figure 4.29: Scrap Entities in Odoo

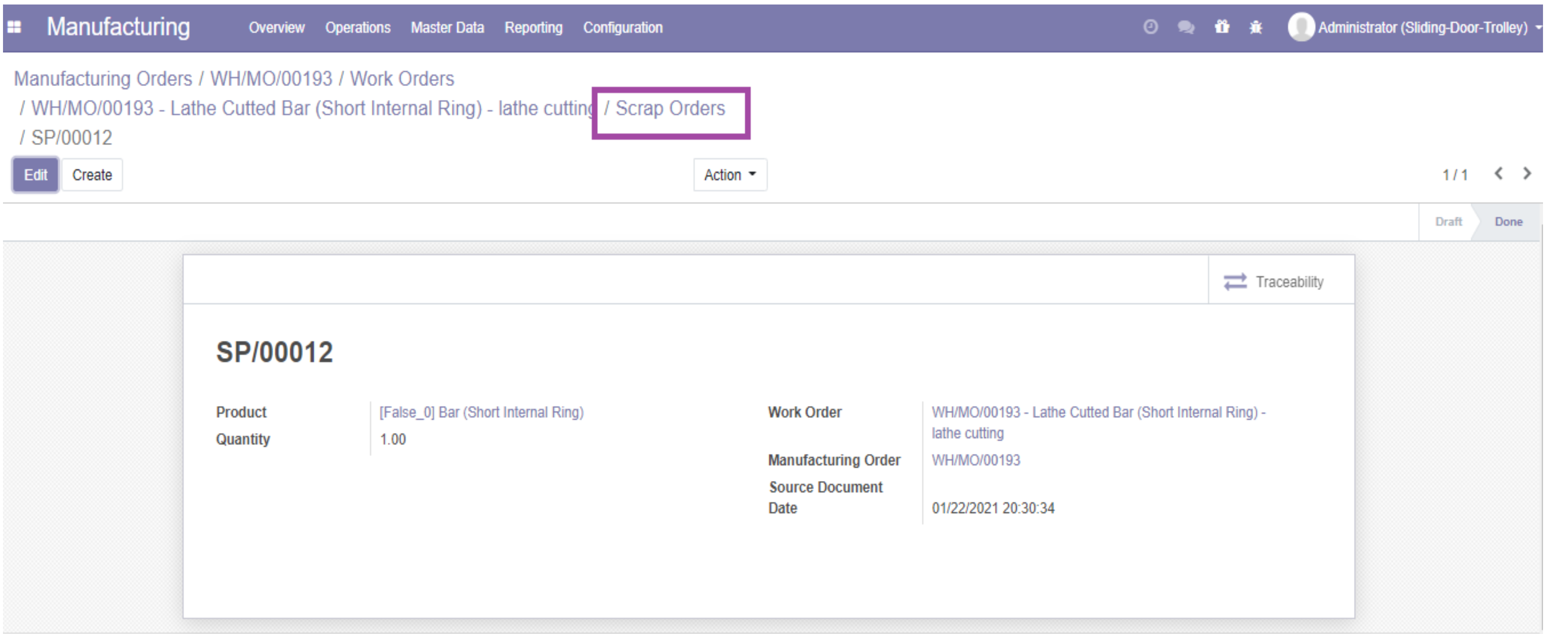


Figure 4.30: Scrap Orders' Entities in Odoo

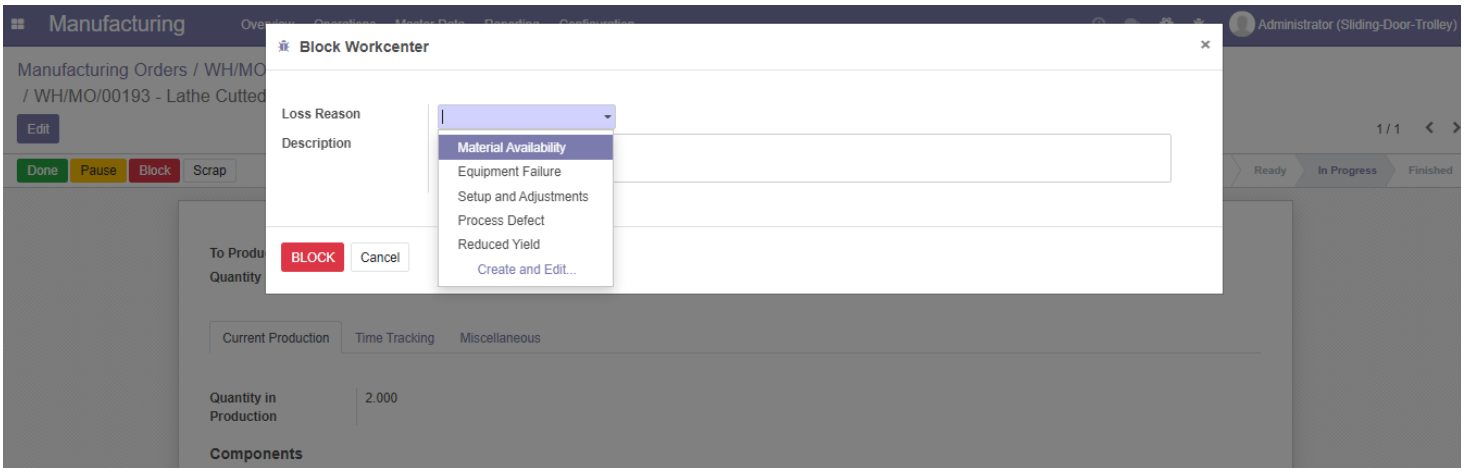


Figure 4.31: Workcenter Block Reason in Odoo

In the ***Reporting*** tab in the Manufacturing module where an evaluation of the manufacturing process and the corresponding workcenters and the products produced takes place, the following data is included and underneath will be reported production cycles for the production of the sliding door trolley considered:

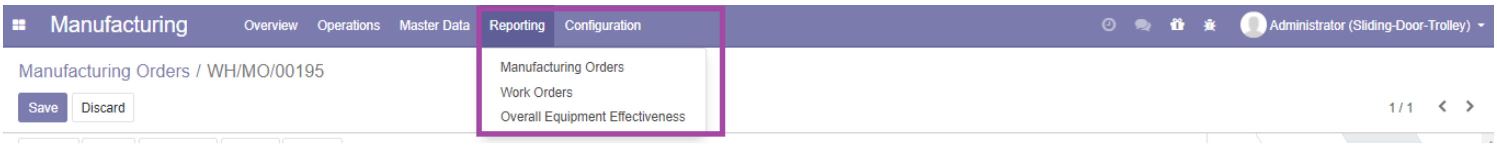
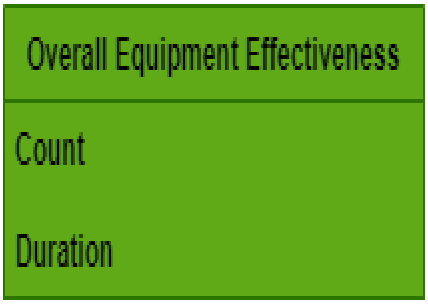


Figure 4.32: Reporting Tab in Odoo

3.8 Overall Equipment Effectiveness



- The following values can be grouped by according to User, Workcenter, Loss reason or add a custom group.
- You can add Time Ranges or compare current values to values of previous dates.
- Values can be demonstrated by a bar chart, line char or a pie chart.

