

The work order is the main form in which the manufacturing operators interact with Odoo,

工單是製造操作員與 Odoo 互動的主要形式，

it presents all the instructions specified by the operation item, as well as control towards its completion.

它呈現操作項指定的所有指令，以及對其完成的控制。

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).

當 WO 發生時，操作員透過介面發出開始、完成甚至所需的任何品質控制檢查點的訊號，同時系統追蹤時間和效能（圖 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.

一旦完成所有 WO，就可以聲明 MO 已完成，並消耗 BOM 中指定的材料和組件，並將產品的 N 個副本添加到庫存中。

All that makes the work order a central piece as far as MES is concerned.

所有這些使得工單成為 MES 的核心部分。

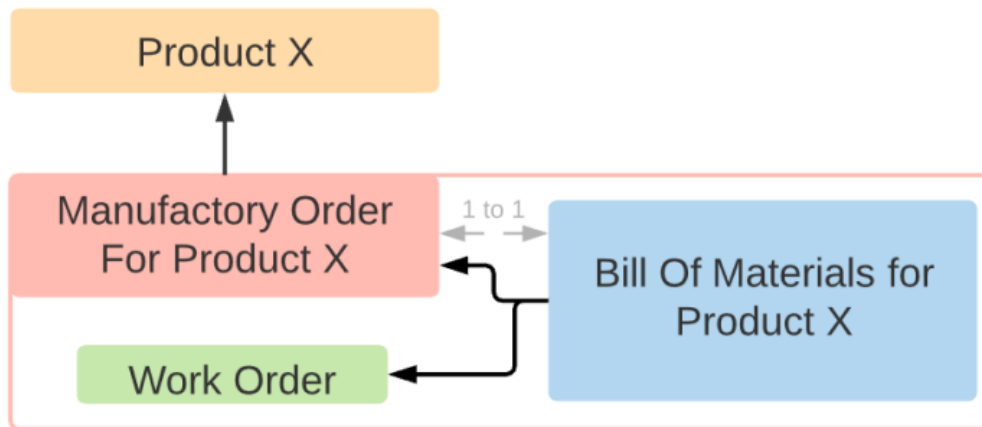


Figure 25 Simplified orders diagram

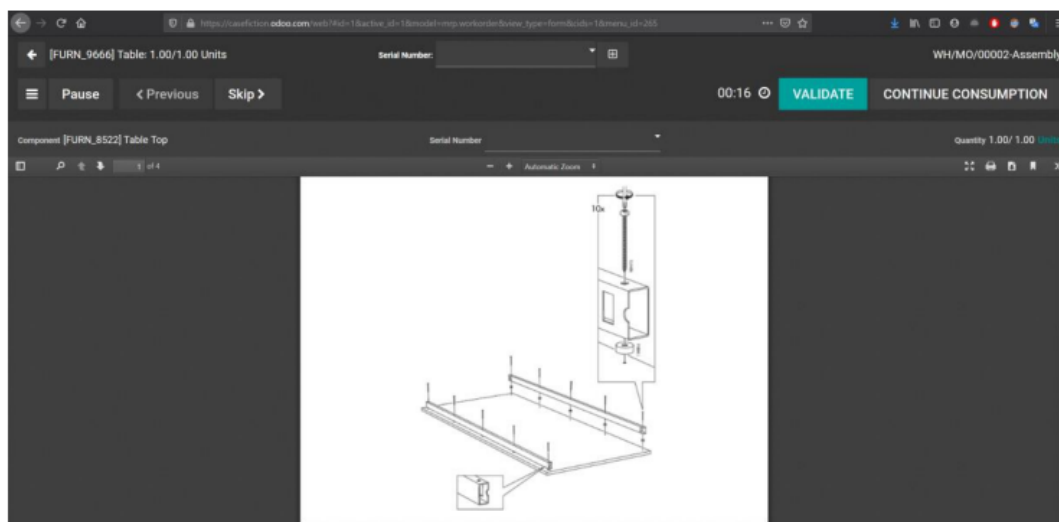


Figure 26 Operator interface during the WO

5.1.3.5. 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 章開頭所解釋的，Odoo 管理軟體考慮 PLM 主要作為追蹤變更和改進的工具。其應用模組為位於正常製造流程之外，但充當其擴展。其重點項目類別是工程變更單（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 是一個項目類別，概述了產品或零件的建議變更將受到該變化的影響。換句話說，就是每個人的中央資訊中心與給定產品相關聯。

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 all the previous changes. All very useful in the future and serve as a process to streamline product development and help improve products/production.

這個想法是表明需要更改產品項目或 BOM 項目，保存文件與變更相關並應用變更或至少表示變更已經實施，同時保留所有先前更改的歷史記錄。一切都非常有用未來並作為簡化產品開發並幫助改進的流程產品/生產。

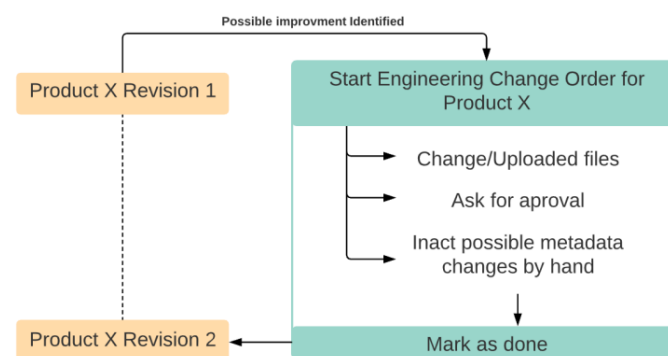


Figure 27 Simplified ECO function diagram

5.2.Starting the simulation 開始模擬

5.2.1. Software option chosen for the simulation 為模擬所選的軟體選項

For this simulation, it has been decided that the best evaluation of the Odoosoftware 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:

對於本次模擬，已確定 Odoo 軟體的最佳評估將透過其基於網路的線上服務。如此選擇而不使用的原因軟體的社群版如下：

- 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 的服務相對於管理伺服器的實用性本地或遠端。儘管社區應用程式已作為測試的一部分進行了測試對這項工作進行了研究，並被認為是一個非常適合初學者的伺服器應用程式的事實是，託管伺服器本身就是一項工作需要經驗和知識。市場已經發生了轉變這種針對產品即服務的應用是有充分理由的。在在撰寫本文時，COVID-19 大流行迫使許多人員工遠距工作，並向市場表明 IT 並不是一個簡單的工作工作，網路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.

