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.

然後被包含在製造其他產品的 BOM 中。這被認為是主要項目類，因為它既是製造的來源，也是目標。

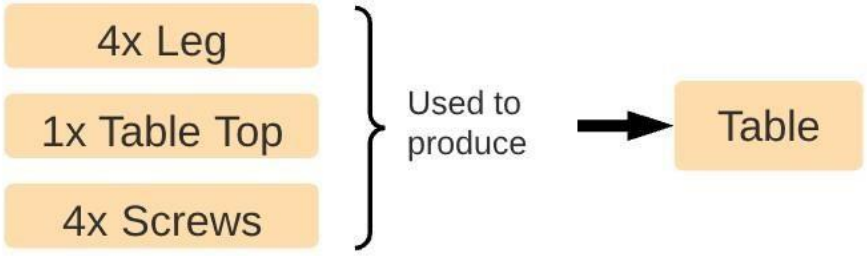

Figure 22 simplified Product relation diagram

第 22 圖 簡化的產品關係圖

5.1.3.2. Operation item class and workcenter item class

5.1.3.2. 操作項目類和工作中心項目類

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.

操作項目代表了一個製造操作，該操作需要將零件或原材料轉化為產品或新零件，而工作中心項目則代表了進行該操作的地點，例如，對木材進行砂紙打磨將在具有適當設備的砂紙打磨站（見圖 23）進行。工作中心最終在 Odoo 中被用作生產計劃中的時間/設備管理工具。基本上，當生產中心處於滿負荷狀態時，它會暫停以下工序，或將工序重定向到另一個替代的工作中心。操作項目還負責保存在生產過程中參考的指導文件。

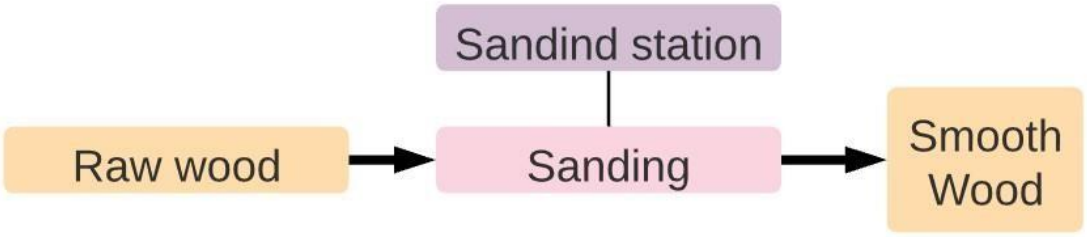

Figure 23 Simplified Operation diagram

第 23 圖 簡化的操作圖

5.1.3.3. The Bill of Materials item class

5.1.3.3. 物料清單項目類

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.

Bill of Materials（BOM）是建造產品所需零部件的清單。然而，在 Odoo 中，BOM 最好由 PLM 認為的生產過程的虛擬表示來描述。一開始，這可能看

起來有些反直覺，考慮到前面提到的操作項目類，但實際上，由於 BOM 是一個複合項目，它直接指向生產結束產品所需的所有項目類型（見圖 24）。例如，假設建造一個產品需要 3 個不同的零件和 4 個不同的操作; 該產品的 BOM 將列出所有這些，並指定它們使用的順序。