Figure 4.33: OEE Measures in Odoo

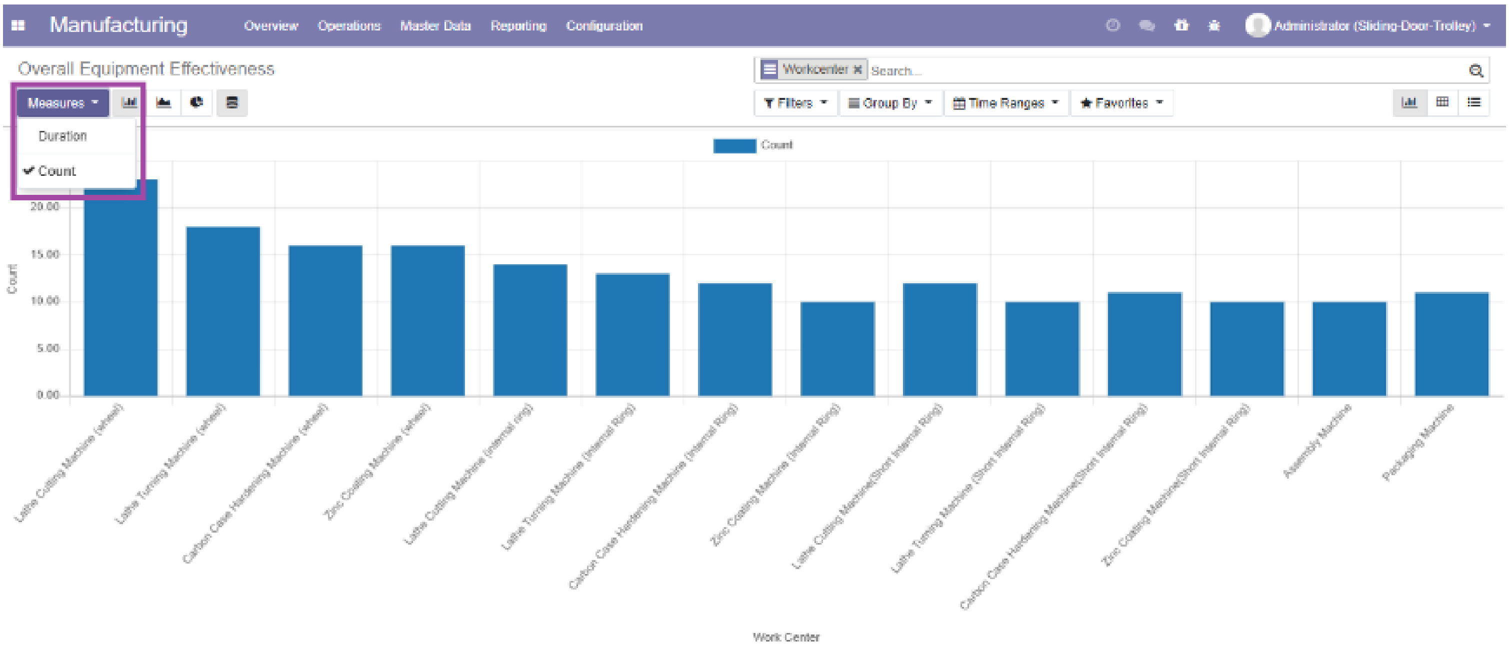


Figure 4.34: Overall Equipment Effectiveness (Bar Chart)

