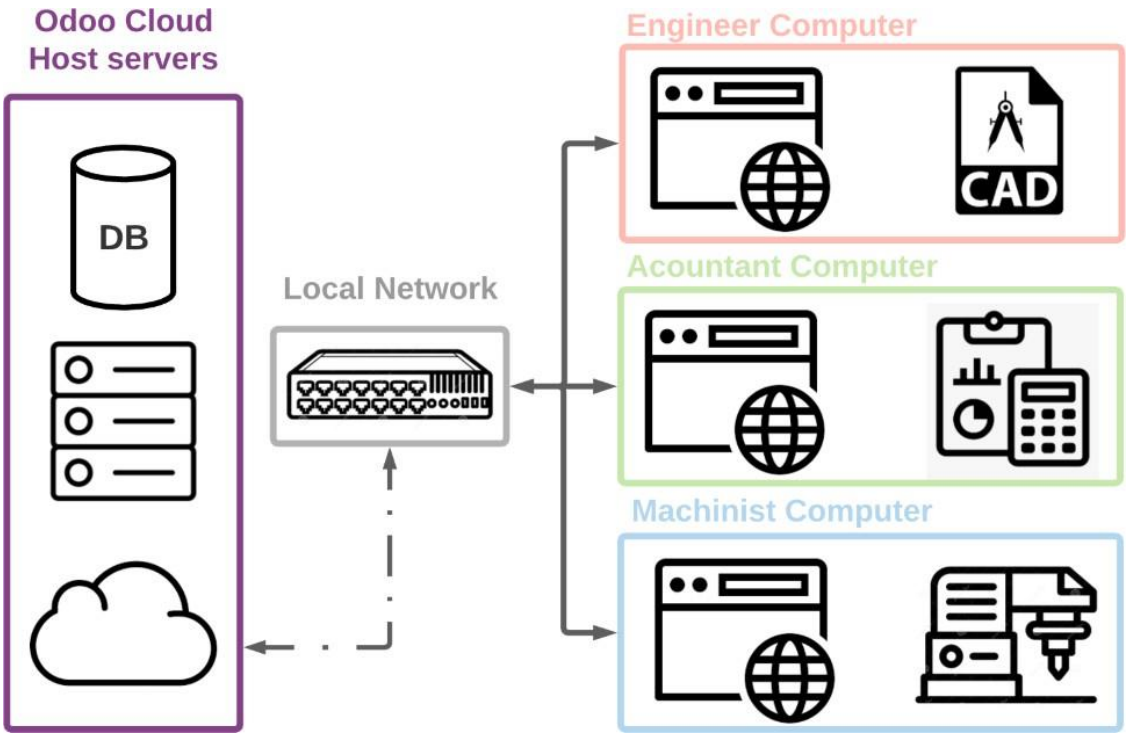

Figure 17 Function Diagram of Odoo configuration B

圖17 Odoo配置B功能圖

Users essentially interact with the system through the graphical user interface (GUI) and use it to access the different modules available as need by a per user basis. This means that restrictions can be applied to different users in order to maintain control over the different aspects of the business activity, e.g., accountants would get access to accounting module, sales module and inventory module but they would be restricted from the manufacturing module. This sort of restriction guarantees control over the processes only to the proper employees.

使用者基本上通過圖形使用者介面（GUI）與系統交互，並使用它來訪問每個用戶根據需要提供的不同模組。這意味著可以對不同的使用者施加限制，以保持對商務活動不同方面的控制，例如，會計師可以訪問會計模組、銷售模組和庫存模組，但他們將受到製造模組的限制。這種限制保證了對流程的控制只對適當的員工。

Within said GUI the different modules appear as app icons (Figure 18) and, from the get-go, the company has available a reasonable selection of well-integrated applications not to mention a vast app store filled with community made modules.

在上述 GUI 中，不同的模組顯示為應用程式圖示（圖 18），並且從一開始，該公司就提供了合理選擇的集成良好的應用程式，更不用說充滿社區製作模組的龐大應用商店了。

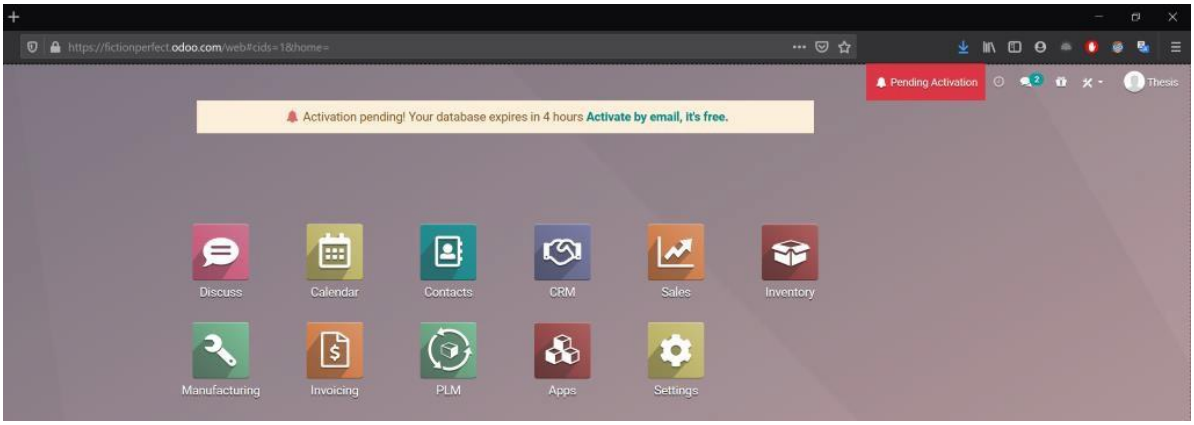

Figure 18 Screenshot of GUI from Odoo in configuration B

圖 18 配置 B 中 Odoo 的 GUI 螢幕截圖

1.1.1. Odoo's view on manufacturing: Odoo對製造業的看法：

Odoo considers that the responsibilities regarding manufacturing of anything is distributed throughout different company departments, each of which is responsible for specific file types and dealt with using specific apps (Table 2). From the perspective of PLM this is very positive because as mentioned by (Saaksvuori and Immonen, 2008) about User privilege management – the PLM system is used to define information access and maintenance rights. The PLM system defines the people who can create new information or make, check and accept changes, and those who are allowed only to view the information or documents in the system. user privilege management is usually a challenge when regarding integration of PLM with other systems.