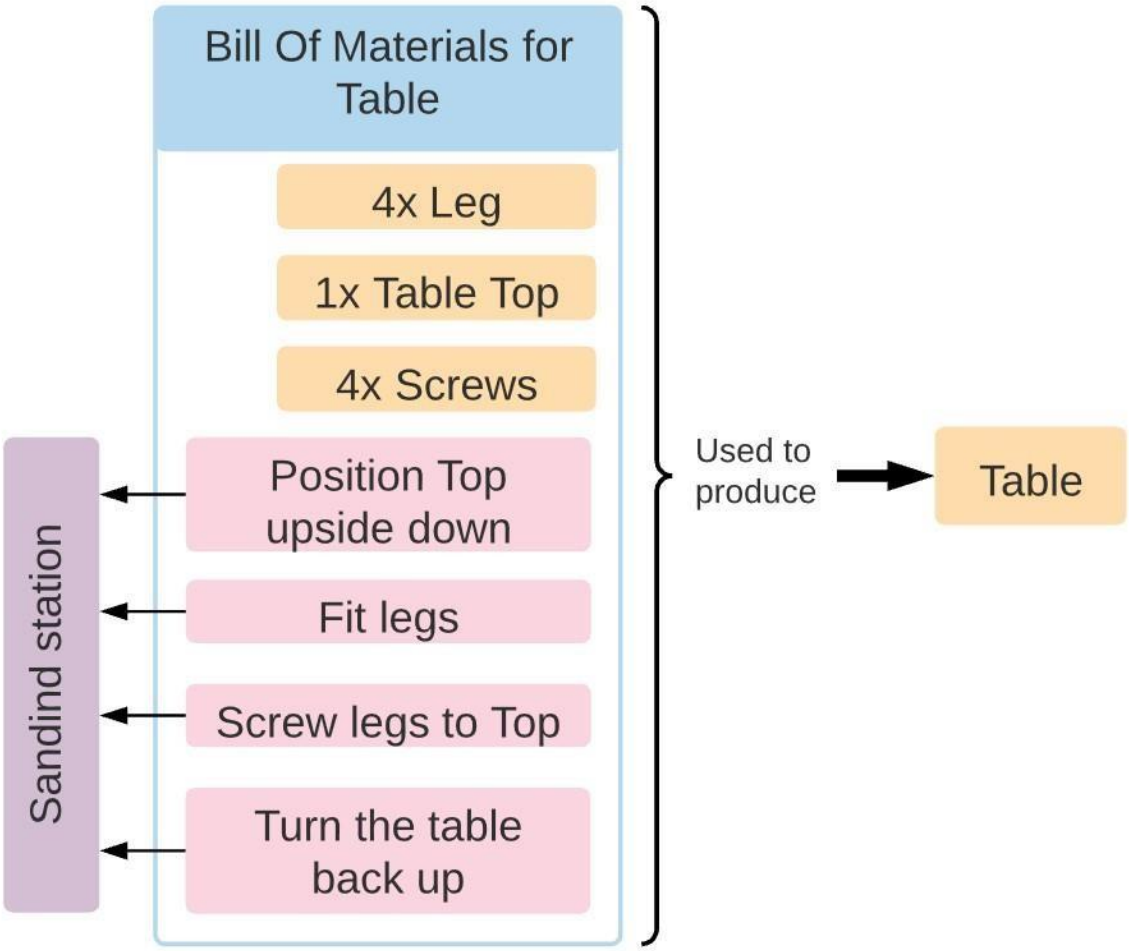

Figure 24 Simplified BOM diagram

第 24 圖 簡化的 BOM 圖

5.1.3.4. Manufacturing order item class and work order item class

5.1.3.4. 製造訂單項目類和工單項目類

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，標準項目中被考慮的其中一種是訂單，它們代表了系統中的開始。它們發出信號，表明某種變化正在某個地方發生。對於製造訂單，它代表了使用其 BOM 作為基礎製造特定產品的 N 個數量的訂單。正是由於該製造訂單，Odoo 會自動生成工作訂單（BOM 中列出的每個必要操作都對應一個）並分配到可用的必要工作中心（見圖 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.

工作訂單是製造操作員與 Odoo 互動的主要形式，它呈現了操作項目指定的所有指令，以及對其完成的控制。當工作訂單進行時，操作員通過界面信號其開始、完成甚至任何質量控制檢查點，而系統則跟蹤時間和性能（見圖 26）。一旦所有工作訂單完成，製造訂單就可以宣布完成，BOM 中指定的材料和零件被消耗，並且 N 份產品被添加到庫存中。所有這些使得工作訂單在 MES 方面成為一個核心組件。

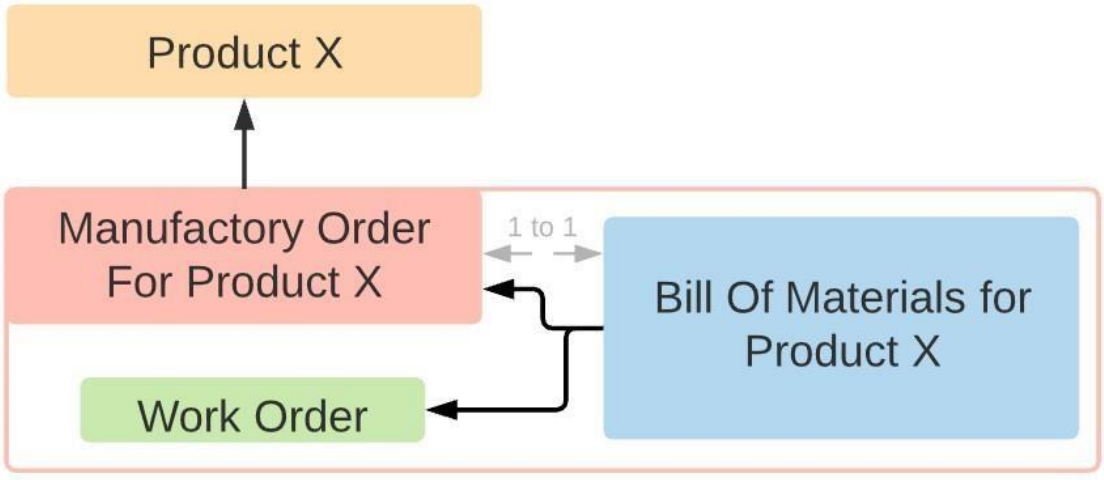

Figure 25 Simplified orders diagram

第 25 圖 簡化的訂單圖

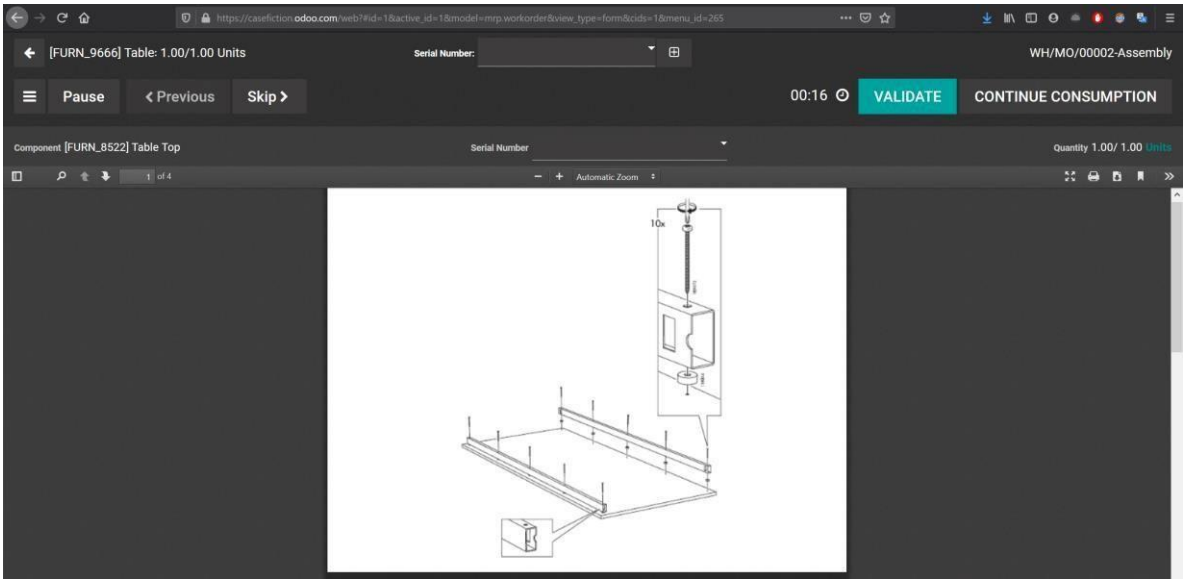

Figure 26 Operator interface during the WO

第 26 圖 工單期間的操作界面

5.1.3.5. The engineering change order

5.1.3.5. 工程變更訂單

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).