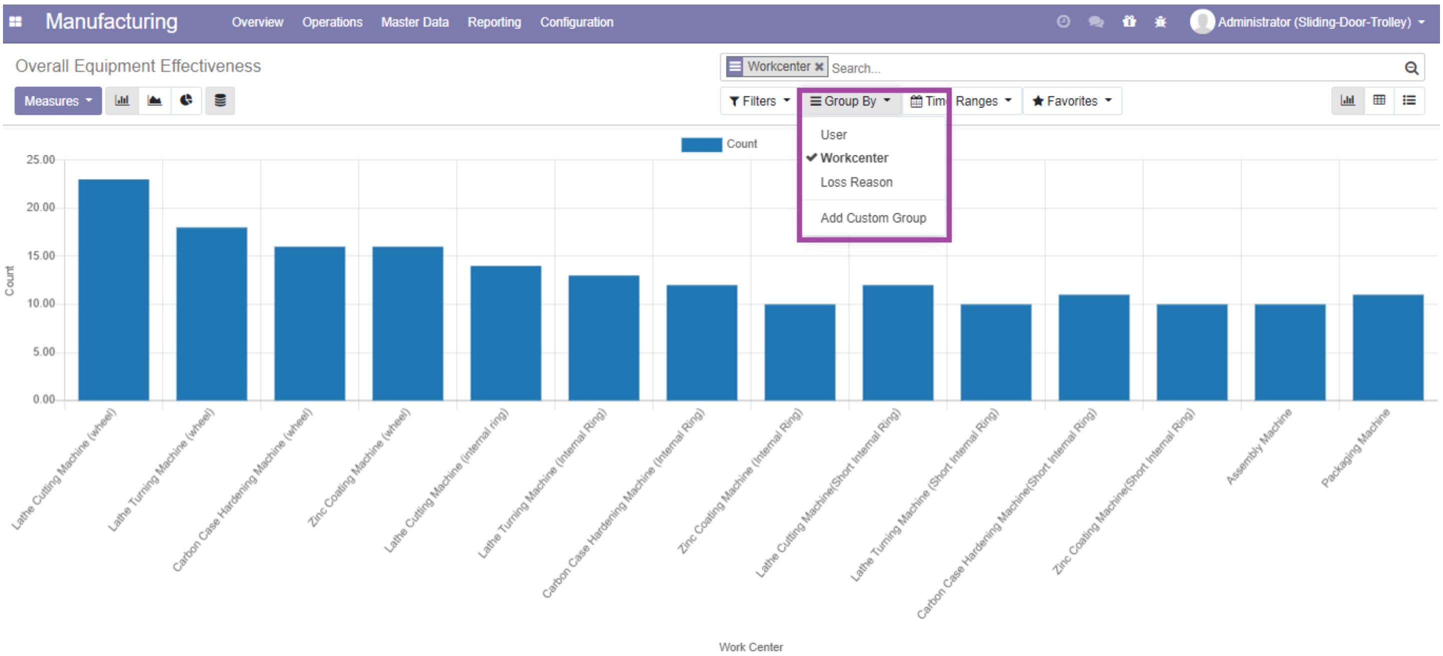


Figure 4.35: Overall Equipment Effectiveness “Group By” Categories

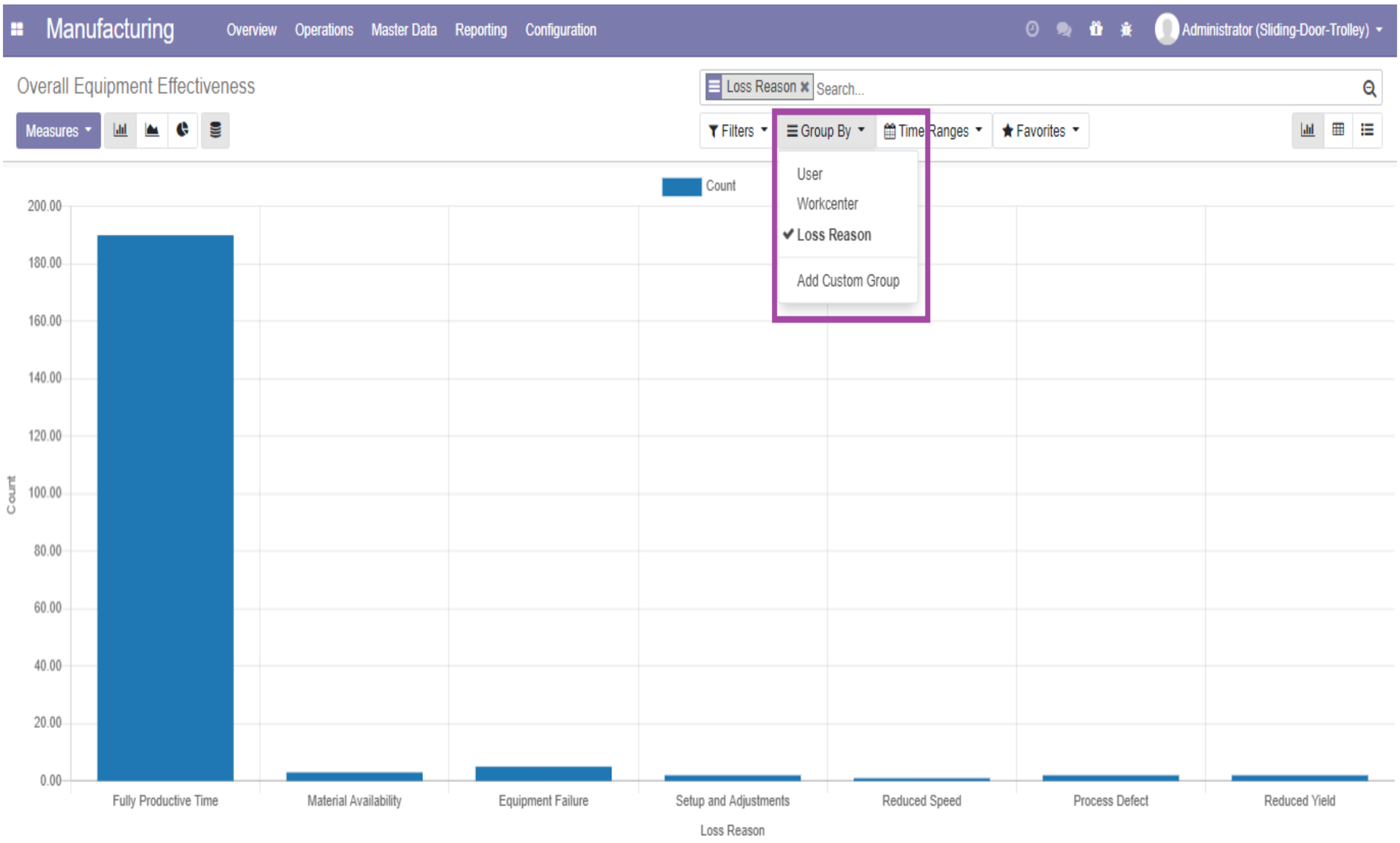


Figure 4.36: OEE Group By Loss Reason

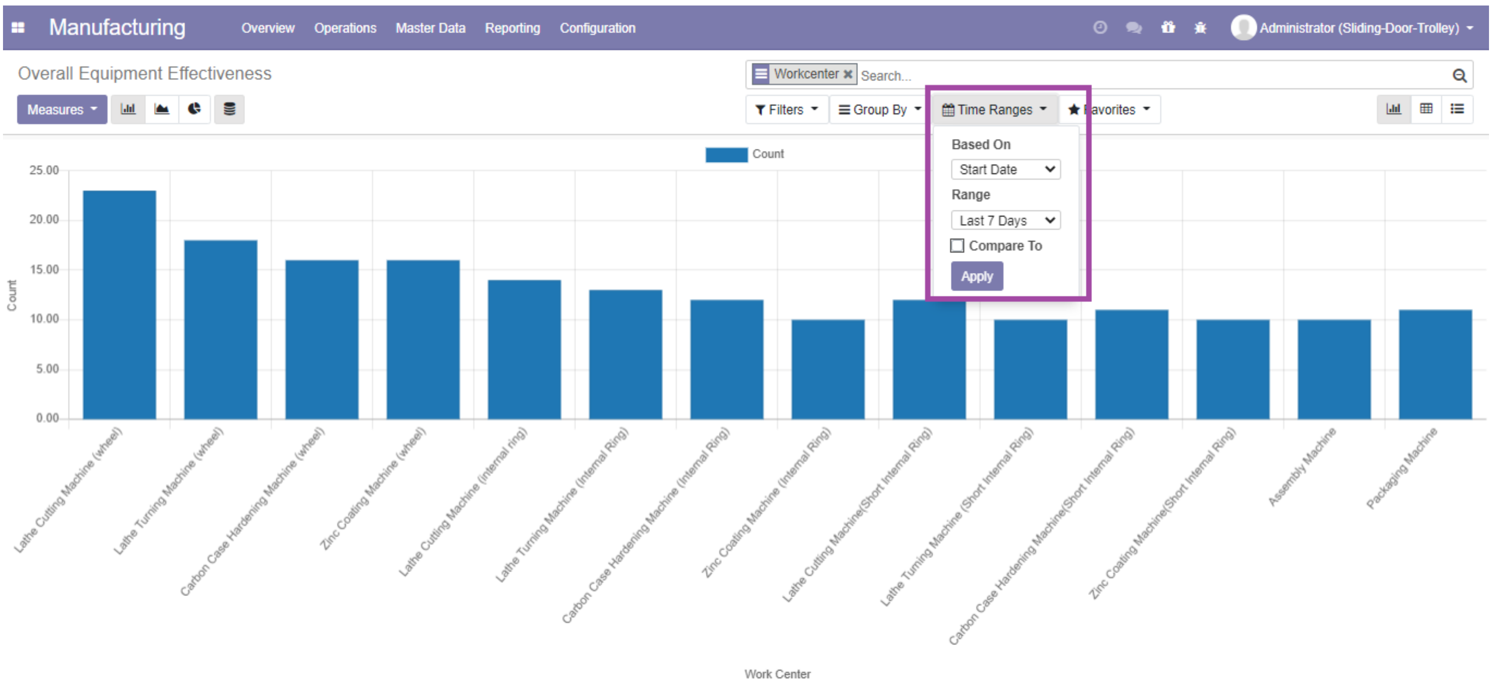


Figure 4.37: Overall Equipment Effectiveness Time Ranges

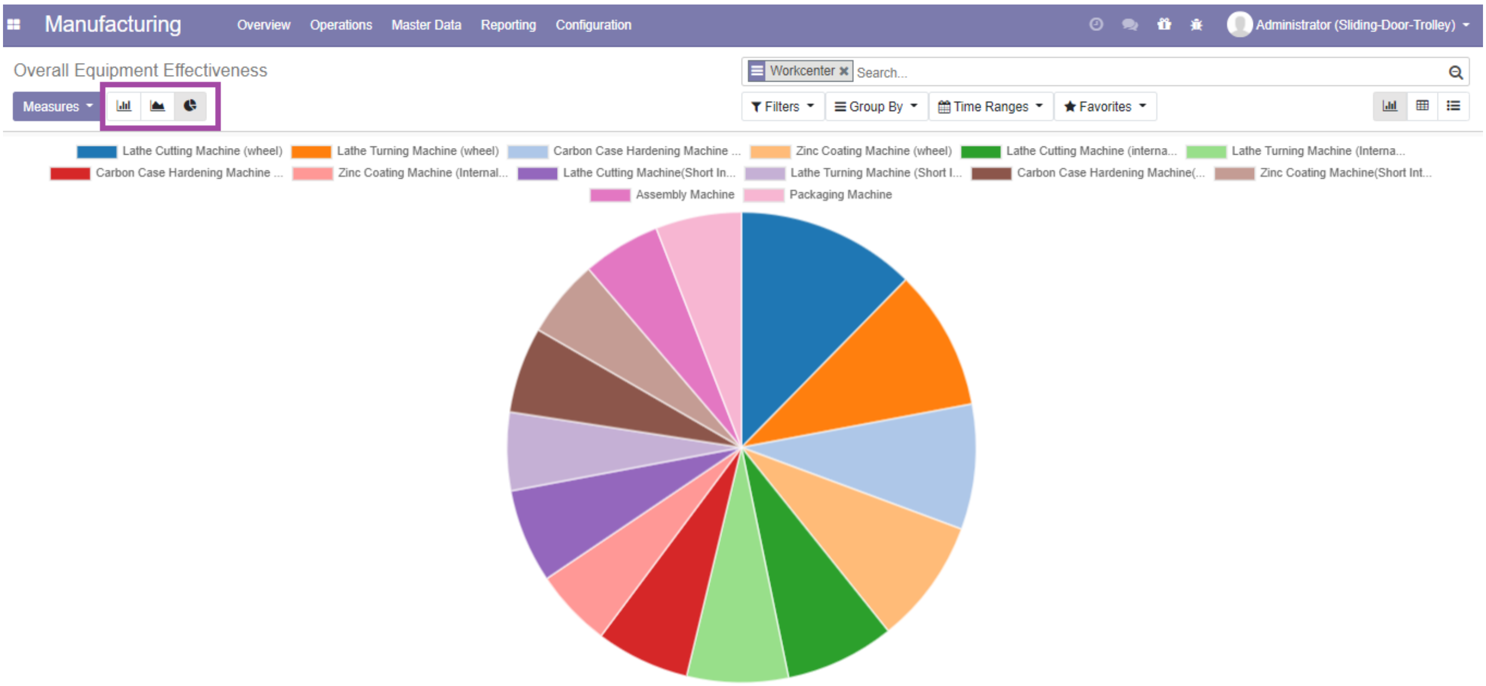


Figure 4.38: Overall Equipment Effectiveness (Pie Chart)