Odoo 認為，製造任何產品的責任都分佈在不同的公司部門，每個部門負責特定的檔類型，並使用特定的應用程式進行處理（表 2）。從 PLM 的角度來看，這是非常積極的，因為正如（Saaksvuori 和 Immonen，2008）關於用戶許可權管理所提到的，PLM 系統用於定義資訊訪問和維護許可權。PLM 系統定義了可以創建新資訊或進行、檢查和接受更改的人員，以及僅允許查看系統中的資訊或文檔的人員。在將 PLM 與其他系統整合時，用戶許可權管理通常是一個挑戰。

Table 2 Correlation between department and Documents/Apps
表2部門與文檔/應用程式的相關性

Department 部門	Documents/Apps 文件/應用程式
Engineering 工程	CAD & BOM CAD 和 BOM
Manufacturing Engineering 製造工程	Routings, Worksheets, Workcenters 工藝路線、工作表、工作中心
Purchase/Procurement 採購/採購	Procurement order, Request for quotation 採購訂單， 詢價
Inventory Operators 庫存操作員	Receipt, Barcode 收據、條碼
Manufacturing Foreman 製造工頭	Manufacturing order, Planning 製造訂單、計劃
Manufacturing Operators 製造運營商	Work order 工作訂單
Inventory Operators 庫存操作員	Delivery 交貨
Quality 品質	Alert, Analysis, Control points 警報、分析、控制點
Department 部門	**Documents/Apps 文件/應用程式**
Engineering 工程	Engineering change order 工程變更單
Maintenance 保養	Preventive/Corrective 預防/糾正

From Odoo's perspective in the beginning of any usual manufacturing process, the first step will be the engineers designing the product usually using a CAD software. Once that is done, they will create a Bill of materials (BOM) this is a list of components or materials necessary to produce the product. At this point the focus goes to the manufacturing process itself.

從Odoo的角度來看，在任何常規製造過程的開始，第一步將是工程師通常使用CAD軟體設計產品。完成後，他們將創建物料清單（BOM），這是生產產品所需的元件或材料清單。在這一點上，重點放在製造過程本身。

The software view of process is focused on routings, worksheets and work centers this is done by the manufacturing engineering team. A routing is a set of steps a product goes through for production. Worksheets are the instructions for the manufacturing operator, and work centers are the places where the production is being conducted. Odoo considers that these are the requirements for putting engineers plans in motion

流程的軟體檢視側重於工藝路線、工作表和工作中心，這是由製造工程團隊完成的。工藝路線是產品在生產過程中經歷的一組步驟。工作表是製造操作員的指令，工作中心是進行生產的地方。Odoo認為這些是將工程師計劃付諸實施的要求

A procurement department will be responsible for requesting for quotations (RFQ) or purchase orders (PO). Inventory operators take care of receipts based on those POs, which is usually done using a barcode application within Odoo. As explained in the first section of this chapter Odoo is primarily an ERP system and it is at this point that it is possible to notice some ERP centric characteristics like the focus on inventory and management of resources. This will be further analyzed in the following sections, but it is fair to point out that those RFQ and PO are considered items within the data base.

採購部門將負責詢價 （RFQ） 或採購訂單 （PO）。庫存操作員根據這些採購訂單處理收據，這通常是使用Odoo中的條碼應用程式完成的。如本章第一節所述，Odoo主要是一個ERP系統，在這一點上，可以注意到一些以ERP為中心的特徵，例如對庫存和資源管理的關注。這將在以下各節中進一步分析，但公平地指出，這些 RFQ 和 PO 被視為資料庫中的專案。

Only when you have the design the process and the materials required Odoo considers manufacturing possible. Then the manufacturing foreman will create a manufacturing order (MO) and manage the planning of the manufacturing operators through work orders (WO) and work centers. Then the manufacturing operators can start production following a work order. After the products are produced, they automatically appear in the inventory database which alongside packaging and delivery is managed by the Inventory department.

只有當您擁有所需的設計、工藝和材料時，Odoo才會考慮製造。然後，製造領班將創建製造訂單 （MO） 並通過工作訂單 （WO） 和工作中心管理製造操作員的計劃。然後，製造操作員可以按照工作訂單開始生產。產品生產完成後，它們會自動出現在庫存資料庫中，該資料庫與包裝和交付一起由庫存部門管理。

Odoo considers that quality team is responsible for assign control/check points as well as identify possible issues within the product or production. These quality control check points are very interesting from the MES perspective because it represents valuable production data that is collected in real time as production occurs, i.e., it is possible to assign a dimension

check after the production of every piece where the machinist will fill in the dimensions to track quality over time.

Odoo認為質量團隊負責分配控制/檢查點，並識別產品或生產中可能存在的問題。從MES的角度來看，這些品質控制檢查點非常有趣，因為它代表了在生產過程中即時收集的有價值的生產數據，即，可以在每件作品生產後分配尺寸檢查，機械師將填寫尺寸以跟蹤品質隨時間推移。

If it's a problem of design or if there is possibility for improvement an engineering change order (ECO) can be issued. This falls back to the hands of the manufacturing engineering team and will focus on updating documents and the BOM. The ECO is the heart of how Odoo deals with tracking change within the system. That is key when regarding PLM and in fact is the focus of the Odoo application called PLM. To which lengths said application is capable to perform is the subject of the next section.

如果是設計問題或有改進的可能性，可以發出工程變更單 （ECO）。這又回到了製造工程的手中 團隊，並將專注於更新文檔和 BOM。ECO是Odoo處理系統內跟蹤變化的核心。在PLM方面，這是關鍵，事實上，這是Odoo應用程式PLM的重點。所述應用程式能夠執行到什麼程度是下一節的主題。

1.1.2. The information structure of Odoo
Odoo的信息結構

Each module focuses in the manipulation of specific object-oriented classes that hold metadata within the database. These are the virtual Items that are responsible for virtualizing the aspects of the product lifecycle as referred by in (Section 3.1). Different types of items have different types of accounts and hold different sorts of data, i.e., a product item is representative of a certain product and holds metadata that is relevant to its interactions and use as well as links to other possible items that are closely relevant like their responsible user or the bill of materials necessary to its manufacturing. Odoo them makes all that information accessible and interactable through its browser interface (Figure 19 and Figure 20). For the sake of consistency this document will refer to specific item representations (E.g. Bolt) as 'item' and refer to a type of item (Product) as 'item class'.