正如在第 2 章開頭所解釋的，Odoo 管理軟件主要將 PLM 視為跟蹤變更和改進的工具。其應用模塊是外部於製造的正常流程，但作為其擴展。其焦點項目類是工程變更訂單（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.

工程變更訂單（ECO）是一種項目類，概述了對產品或將受到變更影響的部
件的建議變更。換句話說，它是與特定產品有關的所有人的中央信息中心。

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.

這個想法是向產品項目或 BOM 項目發出變更需求信號，保存與變更相關的文件，並應用變更，或者至少表示變更已經實施，同時保留所有先前變更的歷史記錄。這些都非常有用，可以作為未來的參考，並作為一個流程，以簡化產品開發，幫助改進產品/生產。

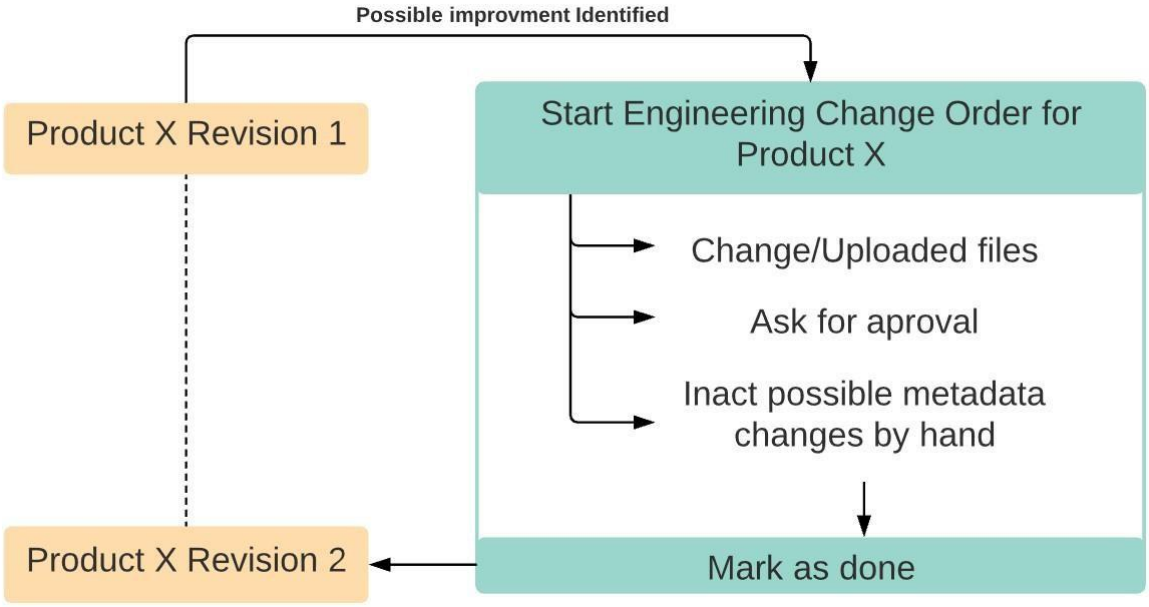

Figure 27 Simplified ECO function diagram

第 27 圖 簡化的 ECO 功能圖

5.2. Starting the simulation

5.2. 開始模擬

5.2.1. Software option chosen for the simulation

5.2.1. 模擬所選擇的軟件選項

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:

對於這個模擬，決定評估 Odoo 軟件最好的方式是通過其在線網絡服務。與使用軟件的社區版相比，選擇這樣的原因如下：

- 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 的服務的實用性，與在本地或遠程管理服務器相比。儘管社區應用程序作為這項工作的研究的一部分進行了測試，並且被認為是一個非常適合初學者的服務器應用程序，但事實是，單獨擁有一個服務器是一項需要經驗和知識的工作。市場對於這類應用程序已經發生了變化，趨向於產品作為服務，這是有充分理由的。在寫作這篇論文的時候，COVID-19 大流行迫使許多員工遠程工作，並且向市場明確表明 IT 不是一項簡單的工作，Web 服務是一個吸引人的選擇。

- 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.

- Odoo 社區版缺乏官方的 Odoo PLM 應用程序。儘管 Odoo 社區版有大量由社區製作的應用程序，但這些應用程序的組織、描述、集成和支持都很零散。與其依賴可能跟不上主要軟件的應用程序，不如基於官方應用程序進行平台評估更公平。換句話說，隨意組合一個免費解決方案，只是依靠將來的支持是非常低效的。PLM 是這裡的焦點，因此這是一個不可商議的情況。

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).

在撰寫這份工作的時候，Odoo 允許您選擇其額外功能之一，如 PLM，在其雲端托管的服務器上無限期免費使用。如果這份工作的唯一重點是 PLM 和製造，這是一個非常有吸引力的選擇。然而，這份工作的 MES 方面高度依賴於 Odoo 的其他應用程序，這意味著幾乎沒有什麼可以做的。為此，實驗是在 Odoo 企業試用版中進行的，該試用版允許用戶在 Odoo 雲端服務器上無限制地使用系統，沒有存儲或應用程序限制，該試用期為 14 天（見圖 17）。

5.2.2. Setings details that are relevant

5.2.2. 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.

Odoo 的設置中有一些細節與其製造功能的正確運作密切相關。特別是在製造設置中啟用工單是一個必要的步驟，以便正確使用工單項目、工作中心項目和操作項目。

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).