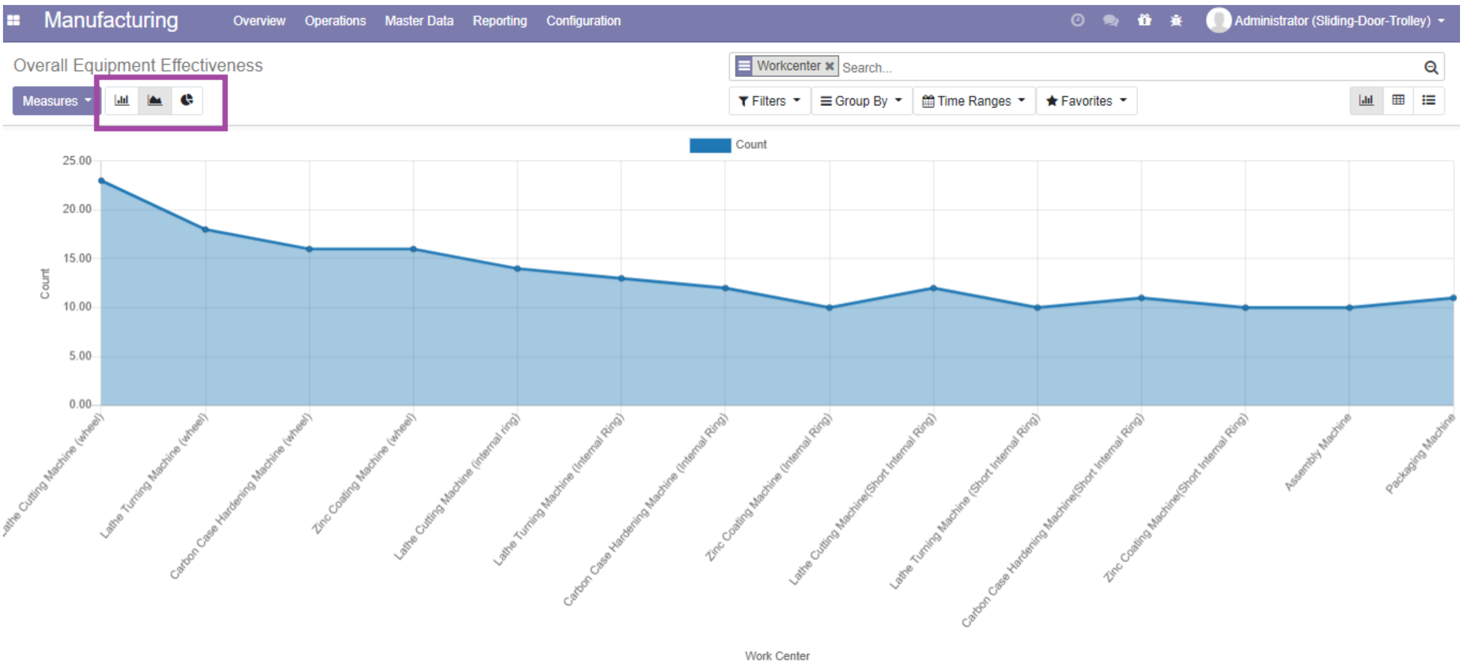


Figure 4.39: Overall Equipment Effectiveness (Line Graph)

3.9 Reporting-Manufacturing Orders

- The following values can be grouped by according to the Product, Routing, Status, Material Availability, Scheduled Date or add a Custom Group.
- You can add Time Ranges or compare current values to values of previous dates.
- Values can be demonstrated by a bar chart, line char or a pie chart.

Figure 4.40: Reporting-Manufacturing Orders Measures in Odoo

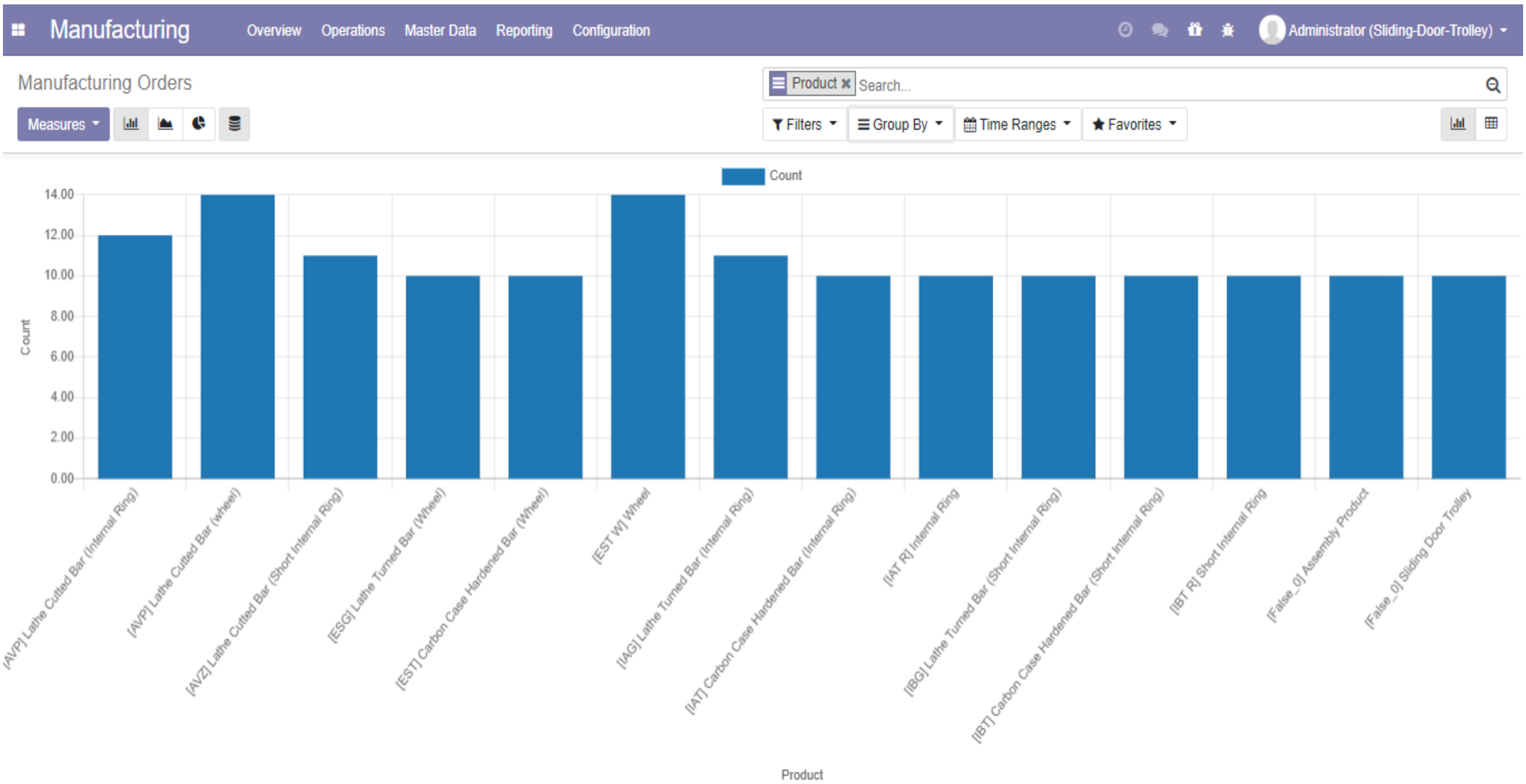
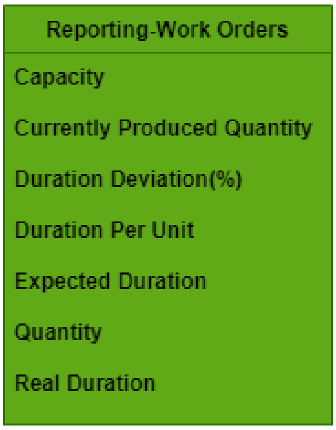


Figure 4.41: Reporting Manufacturing Orders in Odoo

3.10 Reporting-Work Orders



- The following values are grouped by according to the different manufacturing orders and a custom group can be added.
- You can add Time Ranges or compare current values to values of previous dates.
- Values can be demonstrated by a bar chart, line char or a pie chart.