每個模組都側重於操作在資料庫中保存元數據的特定面向物件類。這些是負責虛擬化產品生命週期各個方面的虛擬專案，如（第3.1節）中所述。不同類型的專案具有不同類型的帳戶並持有不同類型的數據，即產品專案代表特定產品，並包含與其交互和使用相關的元數據，以及指向其他可能專案的連結，這些專案密切相關，例如其責任使用者或製造所需的物料清單。Odoo使所有這些資訊都可以通過其瀏覽器介面訪問和交互（圖19和圖20）。為了保持一致性，本文檔將特定專案表示（例如Bolt）稱為"專案"，並將專案類型（產品）稱為"專案類"。

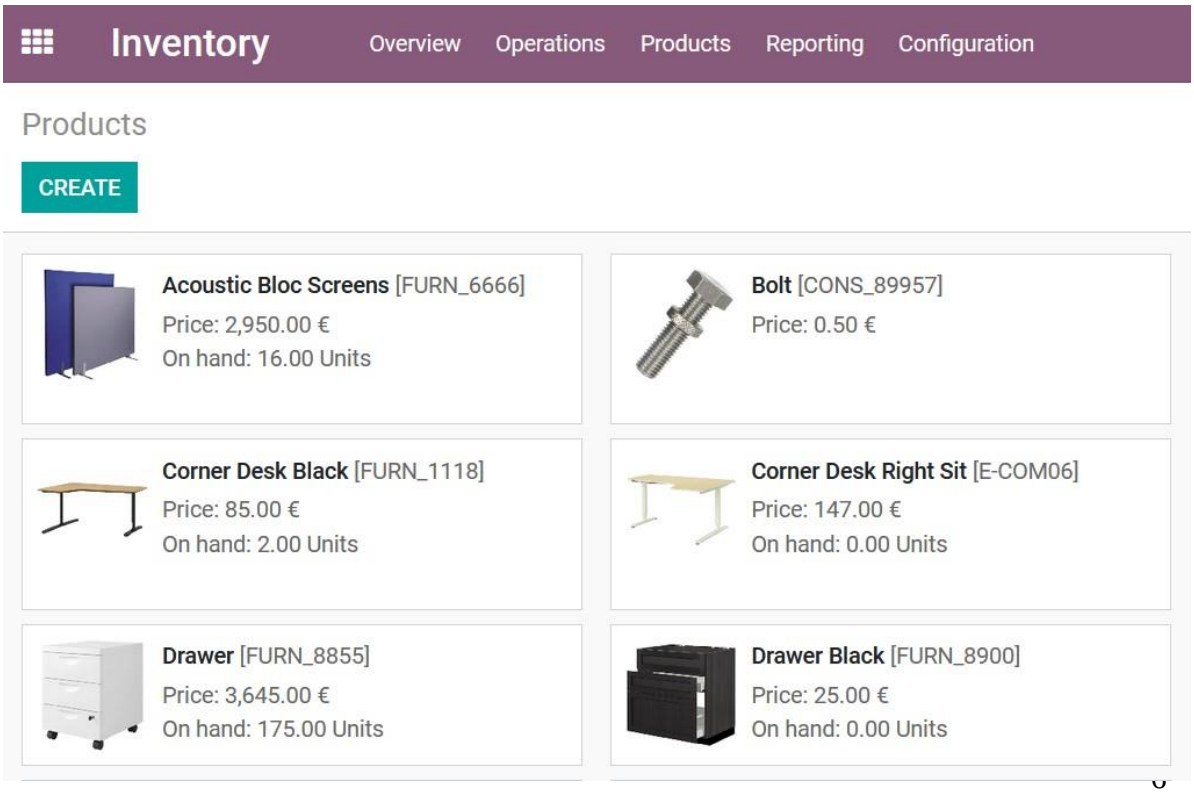

Figure 19 Example of Odoo's interface regarding items

圖19 Odoo關於專案的介面示例

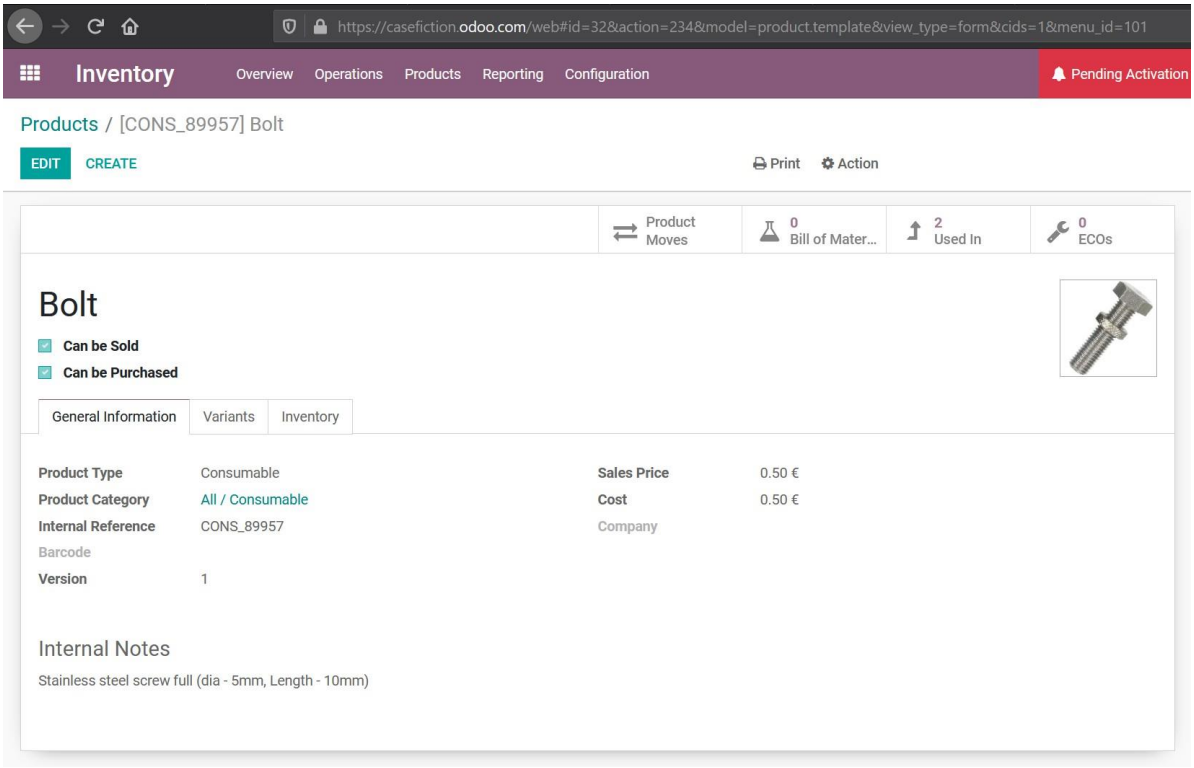

Figure 20 Example of specific item and its metadata as displayed by GUI
圖20 GUI顯示的特定專案及其元數據示例

Within Odoo, there are several types of those item classes (some holding a lot of metadata and some holding very little) all with a varying degree of relationships and integration. Since the scope of this work is limited to the PLM and MES capabilities, the focus is on the items that are related to it. The following sections will provide short explanations for the main 7 item classes of Odoo's manufacturing process since its basic understanding is helpful for the reader to follow the simulation. These are represented in the following diagram (Figure 21). Other items that are external to the manufacturing procedure will be presented throughout the simulation.