- 缺乏 Odoo 社群版的官方 Odoo PLM 應用程式。儘管有大量社區製作的應用程式 Odoo 社群版的組織、描述、整合和支持這些應用程式最多只能被發現。而不是依賴可能的應用程式跟不上主要軟體的步伐，因此決定對使用者更公平平台評估是否基於官方應用程式。IE。這將是非常僅僅依靠運氣來拼湊一個免費的解決方案是沒有成效的未來會得到支持。PLM 是這裡的焦點，所以這是一個不容協商的問題情況。

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

在撰寫本文時，Odoo 允許您選擇其額外功能之一，例如 PLM 並在其雲端託管伺服器上無限期中免費使用它。這如果這項工作的唯一重點是 PLM 和製造，那麼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 Odoo 的其他應用程式這意味著我們無能為力。為此進行了實驗 Odoo Enterprise 的試用版允許使用者無需使用系統即可使用該系統 14 天內的儲存或應用程式限制全部託管在 Odoo 雲端伺服器中

5.2.2. Settings details that are relevant. 相關設定詳細信息

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 設定的一些細節與其正常功能相關製造功能。即在製造設定中啟用工單是正確使用工作訂單項目、工作中心項目和操作的必要步驟專案。

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

這項工作的一個假設是，這是 ERP 起源的延續。軟體，因為預設不啟用此設定是相當不直觀的，如果您將使用 Odoo 對製造進行嚴格控制。不管 Odoo enterprise v14 此選項可以在設定 > 製造 > 操作 > 工作中設定命令

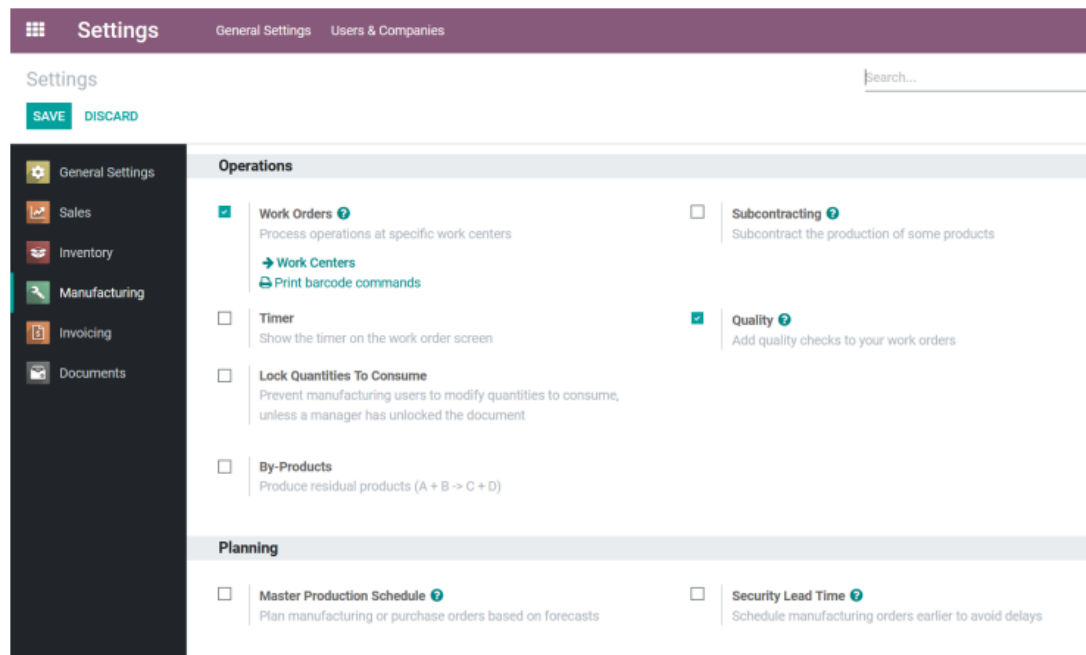


Figure 28 Screenshot of the specific setting to be enabled

圖 28 要啟用的具體設定的螢幕截圖

5.3. Building the company structure 建立公司架構

5.3.1. 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, 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)

透過設定選單設定和邀請使用者。可以指定不同的級別有關業務運作不同方面的權限。訊息、權限、40 審批、職責均分配給使用者。這個很方便而且可以掙即使其使用範圍有限，也屬於虛擬物品類的範疇製造業。它們的創建並不是絕對必要的，軟體可以正常運行只有我作為具有完整管理員憑證的用戶，但對於此模擬，有 5 個用戶建立如下所列以代表公司內的不同員工。這下面（圖 29）是我的使用者帳戶項目及其「Asses Rights」的螢幕截圖由為公司創建的虛構用戶之一（圖 30）