Figure 4.42: Reporting-Work Orders Measures in Odoo

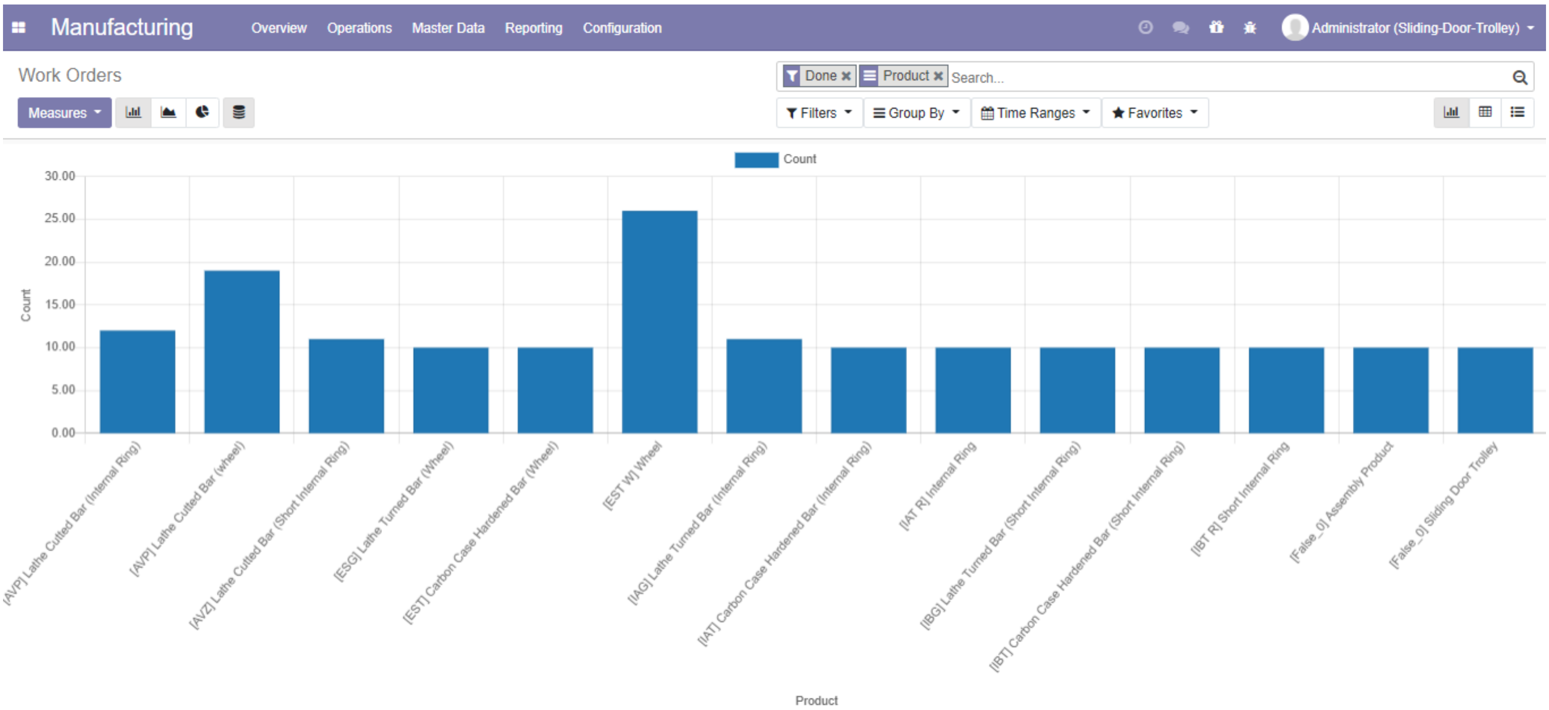


Figure 4.43: Reporting Work Orders in Odoo

4 Product Lifecycle Management (PLM) Module

The Product Lifecycle Management module was downloaded for free from the Odoo Appstore and it is developed and customized by *Omnia Solutions* which is a company specialized in in consulting services and customization of ERP and PLM as well as optimizing customers' workflow.

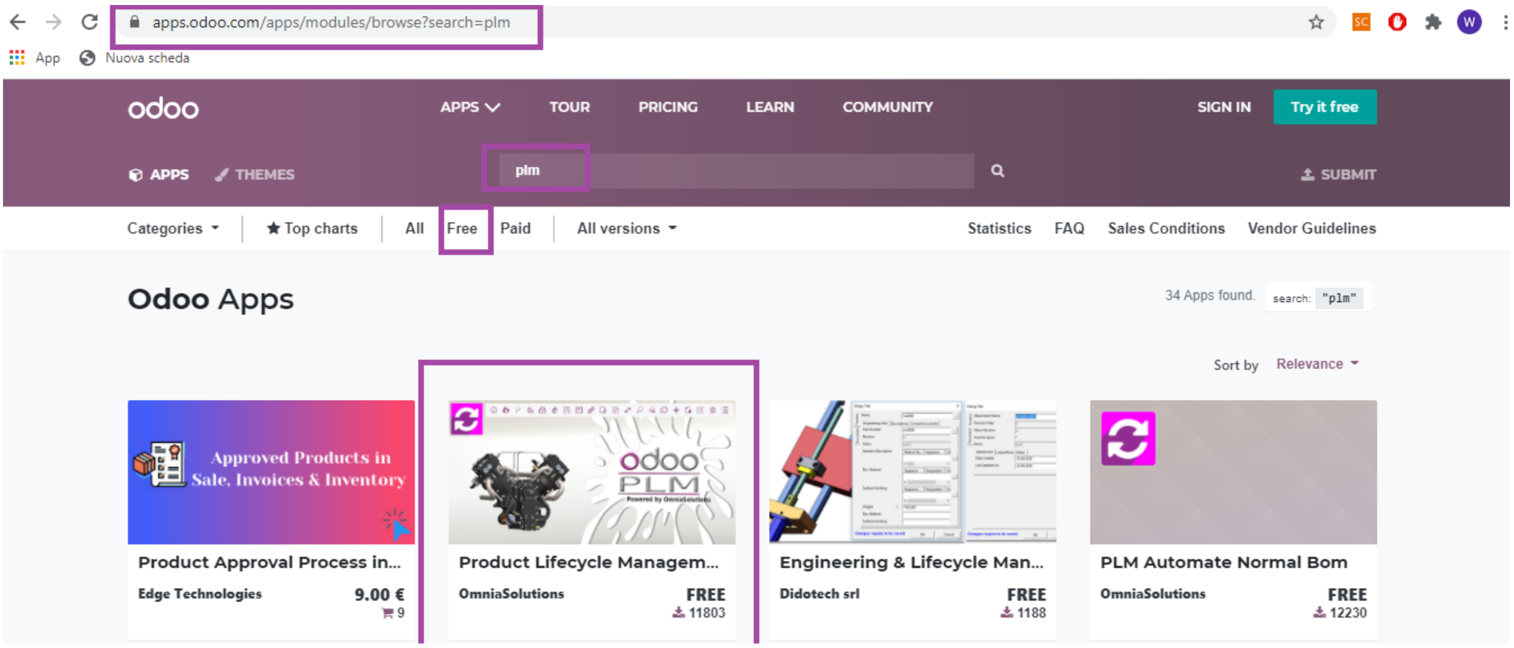


Figure 4.44: Odoo Appstore Website

Products
Product Name
Part Number
Can be Purchased
Can be Sold
Product Type
Sales Price
Cost
Supply Chain Routing
Barcode

Bill Of Materials (BOM)
Product
BOM Type
Product Quantity
Components' Name
Components' Quantity
Manufacturing Routing
Consumed In Operation

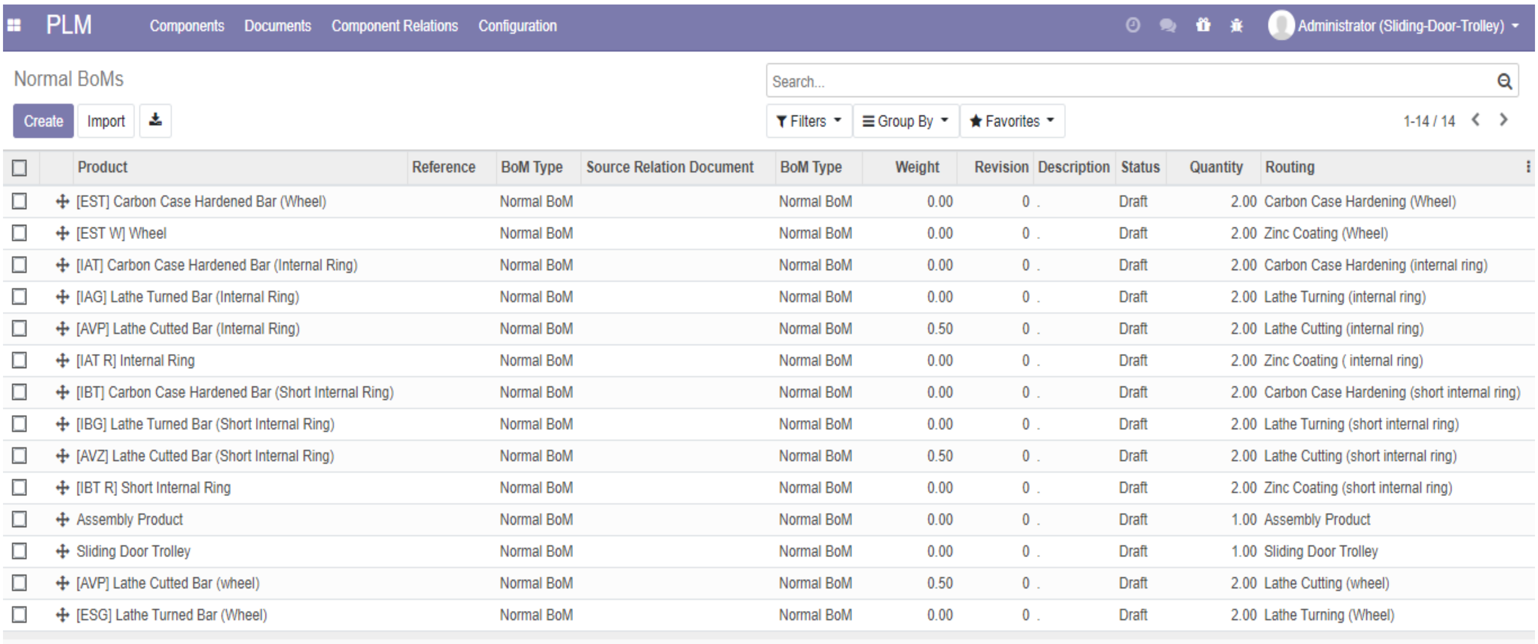
- Thanks to Odoo integration and data flow properties, the **Products and Bill of Materials (BOM)** data that was stored in the Manufacturing module will be transferred and stored in the PLM module automatically.