在Odoo中，有幾種類型的專案類（有些包含大量元數據，有些保存很少），它們都具有不同程度的關係和集成。由於這項工作的範圍僅限於 PLM 和 MES 功能，因此重點放在與之相關的專案上。以下各節將對Odoo製造過程的主要7個專案類別進行簡短的解釋，因為它的基本理解有助於讀者遵循類比。如下圖所示（圖 21）。製造過程外部的其他專案將在整個模擬過程中呈現。

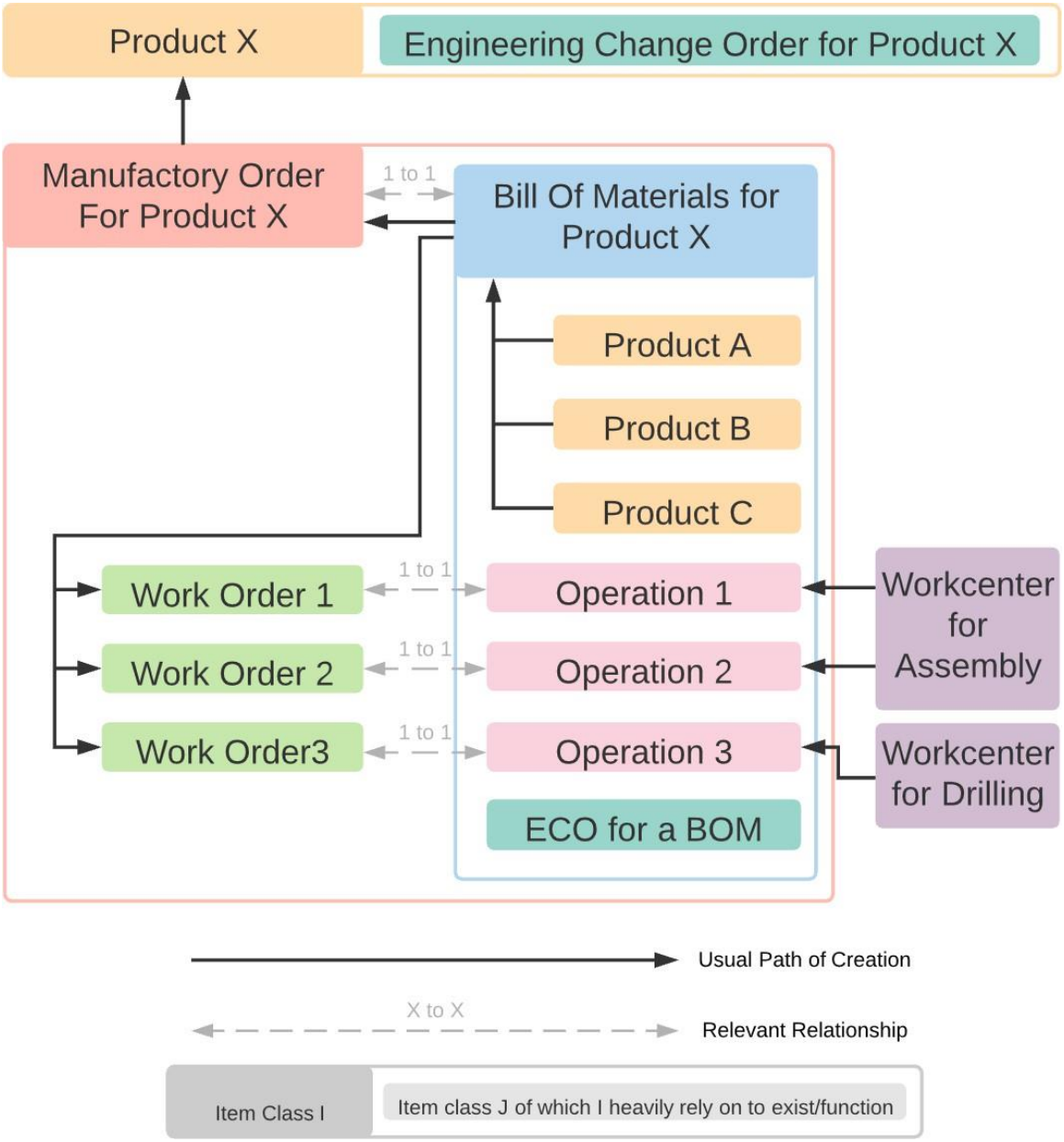

Figure 21 Simplified Item relation diagram to the manufacturing of a product X
圖 21 簡化物料與產品製造的關係圖 X

1.1.2.1. Product Item
產品專案

Every material, component or product is characterized by a PRODUCT type class that is held and mainly managed within the Inventory application of Odoo. That means that within the system product production is dependent on the availability of other products that are either bought as they are or manufactured from another products (Figure 22), i.e., raw

materials are considered products as well, more specifically products that are purchased and then included in the BOM's to manufacture other products. This is considered the main item class since it is both the source and the goal of manufacturing.