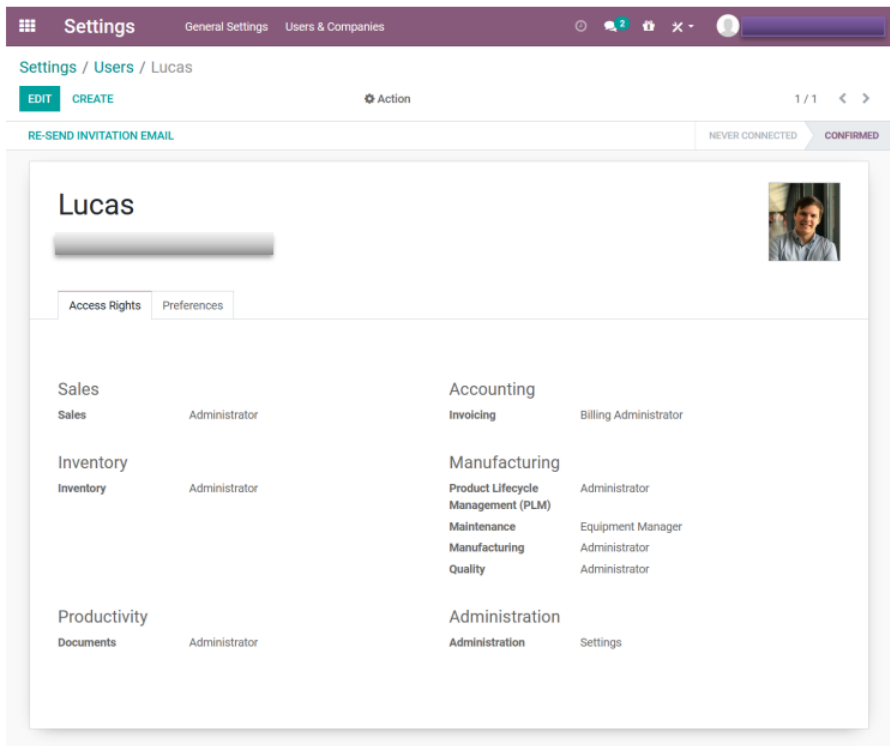


Figure 29 Screenshot of user account interface

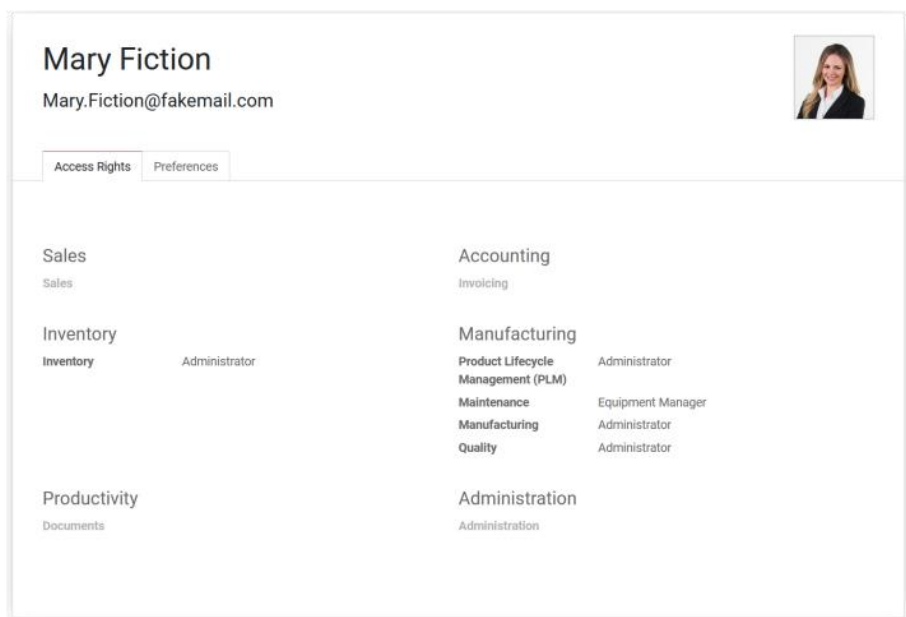


Figure 30 Screenshot of second user account interface

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.

很高興指出兩者在存取權限方面的差異。瑪麗小說已創建在此範例中，作為一名工程師，因此她的大部分權限都圍繞製造過程，而她被拒絕接觸其他部分，如銷售或會計。

5.3.2. Workcenters and Equipment. 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.

工作中心在 Odoo 中非常靈活，因為它們可以更改和根據需要進行擴充。人們可以在創建產品項目後创建工作中心一旦您對車間的內容有了一定的了解，就可以對車間進行重組。產品將進行到底。然而，對於大多數情況來說，這似乎是不切實際的，因為工作中心是現實世界中更嚴格的結構 - 它們的變化不如產品，因為它們往往持有重型機械。

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.

在此模擬中，該公司已擁有 3 個工作中心開始工作，因此工作中心和機器是預先建立的。這更對於有興趣實施 Odoo 並節省時間的讀者很有用。

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。這是一個項目類，強調維護組織。負責管理設備的應用程式是維護應用程式。下圖是 Odoo 如何描繪 3D 列印機的範例裝備項目（圖 31）

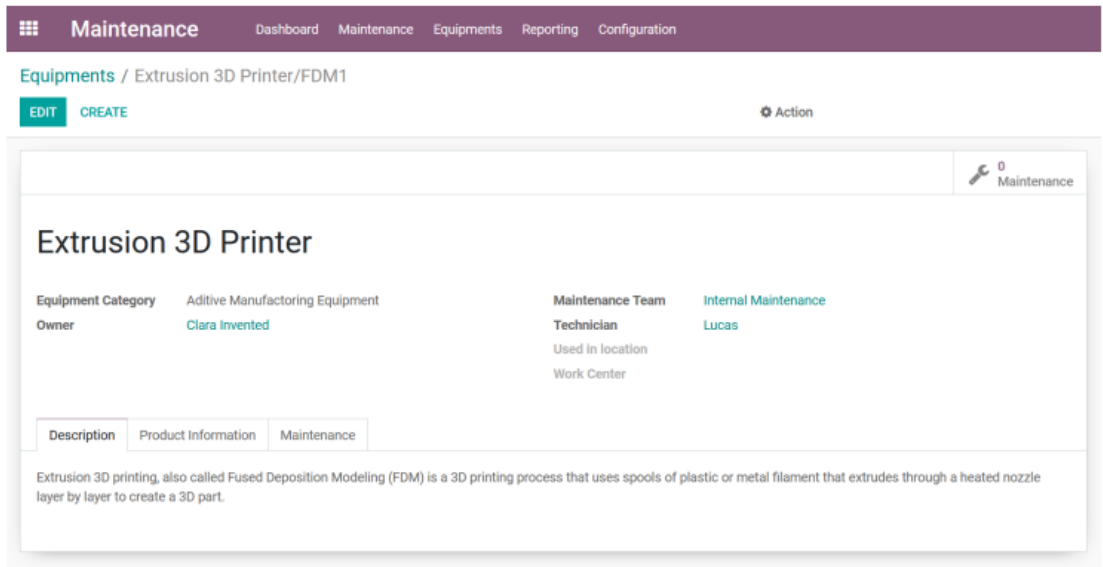


Figure 31 Odoo 3D printer equipment item

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 列印機之外，還創建了以下設備供整個過程使用開發/生產流程（圖 32）：

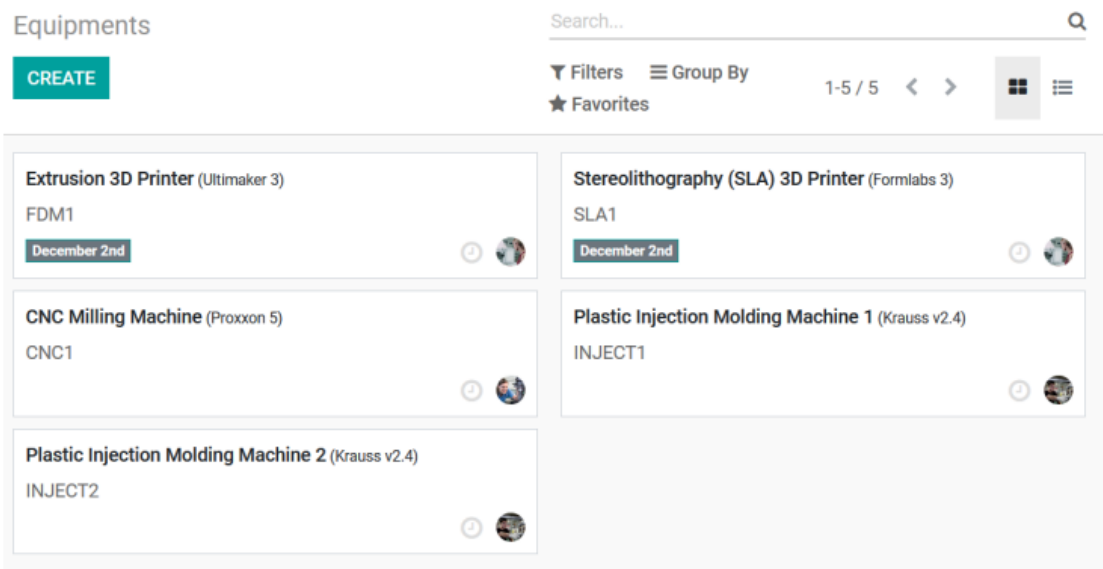


Figure 32 Overview of equipment items

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 PLM 軟體限制開始顯現的地方。雖然裝備專案讓您一定程度的元數據（描述文字、負責的使用者、維護數據和供應商）。它不允許上傳任何類型的文件附加到該項目類（機器手冊、報告等）。這是一個很大的弱點，因為文件管理被一致認為是 PLM 的一個主要方面。這將是一個反覆出現的此模擬的主題，因為允許直接上傳檔案的項目數量在 Odoo 中受到限制。