Figure 4.45: PLM Data in Odoo

- CAD Item
- Operation
- Creation Date
- Last Updated on
- Product Unit of Measure
- Routing
- Source ID

- The PLM module, you can insert for each BOM component the following data with the ability to upload the corresponding CAD item for each component.

Figure 4.46: Data to Insert in B.O.M. Lines in Odoo PLM Module



Product	Reference	BoM Type	Source Relation Document	BoM Type	Weight	Revision	Description	Status	Quantity	Routing
[EST] Carbon Case Hardened Bar (Wheel)		Normal BoM		Normal BoM	0.00	0	.	Draft	2.00	Carbon Case Hardening (Wheel)
[EST W] Wheel		Normal BoM		Normal BoM	0.00	0	.	Draft	2.00	Zinc Coating (Wheel)
[IAT] Carbon Case Hardened Bar (Internal Ring)		Normal BoM		Normal BoM	0.00	0	.	Draft	2.00	Carbon Case Hardening (internal ring)
[IAG] Lathe Turned Bar (Internal Ring)		Normal BoM		Normal BoM	0.00	0	.	Draft	2.00	Lathe Turning (internal ring)
[AVP] Lathe Cutted Bar (Internal Ring)		Normal BoM		Normal BoM	0.50	0	.	Draft	2.00	Lathe Cutting (internal ring)
[IAT R] Internal Ring		Normal BoM		Normal BoM	0.00	0	.	Draft	2.00	Zinc Coating (internal ring)
[IBT] Carbon Case Hardened Bar (Short Internal Ring)		Normal BoM		Normal BoM	0.00	0	.	Draft	2.00	Carbon Case Hardening (short internal ring)
[IBG] Lathe Turned Bar (Short Internal Ring)		Normal BoM		Normal BoM	0.00	0	.	Draft	2.00	Lathe Turning (short internal ring)
[AVZ] Lathe Cutted Bar (Short Internal Ring)		Normal BoM		Normal BoM	0.50	0	.	Draft	2.00	Lathe Cutting (short internal ring)
[IBT R] Short Internal Ring		Normal BoM		Normal BoM	0.00	0	.	Draft	2.00	Zinc Coating (short internal ring)
Assembly Product		Normal BoM		Normal BoM	0.00	0	.	Draft	1.00	Assembly Product
Sliding Door Trolley		Normal BoM		Normal BoM	0.00	0	.	Draft	1.00	Sliding Door Trolley
[AVP] Lathe Cutted Bar (wheel)		Normal BoM		Normal BoM	0.50	0	.	Draft	2.00	Lathe Cutting (wheel)
[ESG] Lathe Turned Bar (Wheel)		Normal BoM		Normal BoM	0.00	0	.	Draft	2.00	Lathe Turning (Wheel)