這項工作的假設是，這是軟件的 ERP 起源的一個遺留問題，因為如果您打算使用 Odoo 來對製造進行任何嚴肅的控制，不啟用此設置實在缺乏直觀性。儘管如此，從 Odoo 企業版 v14 開始，這個選項可以在「設置」>「製造」>「操作」>「工單」中設置（見圖 28）。

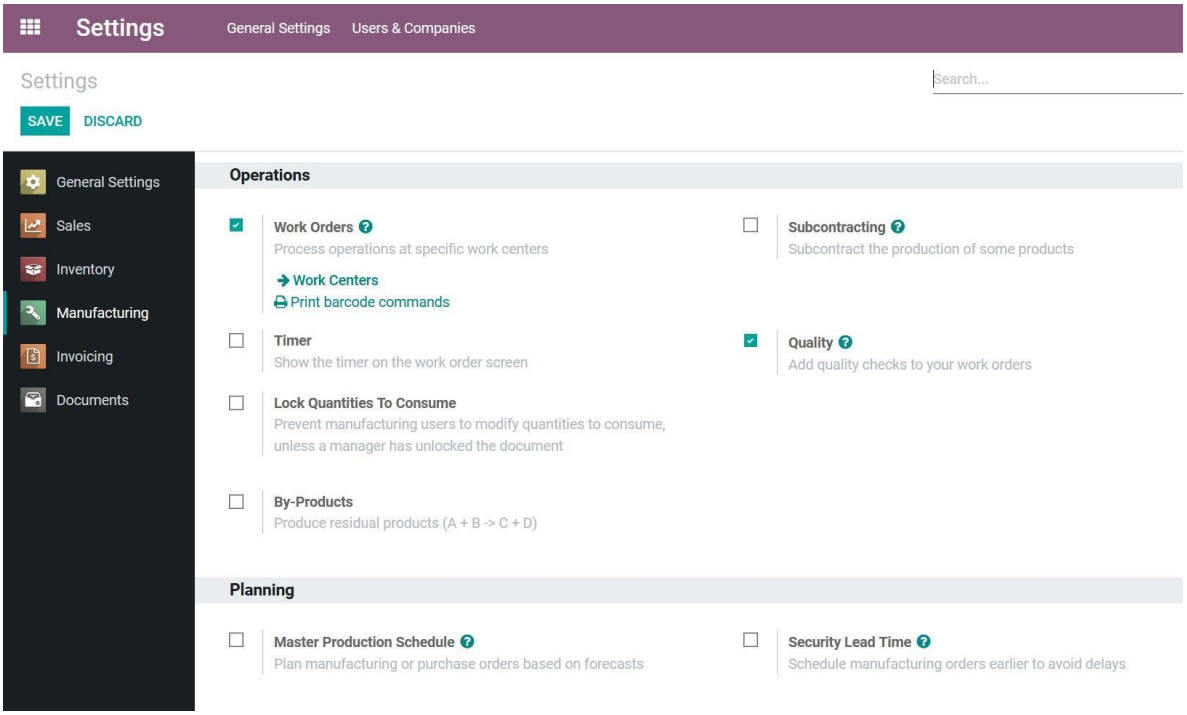

Figure 28 Screenshot of the specific setting to be enabled

第 28 圖 啟用的具體設置的截圖

5.3. Building the company structure

5.3. 建立公司結構

5.3.1. Users

5.3.1. 用戶

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, approvals, responsibilities are all assigned into a user. This is very convenient and can fall within the category of virtual item class even if it has limited use in the scope of manufacturing. Their creation is not strictly necessary, the software would run just fine having just me as a user with full administrator credentials, but for this simulation, 5 users were created as listed below to represent different employees within the company. The following (Figure 29) is a screenshot of my user account item and its 'Asses Rights' followed by one of the fictional users being created

for the company (Figure 30). 用戶通過設置菜單設置並邀請。可以對業務運作的不同方面分配不同級別的權限。消息、權限、批准、責任都分配給用戶。這非常方便，即使在製造範圍內使用有限，也可以歸類為虛擬項目類別。嚴格來說，它們的創建並不是必需的，軟件只需我作為具有完整管理員憑據的用戶運行即可。但是為了這個模擬，創建了以下 5 個用戶，代表公司內的不同員工。以下（圖 29）是我的用戶帳戶項目及其"評估權利"的屏幕截圖，接下來是為公司創建的一個虛構用戶（圖 30）。