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，可以創建他們的工作中心。挺有趣的請記住，工作中心專案的主要用途是管理每個時間和成本小時。這個想法是分配給 WC 的設備不應同時使用，並且理想情況下，運作成本差異很大的設備也應該採用不同的工作中心，以便更好地追蹤時間/成本。

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

下面（圖 33）是一個工作中心專案的範例，用於表示在整個產品開發過程中使用的原型製作站。

Manufacturing

Overview +

2

Work Centers / New

SAVE

DISCARD

0.00% OEE

0.00 Hours Lost

0.00 Minutes Load

0% Performance

Work Center Name

Prototyping Station

Code

PROTO1

Alternative Workcenters

Working Hours

Standard 40 hours/week

General Information

Equipment

Production Information

Time Efficiency

100.00

%

Capacity

1.00

OEE Target

90.00

%

Costing Information

Cost per hour

35

Time before prod.

00:00

minutes

Time after prod.

00:00

minutes

Description

From rapid prototyping to home fabrication: How 3D printing is changing business model innovation

Figure 33 Odoo Prototyping Station item representation 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.

讀者會注意到這個站（圖 34）是 3D 列印機和 CNC 的所在地機位於。通常這些機器會被分開在單一工作中心因為營運成本不同且它們大部分是獨立的然而，就本次模擬而言，這已被認為具有足夠的代表性。

Work Centers / Prototyping Station

EDIT

CREATE

Action

1 / 1 < >

0.00% OEE

0.00 Hours Lost

0.00 Minutes Load

0% Performance

Work Center Name

Prototyping Station

Code

PROTO1

Alternative Workcenters

Working Hours

Standard 40 hours/week

General Information

Equipment

Equipment Name	Technician	Equipment Category	MTBF	MTTR	Est. Next Failure
Extrusion 3D Printer	Lucas	Additive Manufacturing Equipment	0	0	
Stereolithography (SLA) 3D Printer	Lucas	Additive Manufacturing Equipment	0	0	
CNC Milling Machine	Lucas	Subtractive Manufacturing	0	0	

Figure 34 Prototyping Station item representation 2

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

也為模擬創建了以下工作中心並提交給必要設備：

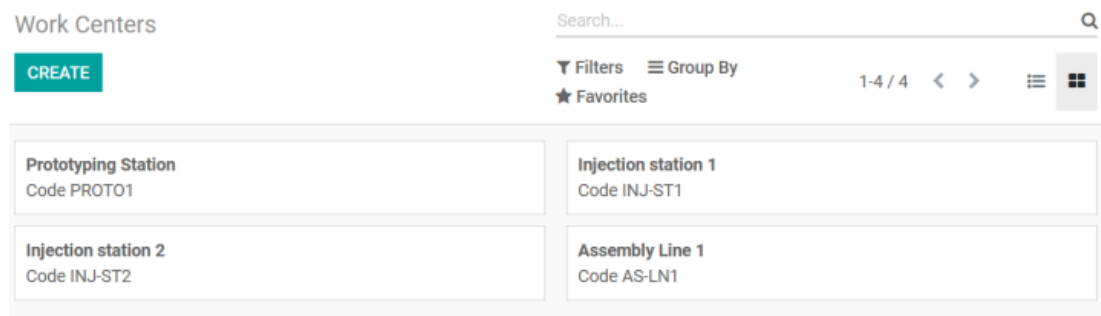


Figure 35 Overview of Workcenter items

5.4. Development 發展

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體中重新創建了，可以開始模擬過程。首先，重點是發展方面最引人注目的是使用 Odoo 的全新產品（圖 9），因為這是該公司的第一個產品要創建的產品，Odoo 組織原型製作過程的可能用途是評價。這包括從想法到設計和原型生產的路徑。然後一旦產品作為原型已達到可接受的結果，有關開發的工作將發生生產過程。產品開發被認為是成功的正式生產運作完成後。

5.4.1. Idea - design - product prototype 創意-設計-產品原型

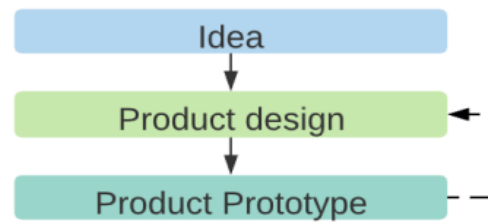


Figure 36 Sectioned diagram regarding product development

It is at this point that the utilization of the Odoo software can officially take place. The first step is to understand what the subject of production is as far as product items are concerned. There are two takes in how to do this:

此時即可正式使用 Odoo 軟體。這第一步是了解生產的主題是什麼，就產品項目而言擔心的。如何做到這一點有兩種做法：

- The first is to consider the prototype an early revision of the final product, that is the prototype item created in Odoo would be the same as the final product item with revisions been carried out during development. That would be the recommended if the prototype is achieved by identical means to the ones used in the final production. An example of this approach would be if the product is simple enough that product and production aspects of development can be carried out together.
- 首先是將原型視為最終產品的早期修訂版，即在 Odoo 中創建的原型項目將與最終產品項目相同在開發過程中進行了修改。那將是如果原型是透過與中使用的相同的方式實現的，則推薦最終的製作。這種方法的一個例子是，如果產品是夠簡單，可以進行產品和生產的開發一起出去。
- The second one is to consider the prototype as a separate item from the final product - this is the path was taken in this simulation. The main reason for this decision was that the ways in which our prototype production were carried out differed from the final production since 3D printing was used for the prototypes.
- 第二個是將原型視為獨立於最終產品的單獨項目產品 - 這是本次模擬中所採取的路徑。造成這種情況的主要原因決定是我們的原型生產的方式由於原型使用了 3D 列印，因此與最終產品有所不同。

Starting from the root, a product item called PROTO Alpha Case (Figure 37) was created (Alpha Case being the name of the product). From this point on we will refer to prototype products as 'proto item'. As we can see, this allows for a nice representation of the proto item. Since it is a prototype, it will not be marked as something that can be sold or purchased, and sales price will be set to 0\$ since it is unimportant. This proto item will be used to connect the different aspects of its development but for now it is left alone.