Figure 4.47: Normal BoMs in Odoo PLM Module

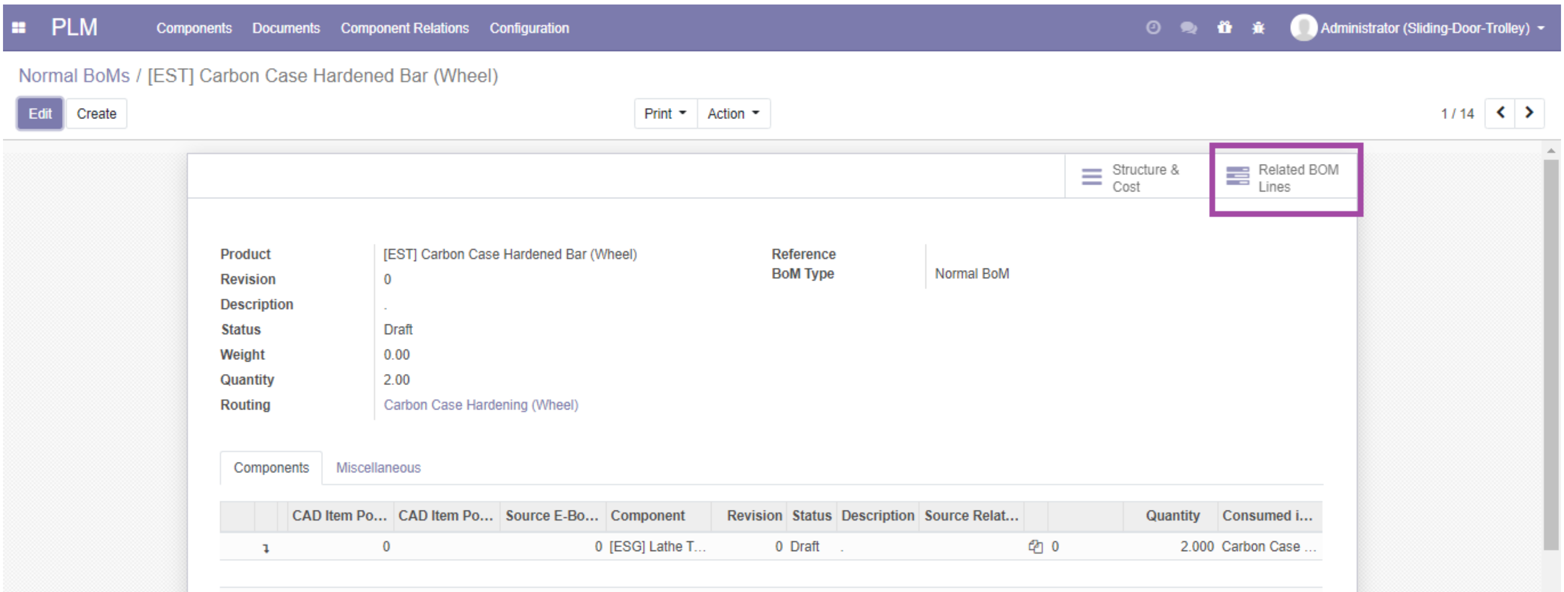


Figure 4.48: Normal BoM entities in Odoo PLM Module

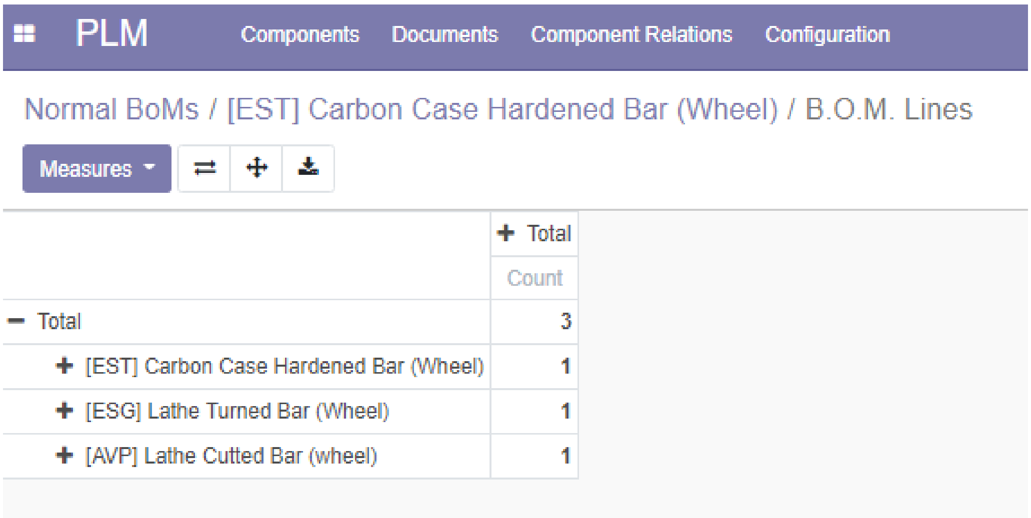


Figure 4.49: B.O.M Lines in Odoo PLM Module

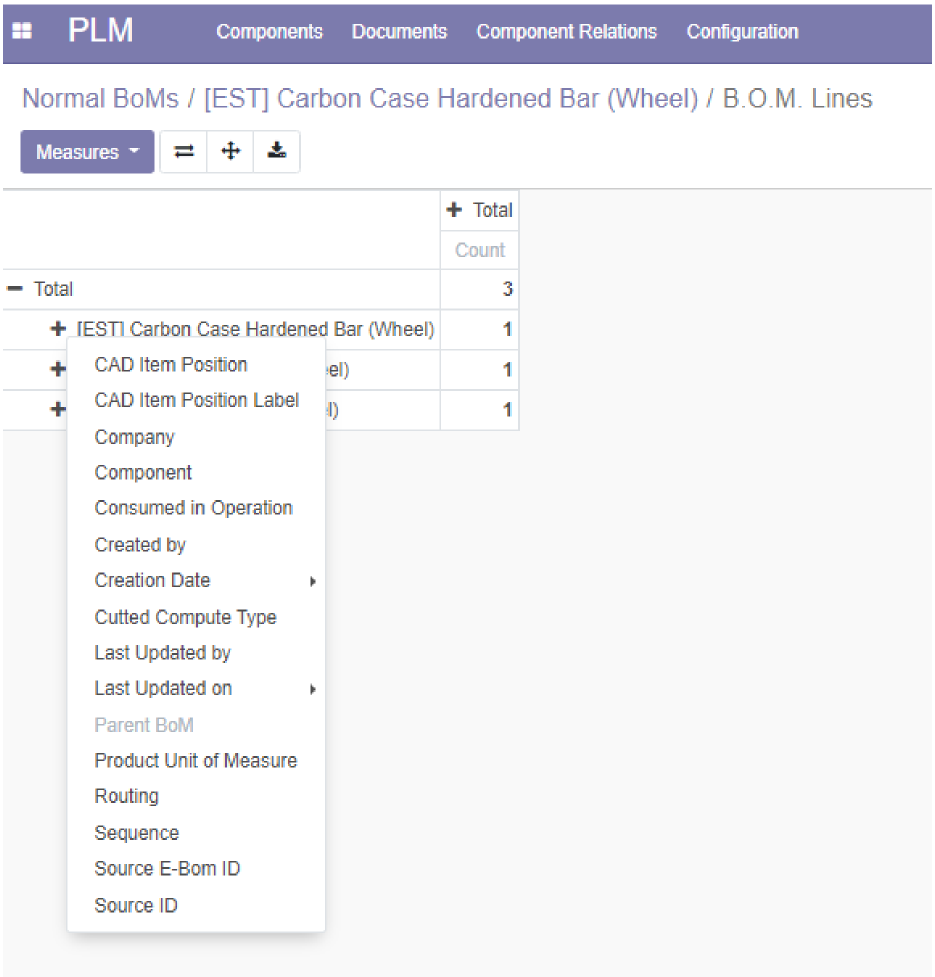


Figure 4.50: B.O.M Lines' Data

5 Purchase Module

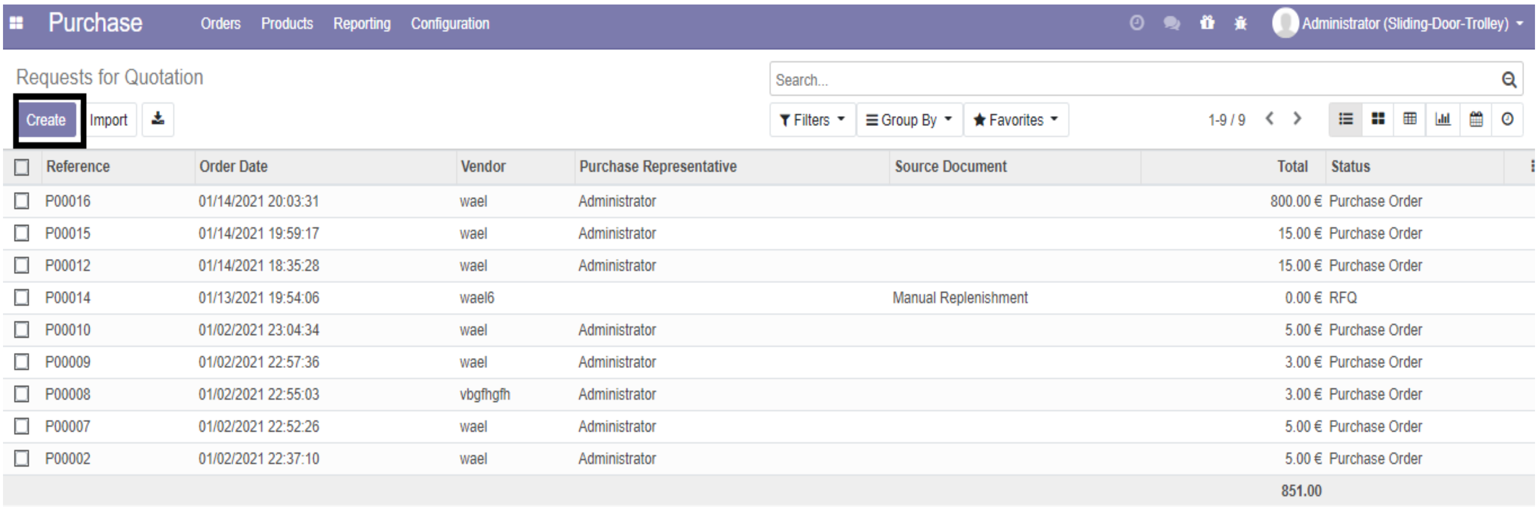
Purchase Order
Vendor
Vendor Reference
Order Date
Product
Quantity
Unit Price
Taxes
Subtotal

Figure 4.51: Purchase Order Entities in Odoo

▪The materials that are supposed to be purchased such as the Nut 12 mm, Pin, Ball Bearings and White Galvanized Brackets are defined as that in when creating the product in Odoo. Thus, when creating a manufacturing order is created and one of these materials are missing, a purchase order for these products are created.

▪Throughout the purchase order in Odoo, a *request for quotation* for specific product is created and saved then printed or sent by email to the vendor. T

- The vendor's pricelist is received and confirmed by the company, the purchase order is confirmed, and a Bill is created containing the quantity, price, bill date, vendor's name and payment terms so that payment is registered.
- The operations regarding receiving the products such as shipping, picking, and storing the products in the warehouse are tracked until the user is able to validate the receipt of the purchased products and a Delivery Slip will be generated and printed.
- It is important to note that a specific tab is reserved in this module to insert data related to the vendors information who represents the company's products suppliers.



Reference	Order Date	Vendor	Purchase Representative	Source Document	Total	Status
P00016	01/14/2021 20:03:31	wael	Administrator		800.00 €	Purchase Order
P00015	01/14/2021 19:59:17	wael	Administrator		15.00 €	Purchase Order
P00012	01/14/2021 18:35:28	wael	Administrator		15.00 €	Purchase Order
P00014	01/13/2021 19:54:06	wael6		Manual Replenishment	0.00 €	RFQ
P00010	01/02/2021 23:04:34	wael	Administrator		5.00 €	Purchase Order
P00009	01/02/2021 22:57:36	wael	Administrator		3.00 €	Purchase Order
P00008	01/02/2021 22:55:03	vbgfhgfh	Administrator		3.00 €	Purchase Order
P00007	01/02/2021 22:52:26	wael	Administrator		5.00 €	Purchase Order
P00002	01/02/2021 22:37:10	wael	Administrator		5.00 €	Purchase Order
					851.00	