每種材料、元件或產品都以產品類型類為特徵，該類主要在Odoo的庫存應用程式中保存和管理。這意味著在系統內，產品生產取決於其他產品的可用性，這些產品要麼按原樣購買，要麼從其他產品製造（圖22），即原材料也被視為產品，更具體地說，是購買的產品和 然後包含在 BOM 中以製造其他產品。這被認為是主要專案類，因為它既是製造的來源，也是製造的目標。

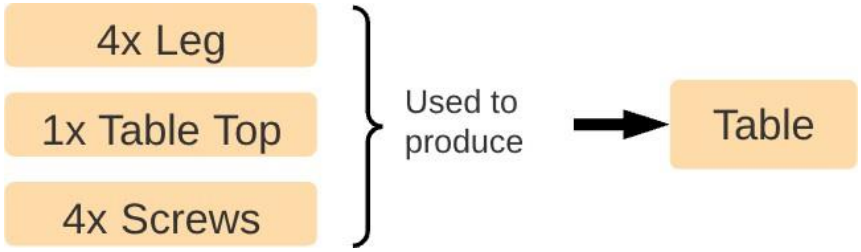

Figure 22 simplified Product relation diagram

圖22簡化產品關係圖

1.1.2.2. Operation item class and workcenter item class 工序物料類和工作中心物料類

The operation item is representative of a manufacturing operation that is required to transform components or raw materials into a product or new component while the workcenter item represents the place at which the operation takes place, e.g., a sanding wood will be carried out in a sanding station (Figure 23) that has the proper equipment. The workcenter is eventually used in Odoo as a time/equipment management tool in its production planning. Basically, when the production center is at full capacity it puts following processes on hold or redirects the processes to an alternative workcenter. The operation item is also responsible for holding the instruction files that are consulted during production.

工序專案代表將元件或原材料轉化為產品或新元件所需的製造工序，而工作中心專案則代表工序發生的地方，例如，在具有適當設備的砂光站（圖 23）中進行打磨木材。該工作中心最終在Odoo中用作其生產計劃中的時間/設備管理工具。基本上，當生產中心滿負荷運轉時，它會暫停後續流程或將流程重定向到備用工作中心。操作項還負責保存生產過程中查閱的指令檔。

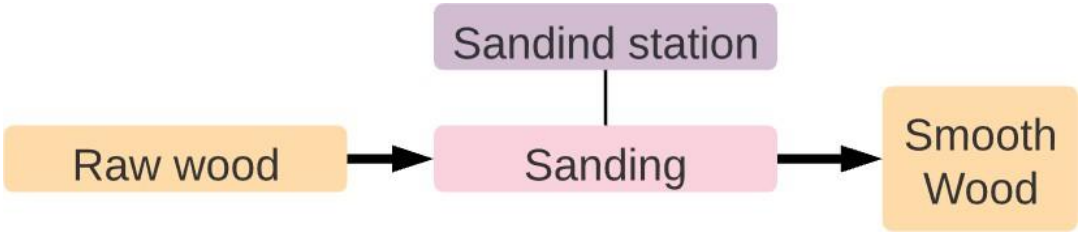

Figure 23 Simplified Operation diagram
圖23簡化操作圖

1.1.2.3. The Bill of Materials item class
物料清單項類

The Bill of Materials is a list of components necessary to build a product. In Odoo, however, the BOM is best described by what PLM would consider the virtual representation of the production process. That might seem counter intuitive at first considering the previously mentioned operation item class, but in fact since the BOM is a compound item it points directly to all item types necessary to produce the end product (Figure 24). For example, let's say that to build a product it is required 3 different parts and 4 different operations; the BOM of said product would list all of them as well as specify the order in which these are utilized.

物料清單是構建產品所需的元件清單。然而，在Odoo中，BOM最好用PLM認為生產過程的虛擬表示來描述。考慮到前面提到的工序物料類，乍一看似乎有悖常理，但實際上，由於物料清單是複合物料，它直接指向生產最終產品所需的所有物料類型（圖 24）。例如，假設要構建一個產品，需要 3 個不同的部件和 4 個不同的操作;所述產品的BOM將列出所有這些產品，並指定它們的使用順序。