從根開始，創建了一個名為 PROTO Alpha Case（圖 37）的產品項（Alpha Case 是產品的名稱）。從現在開始我們將參考原型產品作為「原型項目」。正如我們所看到的，這可以很好地表示原型物品。由於它是原型，因此不會標記為可以出售或購買的東西，銷售價格將設定為 0\$，因為它不重要。此原型項目將用於連接其發展的不同方面，但目前它被擱置了。

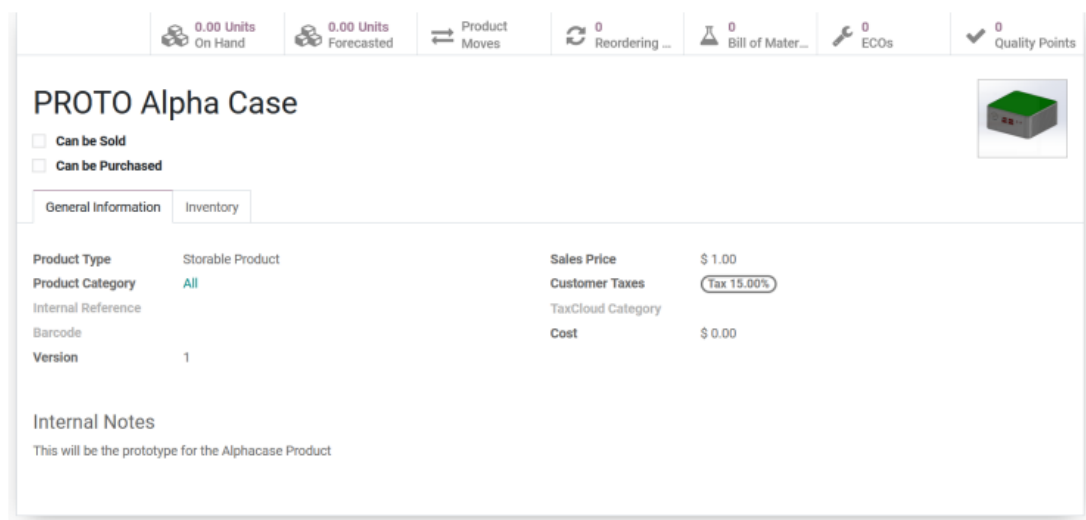


Figure 37 Image of the prototype product item

As we have previously established in chapter 3, the product will consist of 3 pieces Part A, Part B and Part C. These need to be prototyped and created as products as well so that they can be added to the bill of materials of the PROTO Alpha Case. Finally, it was decided to use specific plastic filaments (see section 4.1.1) for the 3D printing of PROTO Part A and PROTO Part B and C and these need to be added as products as well (Figure 38).

正如我們之前在第 3 章中確定的那樣，產品將由 3 個部分組成，即 A 部分，B 部分和 C 部分。這些也需要作為產品進行原型設計和創建，以便它們可以添加到 PROTO Alpha Case 的物料清單中。最後，決定使用特定的塑膠線（參見第 4.1.1 節）進行 PROTO A 部分的 3D 列印，並且 PROTO B 部分和 C 部分，這些也需要作為產品添加（圖 38）。






 ABS Filament - Raw Material [ABS-FIL] Price: \$ 20.00	 PROTO Alpha Case Price: \$ 0.00 On hand: 0.00 Units
 PROTO Part A Price: \$ 0.00 On hand: 0.00 Units	 PROTO Part B and C Price: \$ 0.00 On hand: 0.00 Units
 TPU Filament - Raw Material [TPU-FIL] Price: \$ 20.00	

Figure 38 Overview of Product class items for prototype

At this point, the relevant product items for the prototyping of the Alpha Case were finished, which makes possible the creation of the its relevant BOMs. There are 3 of them and they follow the structure in (Figure 39):

此時，Alpha Case 原型設計的相關產品專案是完成，這使得創建其相關 BOM 成為可能。其中有 3 個它們遵循（圖 39）中的結構：

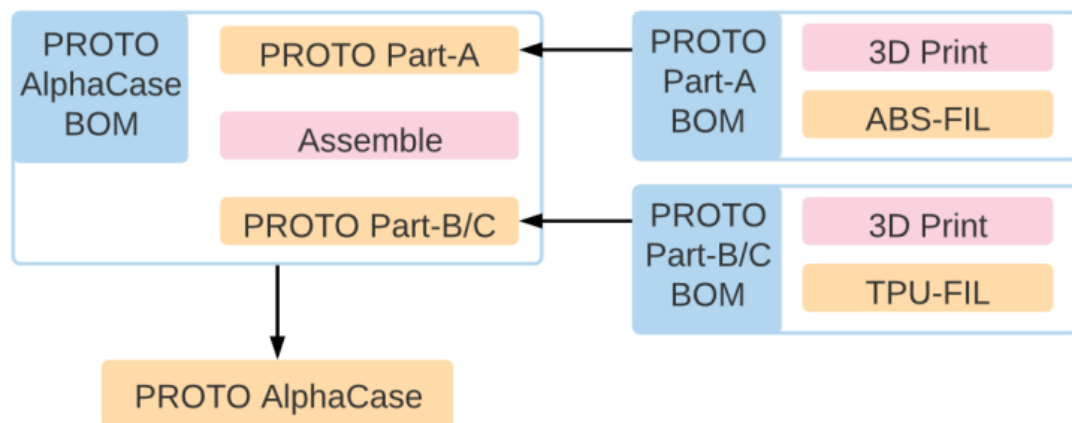


Figure 39 BOM diagrams for prototyping

Something worth mentioning is that Odoo used the kit option (Figure 40) on the item to infer that this product is a component of another product. This is very interesting because it automatically creates dependencies between the product items for production.

值得一提的是，Odoo 在專案上使用了套件選項（圖 40）來推斷此產品是其他產品的元件。這非常有趣，因為它自動在生產產品項之間創建依賴關係。

</

Figure 40 Image of the prototype product BOM (Part-A)

As the reader can see (Figure 41), while making the BOMs it is simple to create the specific operation items necessary for the manufacturing procedure and specify its work center. One of the best functionalities regarding MES in Odoo is the ability to track the time of operations based on default duration. This can be dynamically changed based on tracked time or set manually. It is also in the operation item that we can add instruction files for the operation. Even though it is limited to PDF text or a link to a google slides file, this is one of the few opportunities presented by Odoo for file management connected directly to an item.

正如讀者所看到的（圖 41），在製作 BOM 時，創建 BOM 很簡單製造程式所需的特定操作專案並指定其工作中心。Odoo 中關於 MES 的最佳功能之一是能夠跟蹤時間基於預設持續時間的操作數。這可以根據跟蹤情況動態更改時間或手動設置。我們也可以在操作項中添加指令檔操作。儘管它僅限於 PDF 文本或指向谷歌幻燈片文件的連結，但這是 Odoo 提供的與專案直接相關的檔管理機會很少。

Open: Operations

Operation: 3D Printing

Work Center: Prototyping Station

Bill of Material: PROTO Part A

Duration Computation: ☐ Compute based on tracked time ☒ Set duration manually

Default Duration: 120:00 minutes

Work Sheet: ☒ PDF ☐ Google Slide ☐ Text

PDF: [UPLOAD YOUR FILE](#)

[SAVE](#) [DISCARD](#)

Figure 41 Image of operation item as presented by Odoo (BOM Part-A)

Bills of Materials Search...