Figure 4.52: Purchase Order Module-Requests for Quotation in Odoo

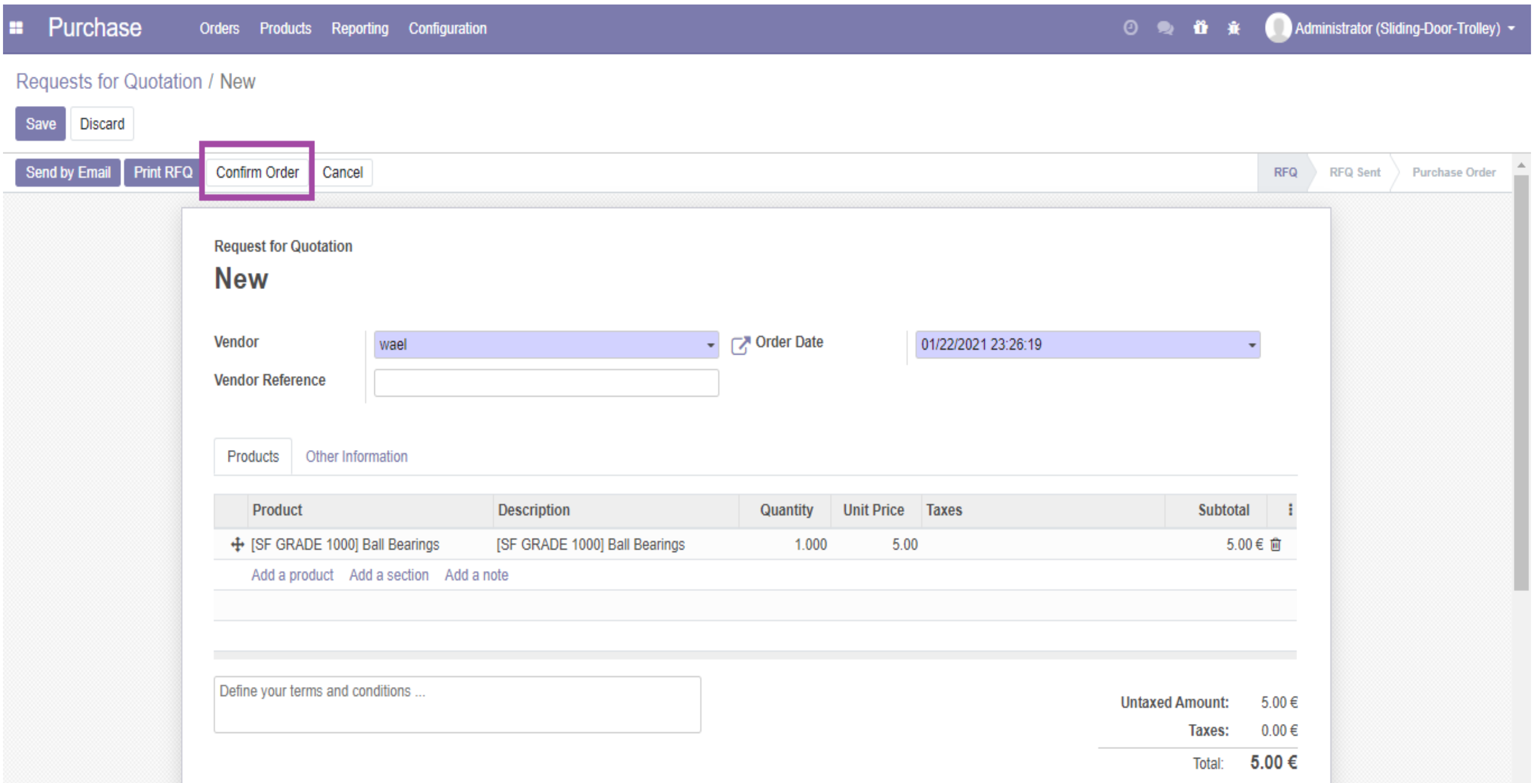


Figure 4.53: Purchase Order Entities in Odoo

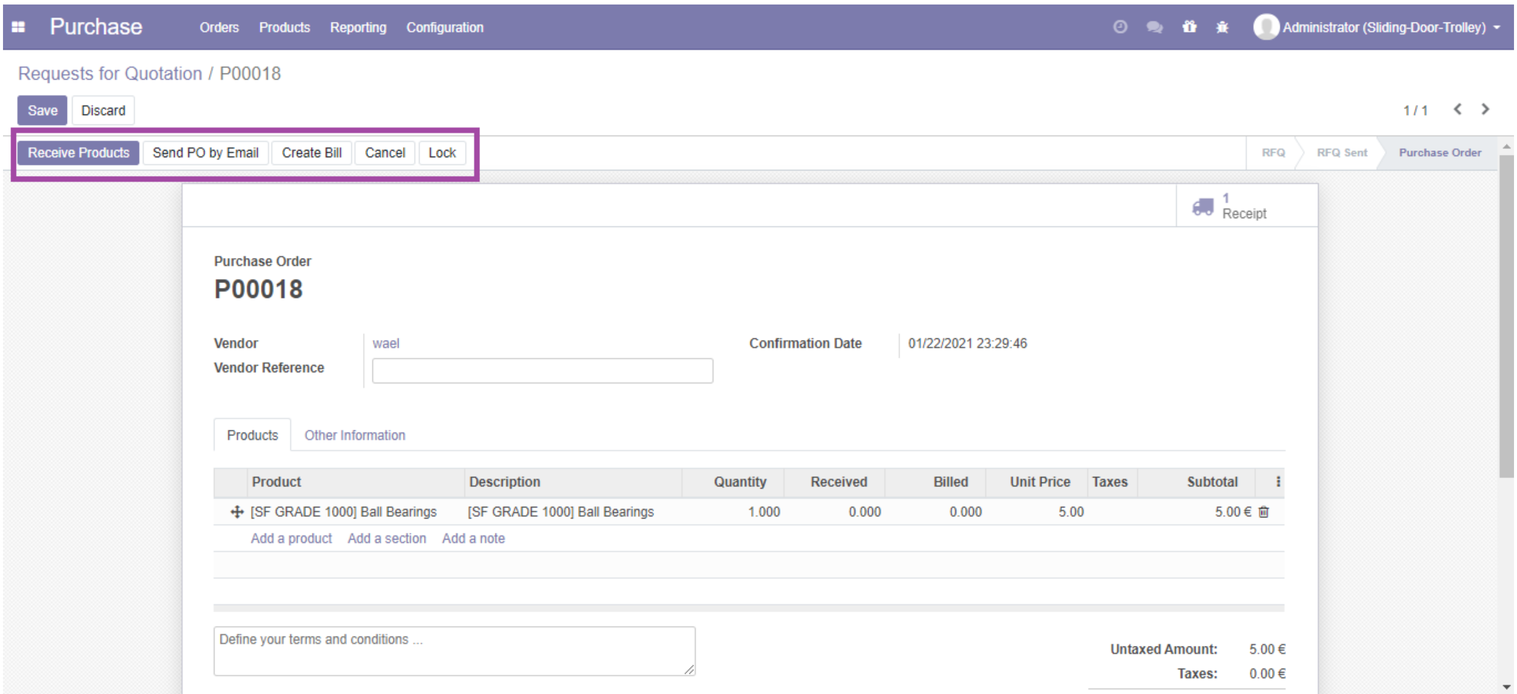


Figure 4.54: Receive Products in Odoo Purchase Module

Chapter 5
Conclusion

The objectives of nowadays companies is to digitize their processes by introducing information systems into their industry which is essential part of the Industry 4.0 revolution. This introduction of information systems into the manufacturing industry requires feasibility studies and analysis depending on the company's size and sector. Besides that, applying technological systems throughout the manufacturing process requires the suitable tools which should be analysed and experimented to show its effectiveness in reaching a certain organizational goal. The main goal of industries recently is targeted toward increasing their market share in the currently highly competitive environment.

Tools to apply information systems in manufacturing has the ability to ensure flow of data between different departments which enhance the communication between departments and between levels in the same department. Hence, this communication caused by the information flow results in a more efficient industry regarding design, processes, new product development, customer, and vendor relationships.

The systems introduced in this thesis work are mainly Manufacturing Execution System (MES) and Product Lifecycle Management (PLM). PLM manages the information related to the product throughout its lifecycle while MES manages shop floor data while manufacturing execution takes place. The main goal of this thesis work was to try to implement the integration between these two information systems through Odoo software. Regarding Odoo, PLM system is able to store data related to the product's design by introducing the corresponding CAD item besides defining the product lifecycle through presenting creation date and the transformations the product undergoes. On the other hand, MES system defines workcenters, routings and manages manufacturing orders and thus manufacturing process taking place in the shop floor.

The introduction of information systems is tough work for all departments of a certain industry because it requires active learning dedication and adaptation to new work routines that doesn't exist in traditional industrial processes. Thus, companies' managers and responsibles should plan for workshops to inform the workers about the benefits of introducing the information systems and how would this transform the company's system besides training the workers to use the new tools introduced to improve the company's competitiveness and take advantage of this industrial revolution in the most efficient manner.

The management of design and shop floor data used to take place orally or manually written between workers and thus information related to past experiences such as errors, misconceptions, design and manufacturing tips weren't digitized or stored in an organized way which limited the competitiveness and efficiency of the production process specially regarding time to develop a new product.

The introduction of PLM and MES systems and their corresponding integration on Odoo is experimented in this thesis work throughout a use case of manufacturing a 2 wheels configuration sliding door trolley. The products needed for production and the Bill of Materials (BOM) were defined in the MES module in Odoo and the automatically transmitted to the PLM module where the products' data where inserted and saved to ensure an efficient product lifecycle management. On the other hand, in the MES module in Odoo manufacturing process management takes place where control of machine errors, productivity and related shop floor data was stored. Thus, a flow diagram is created to highlight the information flow starting from the products definition then the customer order triggering manufacturing order to obtain final product.

An important feature regarding Odoo, is the ability to report manufacturing/work orders which presents statistics and data regarding the efficiency of the machines , the production process, the reason of errors etc. which can be stored and then used in developing future products in less time and more efficient way because past experience is digitized and stored and accessible at any time in a clear and professional image.

This thesis work can be considered as a manual for applying Odoo software which has great potential in data flow and improving manufacturing efficiency and reducing future errors and future production times. While editing information regarding products in the MES module, this information will be automatically edited in the PLM module as well and vice versa thus different departments will be informed about the new data which will ensure communication and thus higher productivity. Besides that, regarding MES module, the user of Odoo will be able to insert data regarding shop floor machines and production process status which will be useful to future works.

Future works regarding this topic would be focusing on experimenting Odoo software in real life use cases of productive companies where real time manufacturing processes and design takes place. When applying Odoo in real life use case, Odoo will be studied, analysed and experimented in a more efficient way where the dynamics and several variables of a real life production take place thus advantages and disadvantages of Odoo software will be exploited in a practical way. Hence, the availability of feedback regarding Odoo based on practical data acquired during a real-life case would make it a serious choice for companies interested in introducing information systems to their industry.

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