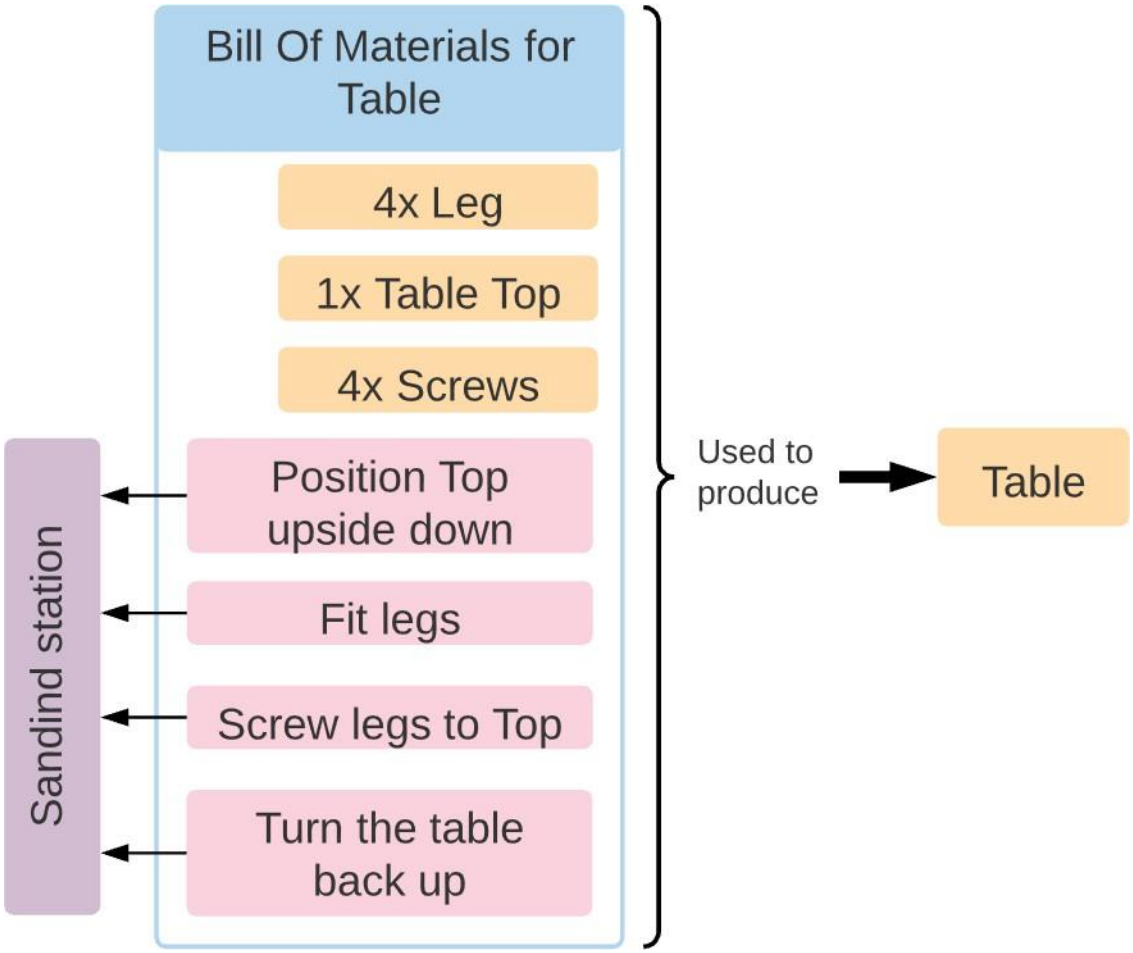

Figure 24 Simplified BOM diagram

圖 24 簡化的 BOM 圖

1.1.2.4. Manufacturing order item class and work order item class 製造訂單項類和工作訂單項類

Along the standard items that are considered within Odoo, orders are the ones that represent commencement within the system. They are signaling that a change is taking place somehow and somewhere. In the case of a manufacturing order it represents the order to manufacture N number of specific products using it's BOM as a base. It is as consequence of that MO that work orders are automatically generated by Odoo (one for each necessary operation listed in the BOM) and allocated throughout available necessary workcenters (Figure 25).

在 Odoo 中考慮的標準專案中，訂單是代表系統內開始的訂單。他們發出信號，表明正在以某種方式和某個地方發生變化。對於製造訂單，它表示使用其物料清單作為基礎製造 N 個特定產品的訂單。正是由於該 MO，Odoo 會自動生成工單（BOM 中列出的每個必要操作一個），並在整個可用的必要工作中心分配（圖 25）。

The work order is the main form in which the manufacturing operators interact with Odoo, it presents all the instructions specified by the operation item, as well as control towards its completion. When a WO takes place the operator signals through the interface its beginning, its completion and even any quality control check points required while the system keeps track of timing and performance (Figure 26). Once all WO are done the MO can be declared done and the materials and components specified in the BOM are consumed and the N copies of the product is added to inventory. All that makes the work order a central piece as far as MES is concerned.

工單是製造操作員與 Odoo 交互的主要形式，它呈現操作項指定的所有指令，以及對其完成的控制。當 WO 發生時，操作員通過介面發出信號，發出信號，發出信號，完成所有 WO 后，可以聲明 MO 完成，並消耗 BOM 中指定的材料和元件，並將產品的 N 份添加到庫存中。所有這些都使工單成為 MES 的核心部分。