[CREATE](#) [Download](#) Filters Group By 1-3 / 3 Favorites

<input type="checkbox"/>	Product	Reference	BoM Type	
<input type="checkbox"/>	✚ PROTO Part A		Kit	
<input type="checkbox"/>	✚ PROTO Part B and C		Kit	
<input type="checkbox"/>	✚ PROTO Alpha Case		Manufacture this product	

Figure 42 Overview of BOMs created for prototyping

Speaking of this lack of upload opportunities, we can notice that while making the product item there was no way to directly upload files regarding the product to the item. In our case, we have the CAD files regarding the parts that we are prototyping, to not be able to upload these files in any way would be a complete failure from a PLM perspective. Thankfully there is a workaround. As explained in section 5.1.3.5, the ECO is an item that is linked to either product items or BOMs and allow uploaded files to be attached to it. It is a minor workaround but basically means that if we want to upload our CAD files to the items in any significative manner, we need to emit an ECO even if there is no “change” being made.

說到缺乏上傳機會，我們可以注意到，在製作產品時 item 無法直接將有關產品的檔案上傳到該 item。在我們的例子中，我們有關於我們正在製作原型的零件的 CAD 文件，但無法上傳從 PLM 的角度來看，這些文件無論如何都將是徹底的失敗。幸虧有是一個解決方法。如第 5.1.3.5 節所述，ECO 是連結到以下任一項目的項目：產品項目或 BOM，並允許附加上傳的檔案。這是一個小解決方法但基本上意味著如果我們想將 CAD 檔案上傳到任何有意義的項目因此，即使沒有做出任何“改變”，我們也需要發出 ECO。

Products / PROTO Part B and C / Engineering Change Orders / ECO0001: Files Upload For PROTO

SAVE DISCARD

UPDATE DOCUMENTS

NEW IN PROGRESS VALIDATED EFFECTIVE

Documents 0

Short Summary
ECO0001: Files Upload For PROTO

Type	New Product Introduction	Responsible	Lucas
Apply on	Product Only	Effectivity	<input checked="" type="radio"/> As soon as possible
Product	PROTO Part B and C		<input type="radio"/> At Date
		Tags	

Note Routing Changes Approvals

Description of the change and its reason.

Figure 43 ECO example

It can only be assumed that this was part of Odoo’s team strategy to implement PLM as an external application in its ERP base. It is reasonable, but still, this is one of the few aspects of this software interface that is not as straightforward. It is an extremely valuable feature, but it is somewhat hidden. The documents icon appears in the top right corner (Figure 43) only after the ECO is created and saved.

只能假設這是 Odoo 團隊實施 PLM 策略的一部分其 ERP 庫中的外部應用程式。這是合理的，但這仍然是少數幾個方面之一這個軟體的介面沒那麼簡單。這是一個非常有價值的功能，但它有些隱藏。文件圖示出現在右上角（圖 43）僅在建立並儲存 ECO 後。

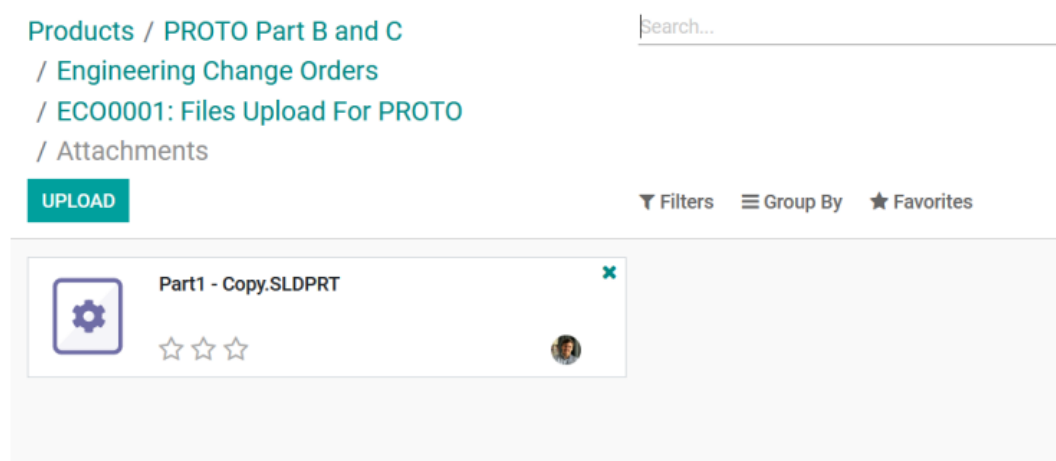


Figure 44 Overview of attached files to ECO

Since there is no direct integration between Odoo and the CAD software, uploading the file do not cause any automatic change to the product metadata. This is not ideal from the PLM perspective, still, it is a well implemented feature. By allowing product items to link directly to not only one existing ECO but to the list of all ECOs ever applied to the item, the software does well in tracking version control and development.

由於 Odoo 和 CAD 軟體之間沒有直接集成，因此上傳文件不會導致產品元資料發生任何自動變更。從這個角度來看，這並不理想從 PLM 的角度來看，它仍然是一個實作良好的功能。透過允許產品項目連結不僅直接指向一個現有的 ECO，還直接指向曾經應用於該專案的所有 ECO 的列表，軟體在追蹤版本控制和開發方面做得很好。

Something interesting that can be done for the sake of process control is adding quality control points to operations. This allows the responsible personnel to give feedback during the production regarding concerning points to the engineering team. In our case, we are concerned about 3D printing warping. This is something that happens when temperature varies too much during the 3D printing procedure. To this end a Quality Control Point item will be created (Figure 45) that will enquire with the operator to check if there is warping in the piece and mark pass or fail.

為了過程控制可以做的一些有趣的事情是提高質量操作的控制點。這使得負責人員可以在期間提供回饋與工程團隊有關的生產問題。就我們而言，我們是擔心 3D 列印翹曲。這是當溫度升高時會發生的事情在 3D 列印過程中變化很大。為此，品質控制點項目將創建（圖 45），它將詢問操作員以檢查是否存在翹曲工件和標記通過或失敗。

The screenshot displays the Odoo Quality Control module interface. At the top, there's a navigation bar with tabs: Overview, Quality Control, Reporting, and Configuration. Below this, the header shows 'Quality Control Points / QCP00001'. There are buttons for 'EDIT' and 'CREATE', and an 'Action' button. The main content area is titled 'QCP00001' and contains a form with the following fields:

Title	Check for warping	Control Type	All Operations
Products	PROTO Alpha Case PROTO Part A PROTO Part B and C	Type	Take a Picture
Operations	CaseFiction Design : Manufacturing	Team	Main Quality Team
Work Order Operation	3D Printing	Responsible	Lucas
		Worksheet	Do not update page

Below the form, there are tabs for 'Instructions' and 'Notes'. The 'Instructions' tab is active, showing the text: 'Print the part and check for warping from the 3D printing, take a picture for reference'.