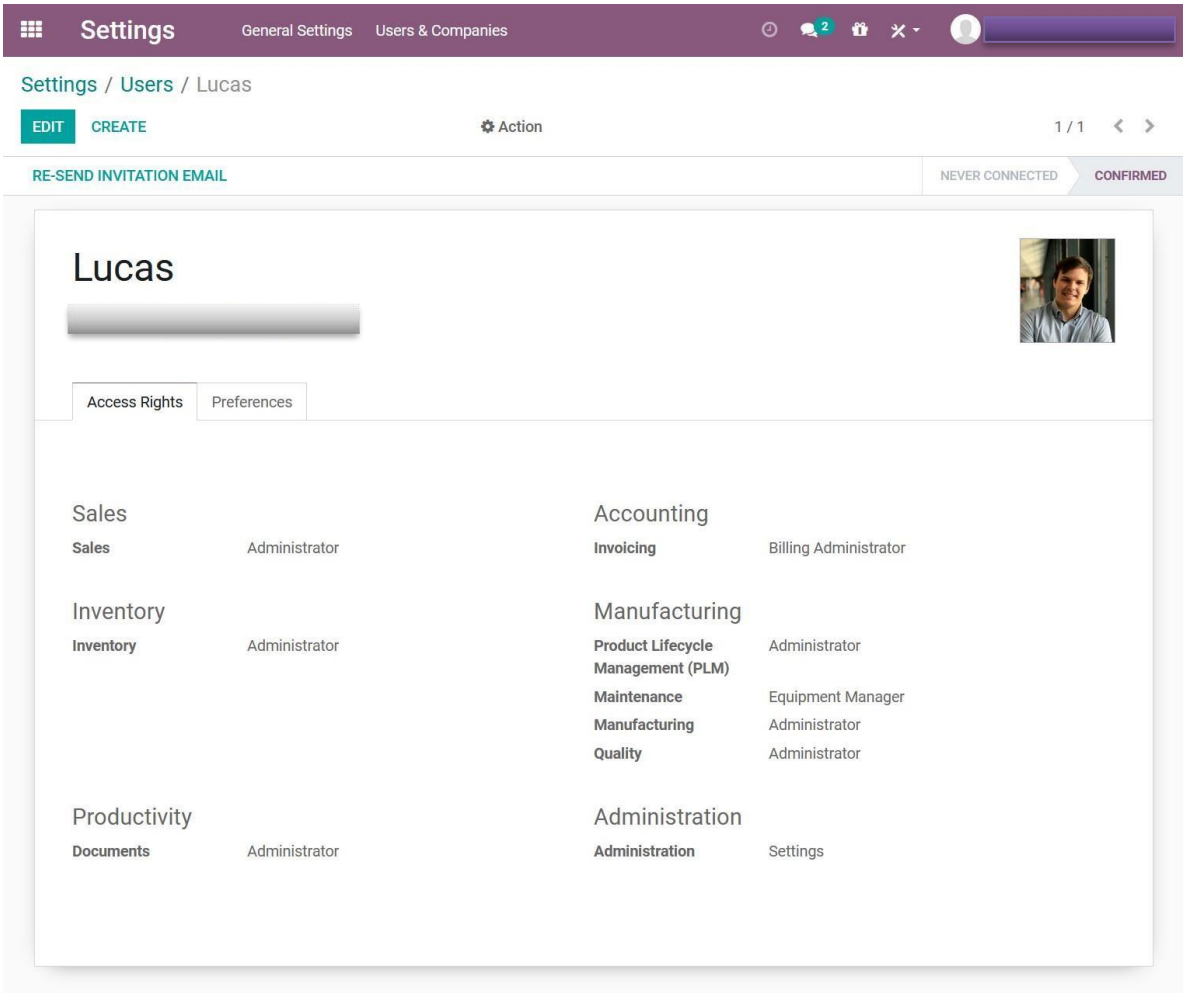

Figure 29 Screenshot of user account interface

第 29 圖 用戶帳戶界面的截圖

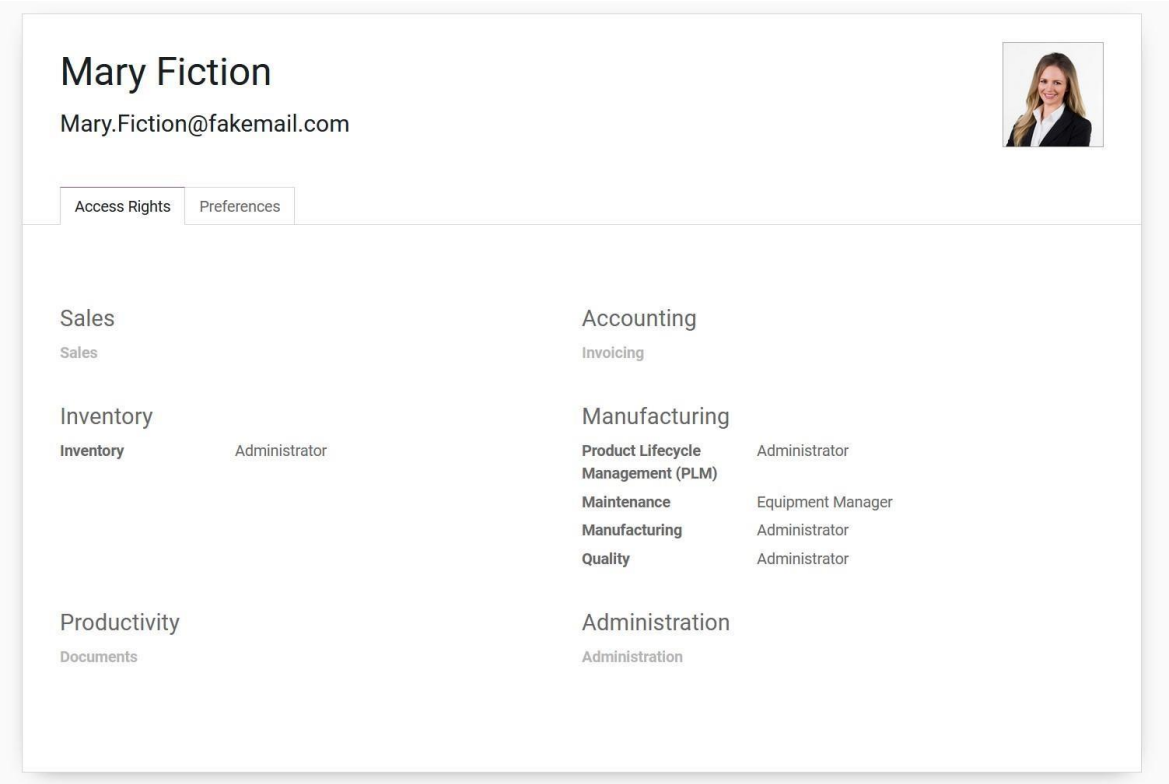

Figure 30 Screenshot of second user account interface

第 30 圖 第二個用戶帳戶界面的截圖

It is nice to point out how the two differ in access rights. Mary Fiction has been created in this example as an engineer and therefore most of her permissions are around the manufacturing procedure while she is denied access to other parts like Sales or Accounting.