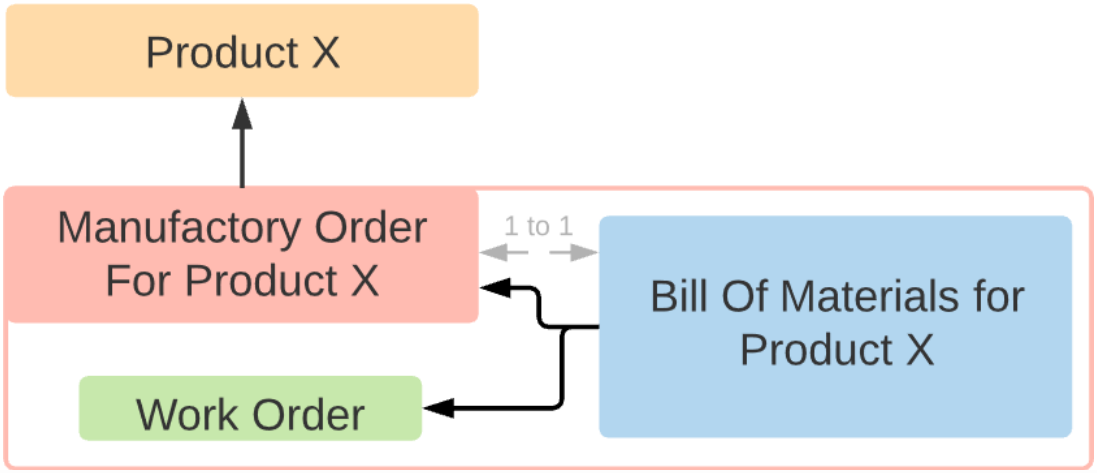

Figure 25 Simplified orders diagram
圖25簡化訂單圖

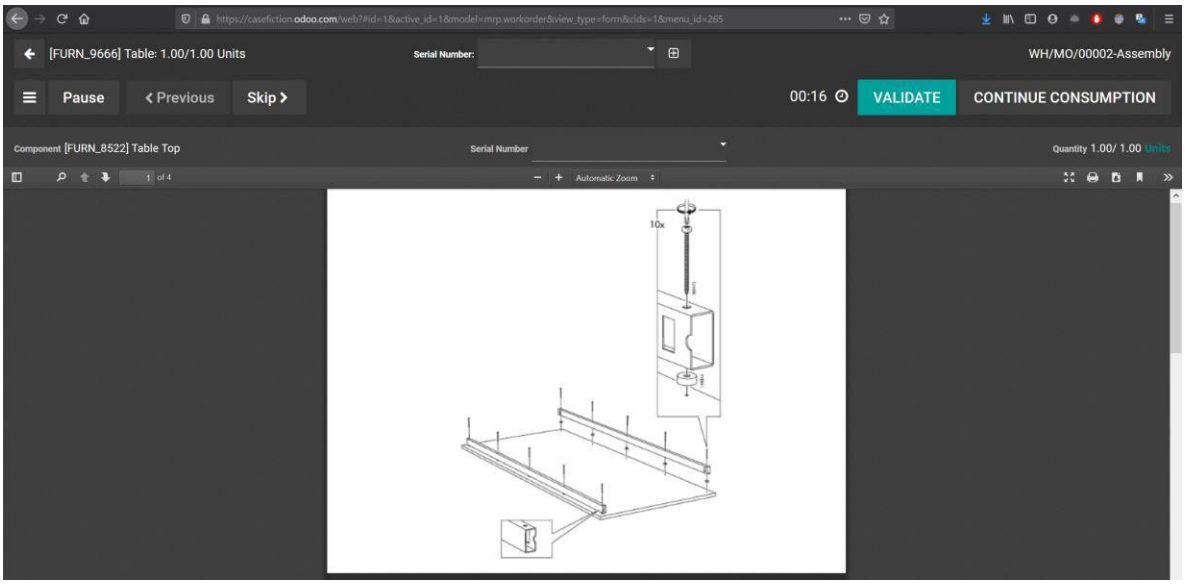

Figure 26 Operator interface during the WO

圖26 WO操作介面

1.1.2.5. The engineering change order
工程變更單

As explained in the beginning of chapter 2 the Odoo management software considers PLM mainly as a tool for tracking change and improvements. Its application module is external to the normal flow of manufacturing but acts as an expansion to it. Its focal item class is the Engineering Change Order (ECO).

如第2章開頭所述，Odoo管理軟體主要將PLM視為跟蹤變更和改進的工具。它的應用模組是正常製造流程的外部，但充當其擴展。其重點專案類是工程變更單（ECO）。

An ECO is an item class that outlines the proposed changes to the product or the parts that would be affected by the change. In other words, is a central information hub for everyone associated with a given product.

ECO 是一個專案類，它概述了對產品或將受更改影響的部件的擬議更改。換句話說，是與給定產品相關的每個人的中央資訊中心。

The idea is to signal the need for change to a product item or a BOM item, hold the files that are relevant to the change and apply the change or at least signal that the change has been implemented, all while keeping the history of al the previous changes. All very useful in the future and serve as a process to streamline product development and help improve products/production.

這個想法是發出需要更改產品項或 BOM 項的信號，保留與更改相關的檔並應用更改，或者至少發出已實施更改的信號，同時保留所有先前更改的歷史記錄。所有這些都在未來非常有用，並作為簡化產品開發和說明改進產品/生產的過程。

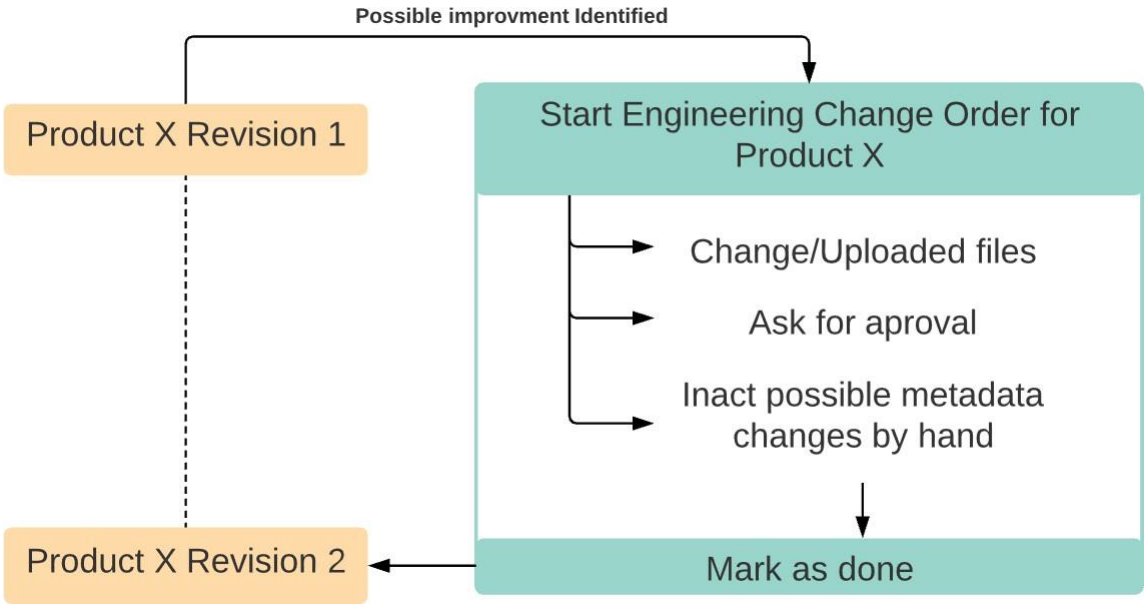

Figure 27 Simplified ECO function diagram
圖27簡化的ECO功能圖

1.2. Starting the simulation
開始類比

1.2.1. Software option chosen for the simulation
為模擬選擇的軟體選項

For this simulation, it has been decided that the best evaluation of the Odoo software would be through its online web-based service. The reasons for such choice instead of using the community edition of the software are as follows:

對於此類比，已決定通過其基於Web的在線服務對Odoo軟體進行最佳評估。選擇不使用該軟體的社區版的原因如下

- The practicality of using a web-based service as oppose to administrate a server locally or remotely. Although the community application was tested as part of the research for this work and has been judged to be a very beginner friendly server application the fact of the matter is that hosting a server is, on its own, a job that requires experience and knowledge. There has been a shift of the market regarding this sort of application towards product as a service and with good reason. At the

time this thesis is being written the COVID-19 pandemic is forcing a lot of employees to work remotely and making clear to the market that IT is not a simple job and that a web service is an attractive option.
使用基於 Web 的服務作為本地或遠端管理伺服器的實用性。儘管社區應用程式作為這項工作研究的一部分進行了測試，並且被認為是一個非常初學者友好的伺服器應用程式，但事實是，託管伺服器本身就是一項需要經驗和知識的工作。關於這種應用，市場已經轉向產品即服務，這是有充分理由的。在撰寫本文時，COVID-19 大流行迫使許多員工遠端工作，並向市場表明 IT 不是一項簡單的工作，Web 服務是一個有吸引力的選擇