Figure 45 Quality Control Point item for the prototype production

The last step of a prototype cycle would be the production of prototypes for testing and evaluation. Production is something quite straightforward in Odoo and really the point where everything we have done before come together. The metadata and the items that have been created allow us to start the Manufacturing Order (MO) (Figure 46). This, in turn, pull the necessary workorders from the operations and components listed in the BOM. The workorders appear for manufacturing operators and production can commence/be tracked.

原型週期的最後一步是生產用於測試和測試的原型評估。在 Odoo 中，生產是相當簡單的事情，而且真正的重點是我們之前所做的一切都聚集在一起。元資料和已新增的項目創建後，我們可以啟動製造訂單 (MO)（圖 46）。這反過來又拉動了 BOM 中列出的操作和組件的必要工單。這為製造操作員顯示工作訂單，並且可以開始/追蹤生產。

Manufacturing Orders / New

SAVE DISCARD

CONFIRM MAINTENANCE REQUEST DRAFT CONFIRMED IN PROGRESS DONE

☆ New

Product

PROTO Alpha Case

Scheduled Date

11/02/2020 19:47:16

Quantity

1.00

To Produce

Responsible

Lucas

Bill of Material

PROTO Alpha Case

Components

Work Orders

Miscellaneous

Product	To Consume
[ABS-FIL] ABS Filament - Raw Material	1.00
[TPU-FIL] TPU Filament - Raw Material	2.00
Add a line	

Components

Work Orders

Miscellaneous

Operation	Work Center	Scheduled Start Date	Expected Duration	Real Duration	Status
Assembly	Assembly Line 1		10:00		
3D Printing	Prototyping Station		120:00		
3D Printing	Prototyping Station		60:00		
Add a line					

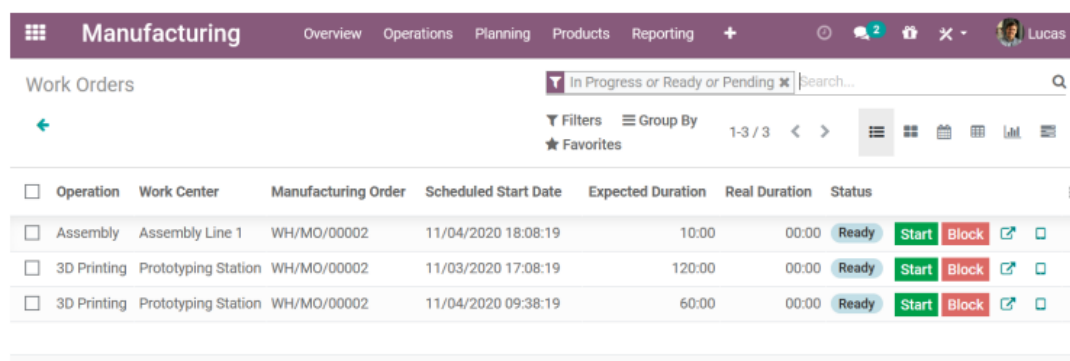
Figure 46 Depiction of the manufacturing order

For the most part this operation is very well automated and clear. There are however a few problems that are result of structural changes from Odoo V13 to Odoo V14. For a long time, the software ordered the operations to be carried out using an extra item class called 'Route'. These were a fundamental part of how the product moved within the inventory and manufacturing, but for some reason, was dropped in the manufacturing aspect of the new version in favor of a simplified sequence data built into the BOM. As of the writing of this work, there have been reports of problems and confusions regarding how that works, which are aggravated by the fact that material explaining the use of this functionality are either nonexistent or still referencing old versions of the software (in which 'routes' are still in use).

在大多數情況下，此操作非常自動化且清晰。不過也有一些由於從 Odoo V13 到 Odoo V14 的結構變化而導致的問題。許久，該軟體指令使用一個名為「Route」的額外項目類別來執行操作。這些是產品如何在庫存中移動的基本部分，製造，但由於某種原因，在新的製造方面被放棄了有利於 BOM 中內建的簡化序列資料的版本。截至撰寫本文時工作中，有報告稱其工作原理存在問題和困惑，其中解釋此功能使用的材料要馬是不存在或仍引用舊版本的軟體（其中“路線”仍在使用）。

The avid reader will notice in Figure 47 that the order in which operations are being made available are not in the correct sequence. This is due to exactly this problem and for now the only solution is to count on the awareness of the operators regarding the order of production or manually scheduling the operations in the plan tab. During the period of research for this work (before Odoo V14) familiarization experiments were made in which there were no problem of this nature. In addition, there are examples online even from Odoo website demonstrating the use of routes and how they are useful for this exact situation.

狂熱的讀者會注意到，在圖 47 中，操作的順序可用的順序不正確。這正是由於這個問題，目前 52 唯一的解決方案是依靠操作員對生產順序的意識或在「計劃」選項卡中手動安排操作。在為此研究期間工作（在 Odoo V14 之前）進行了熟悉實驗，其中沒有這種性質的問題。此外，甚至來自 Odoo 網站的在線示例演示路由的使用以及它們在這種確切情況下的用處。



Operation	Work Center	Manufacturing Order	Scheduled Start Date	Expected Duration	Real Duration	Status
Assembly	Assembly Line 1	WH/MO/00002	11/04/2020 18:08:19	10:00	00:00	Ready Start Block
3D Printing	Prototyping Station	WH/MO/00002	11/03/2020 17:08:19	120:00	00:00	Ready Start Block
3D Printing	Prototyping Station	WH/MO/00002	11/04/2020 09:38:19	60:00	00:00	Ready Start Block

Figure 47 Overview of the resulted Work Orders

The problem has been reported by other people (Figure 48) to the Odoo company and is been and hopefully it will be resolved shortly (this is after all a extremely recent version of the software). That been said, it is a problem even if it is a minor one.