很高興指出兩者在訪問權限上的差異。在此示例中，Mary Fiction 被創建為一名工程師，因此她的大多數權限都是圍繞製造程序，而她被拒絕訪問其他部分，如銷售或會計。

5.3.2. Workcenters and Equipement

5.3.2. 工作中心和設備

Workcenters are quite flexible within Odoo in the sense that they can be changed and expanded as needed. One could create the workcenters after creating the product items to allow for reorganization of the shop floor once you gained some perspective on what the products will be in the end. However, for most scenarios this seems unrealistic since the

workcenters are more rigid structures in the real world - they don't change as much as the products since they tend to hold heavy machinery.

在 Odoo 中，工作中心非常靈活，因為它們可以根據需要進行更改和擴展。可以在創建產品項目之後創建工作中心，以便在獲得一些關於最終產品的視角後重新組織車間。然而，對於大多數情況來說，這似乎不太現實，因為在現實世界中，工作中心是更為固定的結構 - 它們不像產品那樣經常變化，因為它們往往容納重型機械。

In this simulation it was considered that the company already has 3 workcenters from the get-go and therefore the workcenters and machinery were created beforehand. This is more useful for possible readers interested in implementing Odoo as well as saving sometime.

在這個模擬中，考慮到公司從一開始就已經擁有 3 個工作中心，因此工作中心和機械是事先創建的。這對於有興趣實施 Odoo 以及節省時間的潛在讀者來說更加有用。

We begin by creating the equipment we have. This is an item class that emphasizes in maintenance organization. The application responsible for managing equipment is the Maintenance App. The following image is an example of how Odoo portrays a 3D printer equipment item (Figure 31).

我們首先創建我們擁有的設備。這是一個強調維護組織的項目類別。負責管理設備的應用程序是維護應用程序。下圖是 Odoo 展示 3D 打印機設備項目的示例（見圖 31）。

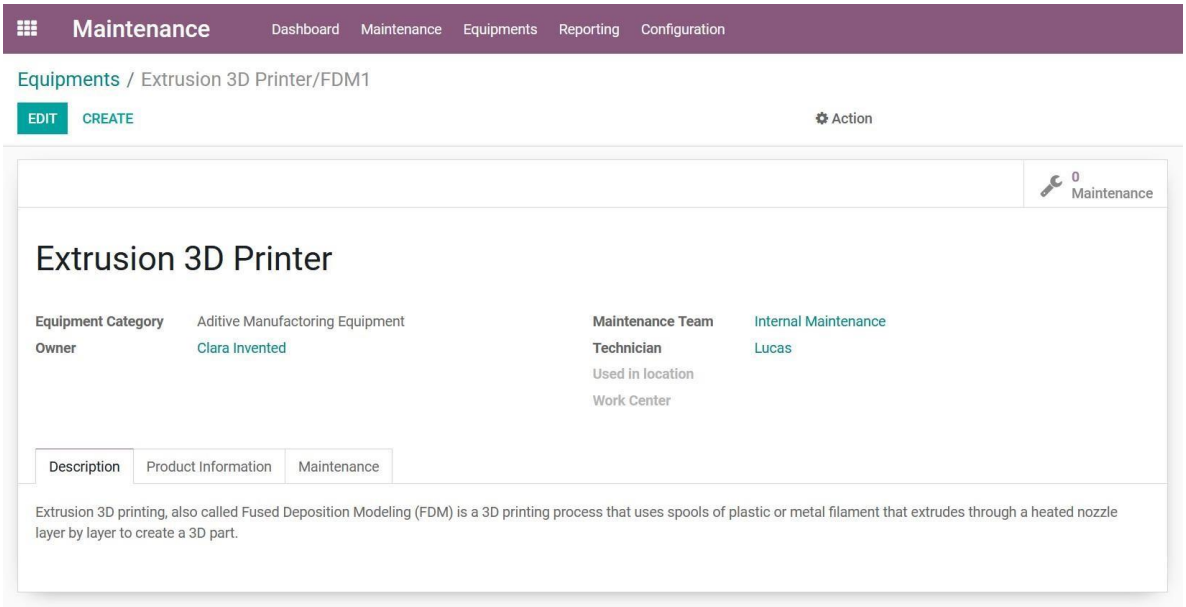

Figure 31 Odoo 3D printer equipment item

第 31 圖 Odoo 3D 打印機設備項

In addition to this 3D printer the following equipment were created to be used throughout the development/production process (Figure 32):