- Lack of official Odoo PLM application for the community edition of Odoo. Although there is a substantial repertoire of community made applications for the community edition of Odoo the organization, description, integration, and support of this applications are spotted at best. Rather than rely on applications that might not keep up with the main software it was decided that it would be a fairer to the platform evaluation if it was based on official applications. I.e. it would be very unproductive to slap together a free solution just to depend on luck regarding how it is supported on the future. PLM is the focus here, so this is an unnegotiable situation.
缺少Odoo社區版的官方OdooPLM應用程式。儘管Odoo的社區版有大量的社區應用程式，但這些應用程式的組織、描述、集成和支援充其量只能被發現。與其依賴可能跟不上主要軟體的應用程式，不如決定如果基於官方應用程式，對平臺評估會更公平。也就是說，僅僅依靠運氣來決定未來如何支援它，就拼湊出一個免費的解決方案是非常徒勞的。PLM 是這裡的重點，所以這是一個不容置疑的情況。

At the time of writing this work, Odoo allows you to select one of its extra features like PLM and use it for free for an indefinite amount of time on their cloud hosted servers. This is a very attractive option if the only focus of this work was PLM and manufacturing. However, the MES aspect of this work is highly dependent of other applications of Odoo which means that there is very little that can be done. To this end the experiment was carried out in the trial version of Odoo enterprise which allow the user to use the system without storage or application limitations for a period of 14 days all hosted in Odoo cloud servers (Figure 17).

在撰寫本文時，Odoo允許您選擇其額外功能之一，例如PLM，並在其雲託管伺服器上無限期免費使用它。如果這項工作的唯一重點是 PLM 和製造，這是一個非常有吸引力的選擇。然而，這項工作的MES方面高度依賴於Odoo的其他應用，這意味著可以做的很少。為此，實驗是在Odoo企業版的試用版中進行的，它允許使用者在14

天內使用系統，而沒有存儲或應用程式限制，全部託管在Odoo雲伺服器中（圖17）。

1.2.2. Setings details that are relevant
相關的設置細節

A few details regarding the settings of Odoo are relevant to the proper function of its manufacturing functionalities. Namely enabling work orders in the manufacturing settings is an obligatory step for proper use of both work order items, workcenter items and operation items.

有關Odoo設置的一些細節與其製造功能的正常功能有關。也就是說，在製造設置中啟用工作訂單是正確使用工作訂單項、工作中心項和工序項的必要步驟。

An assumption made for this work is that this is a holdover of the ERP origins of the software because it is rather unintuitive to not have this setting enabled by default if you are going to use Odoo to make any serious control on manufacturing. Regardless as of Odoo enterprise v14 this option can be set in the Settings > Manufacturing > Operations > Work Orders (Figure 28).

為這項工作所做的一個假設是，這是軟體ERP起源的保留，因為如果您要使用Odoo對製造進行任何嚴格的控制，那麼默認情況下不啟用此設置是相當不直觀的。從 Odoo enterprise v14 開始，可以在 Settings > Manufacturing > Operations > Work Orders 中設置此選項（圖 28）。

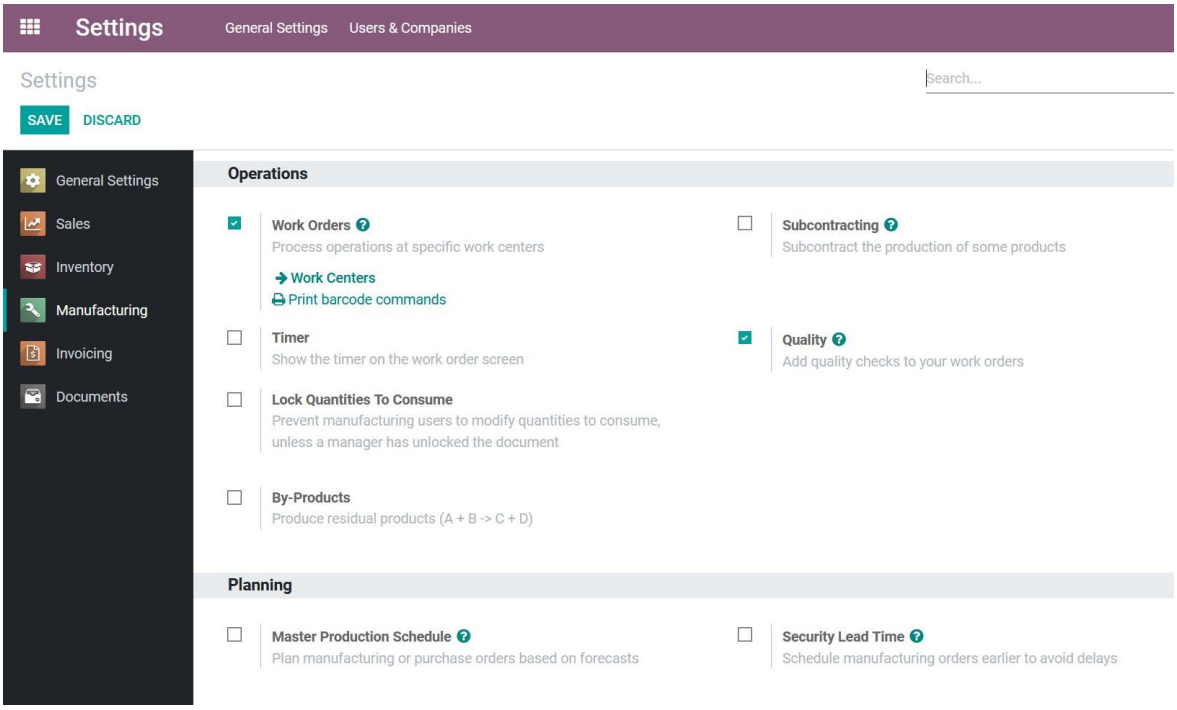

Figure 28 Screenshot of the specific setting to be enabled
圖28 要啟用的特定設置截圖

1.3. Building the company structure
構建公司結構

1.3.1. Users
使用者

Users are set and invited through the setting menu. It is possible to assign different levels of permissions regarding different aspects of the business operation. Messaging, permissions,

通過設置功能表設置和邀請使用者。可以針對業務運營的不同方面分配不同級別的許可權。消息傳遞、許可權、