除了這台 3D 打印機外，還創建了以下設備，以便在整個開發/生產過程中使用（見圖 32）：

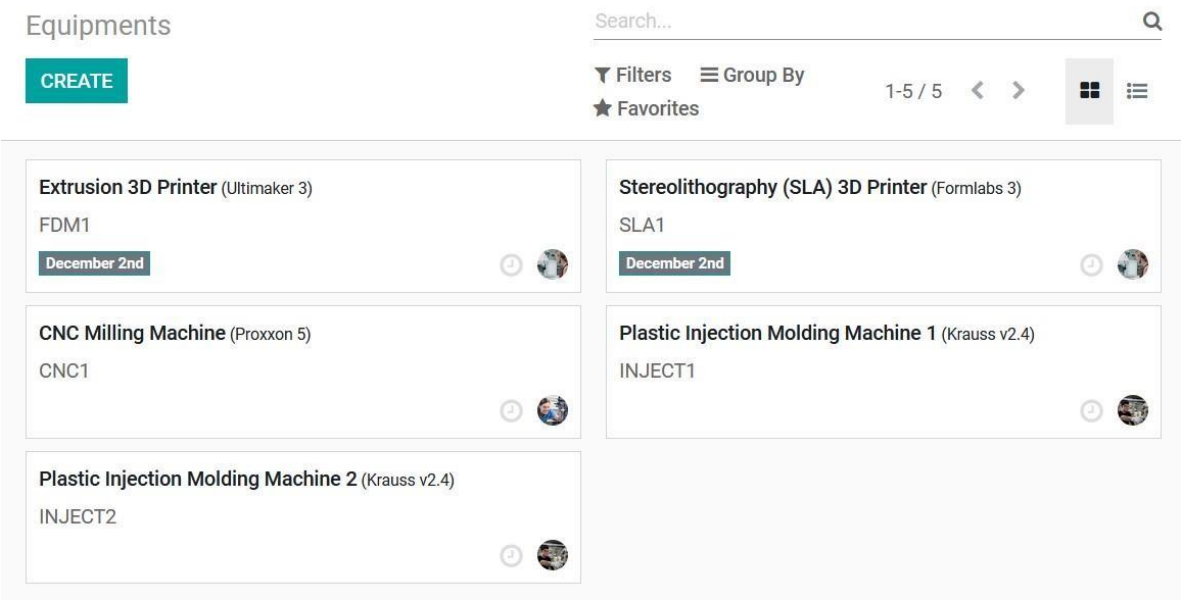

Figure 32 Overview of equipment items

This is where software limitations regarding PLM start to show. Although equipment items allow you some level of metadata (description text, responsible user, maintenance data and vendor). It does not allow for the uploading of files of any kind to be attached to the item class (machine manuals, reports etc). This is a substantial weakness, since file management is something quite unanimously considered a main aspect of PLM. This will be a recurring subject of this simulation since the number of Items that allow upload of files directly to them is limited in Odoo.

這就是軟件在產品生命周期管理（PLM）方面開始顯示限制的地方。雖然設備項目允許您添加一定程度的元數據（描述文本、負責用戶、維護數據和供應商），但它不允許上傳任何類型的文件來附加到項目類別（機器手冊、報告等）。這是一個重大的弱點，因為文件管理被普遍認為是 PLM 的主要方面之一。這將是這個模擬的一個反覆出現的主題，因為在 Odoo 中，允許直接上傳文件的項目數量有限。

Now that the equipment has been created, their workcenters can be created. It is interesting to remember that the main use of the workcenter item is management of time and cost per hour. The idea is that equipment assigned to a WC should not be used at the same time and that ideally equipment that have widely different running costs should also be in different workcenters to allow for better time/cost tracking.

現在設備已經創建，可以創建它們的工作中心了。值得記住的是，工作中心項目的主要用途是管理每小時的時間和成本。理想情況下，分配給工作中心的設備不應該同時使

用，而且具有極大不同運行成本的設備理想上也應該位於不同的工作中心，以便更好地跟踪時間/成本。

The following (Figure 33) is a an example of a workcenter item made to represent the prototyping station that is used throughout the development of the product.

以下（見圖 33）是一個工作中心項目的示例，用來代表在產品開發過程中使用的原型製作站。

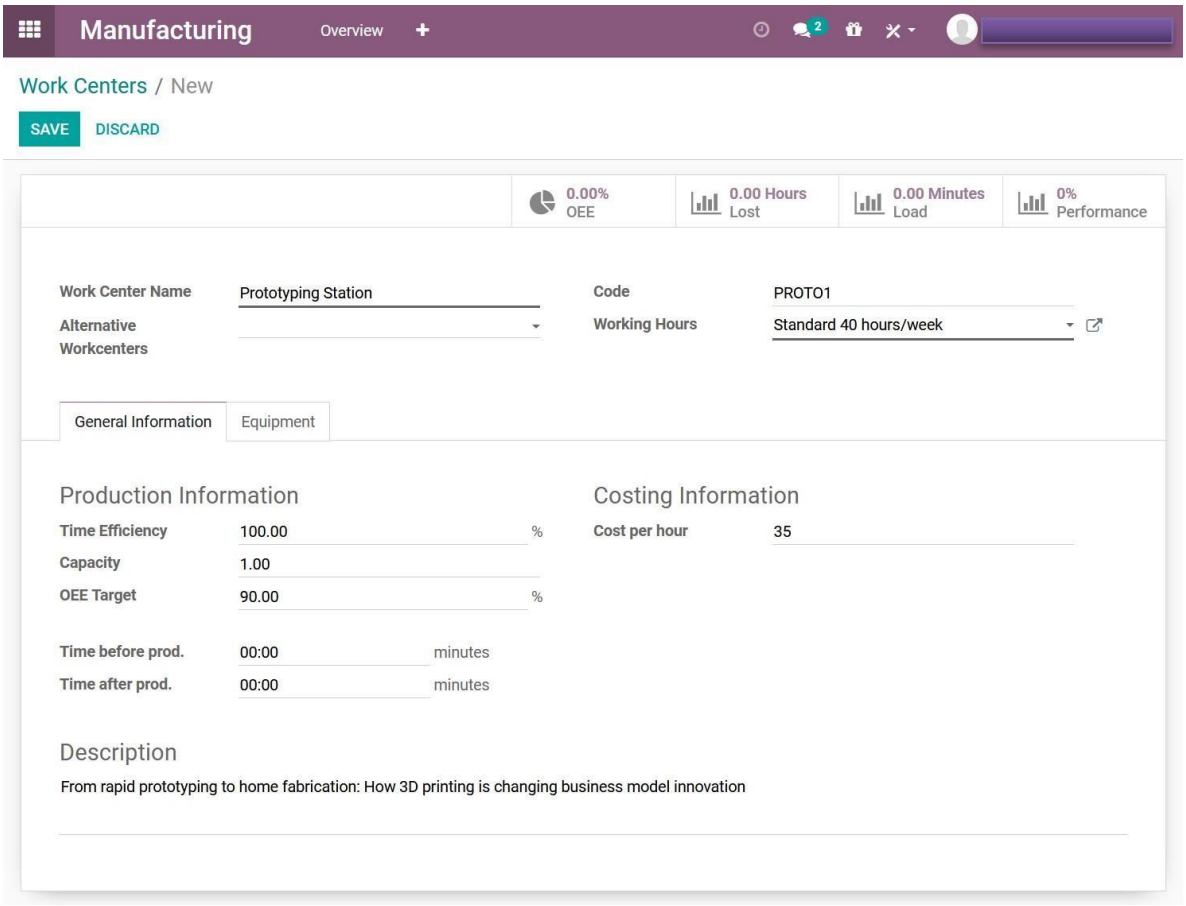

Figure 33 Odoo Prototyping Station item representation 1

第 33 图 Odoo 原型站点项目表示 1

The reader will notice that this station (Figure 34) is where the 3D printers and CNC machine are located. Usually these machines would be separated in singular workcenters because of difference in operation costs and because they are for the most part independent however for the sake of this simulation this has been considered representative enough.

讀者將注意到這個站點（見圖 34）是 3D 打印機和數控機床的所在地。通常，由於操作成本的差異以及它們在很大程度上是獨立的，這些機器會被分開放置在單獨的工作中心中。但是為了這個模擬的緣故，這被認為足夠代表性。

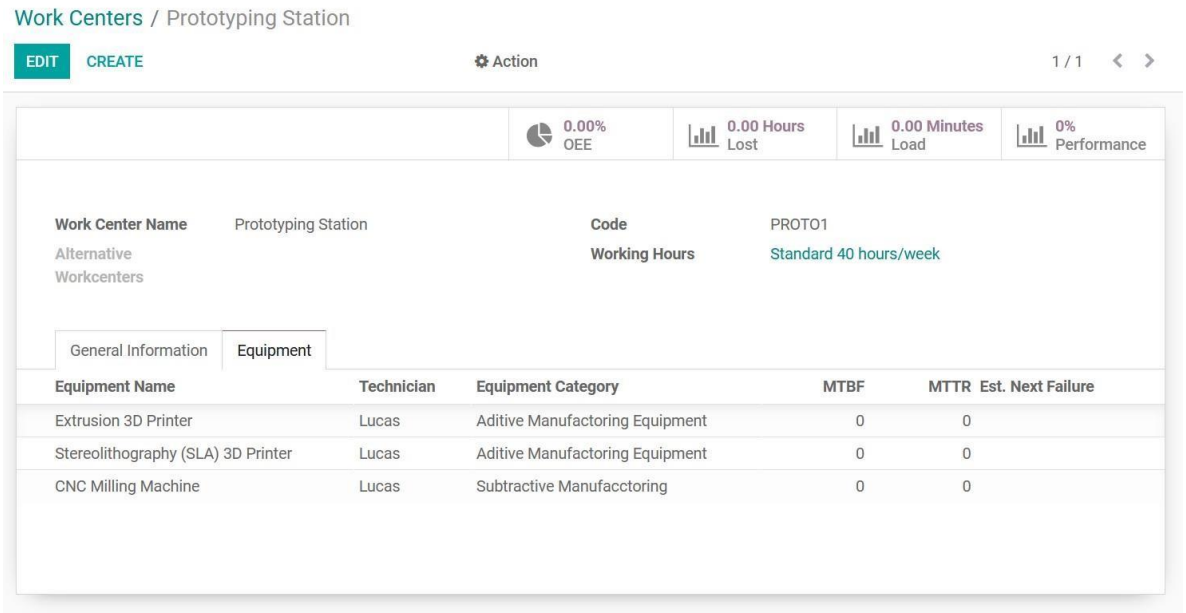

Figure 34 Prototyping Station item representation 2

第 34 图 原型站点项目表示 2

The following workcenters have been also created for the simulation and filed with the necessary equipment:

以下工作中心也已經為模擬創建，並填充了必要的設備：

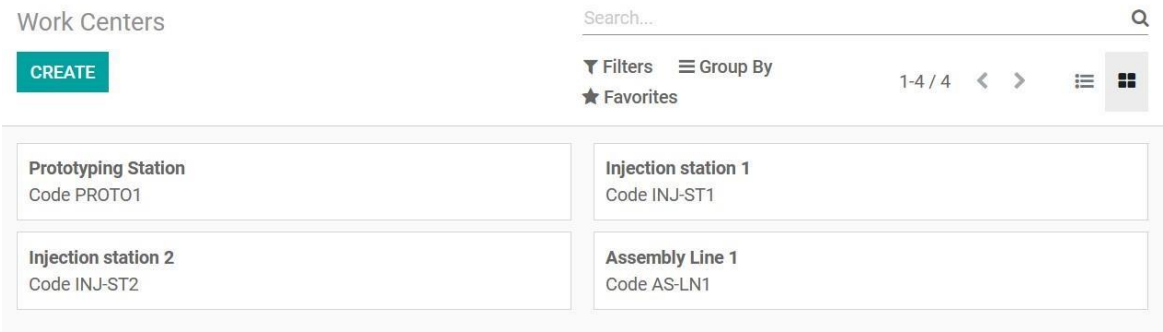

Figure 35 Overview of Workcenter items

第 35 图 工作中心项目概览

5.4. Development

5.4. 开发

Now that the basic structure of the company has been recreated in the software, it is possible to commence the simulation process. At first, the focus is on the development aspect of a brand new product using Odoo (Figure 9) most noticeably, since this is the company first product to be created, a possible use of Odoo for organizing prototyping procedure is evaluated. This include the path from idea to design and prototype production. Then once the product has reached an acceptable result as a prototype, the work regarding the development of the production process will take place. The product development is considered successful once an official production run is done. 現在公司的基本結構已經在軟件中重新建立，可以開始模擬過程了。首先，將重點放在使用 Odoo 進行全新產品開發方面（見圖 9），特別是由於這是公司第一個創建的產品，因此對於組織原型製作過程使用 Odoo 的可能性進行了評估。這包括從想法到設計和原型生產的過程。然後，一旦產品作為原型達到可接受的結果，將進行生產流程的開發工作。當正式進行生產運行時，產品開發被認為是成功的。