其他人（圖 48）已向 Odoo 公司報告了該問題，並且是一直，希望它能很快得到解決（這畢竟是一個非常新的版本軟體）。話雖如此，即使它是一個小問題，這也是一個問題。

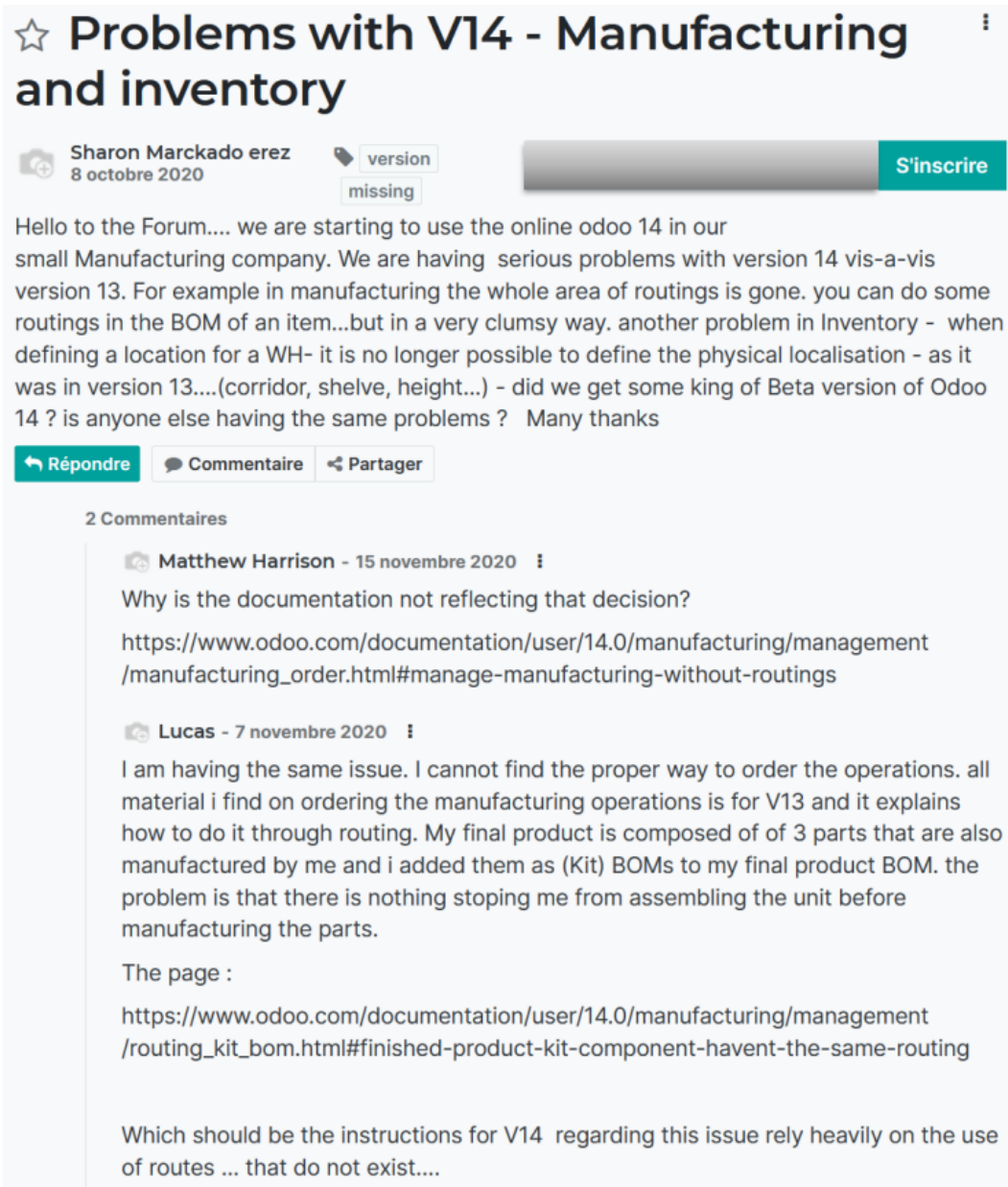


Figure 48 Image of Odoo forum question regarding routes

The manufacturing process was repeated 7 times (Figure 49) to simulate a small batch of prototypes for testing and tolerance checking. It is rare to get a perfect prototype in the first batch, for this reason it was chosen to represent correction through the simulation. In this simulation this problem was a fit problem that resulted in a change of dimension of PROTO Part A.

製造過程重複 7 次（圖 49）以類比小批量的用於測試和公差檢查的原型。在第一個中獲得完美的原型是很少見的批處理，因此選擇它來表示通過模擬進行校正。在這個模擬 這個問題是一個擬合問題，導致了 PROTO 的尺寸變化 A 部分。

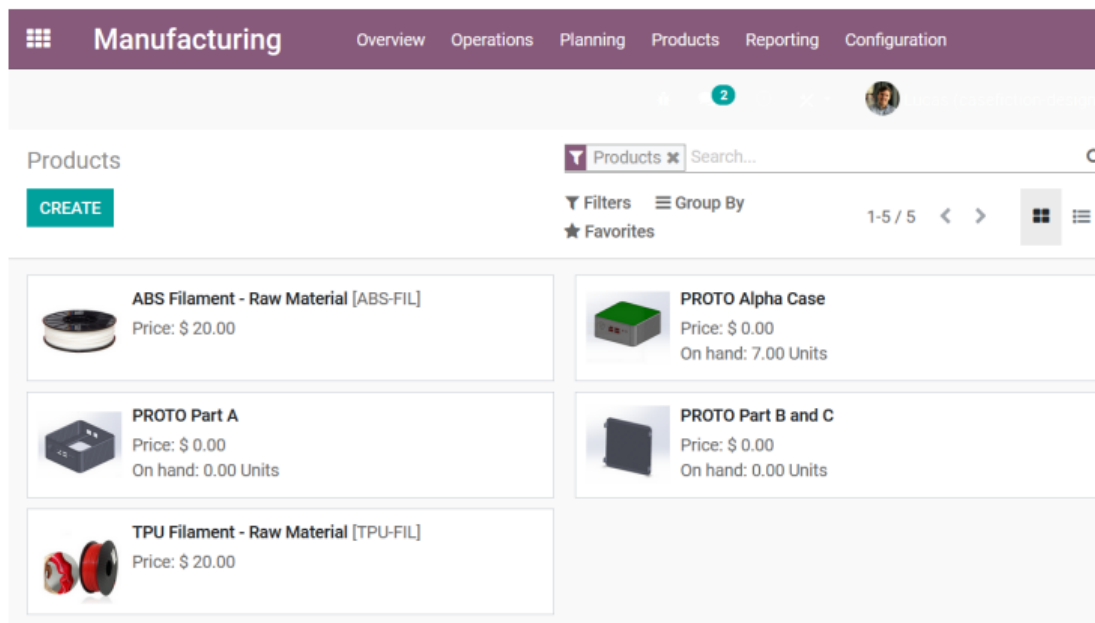


Figure 49 Overview of the products after manufacturing

This gives us the opportunity to use ECOs for their actual purpose, establish and control a change to the product item. The changes to be carried out were on the CAD file regarding the product item. As before we can start the ECO and fill in the description, then the files are uploaded, and the ECO (Figure 50) goes through necessary validation before being made effective.

這使我們有機會將 ECO 用於其實際目的，建立和控制更改為產品項。要執行的更改在 CAD 檔案中有關產品項。和以前一樣，我們可以啟動 ECO 並填寫描述，然後檔是上傳，ECO（圖 50）在製作之前經過必要的驗證有效。

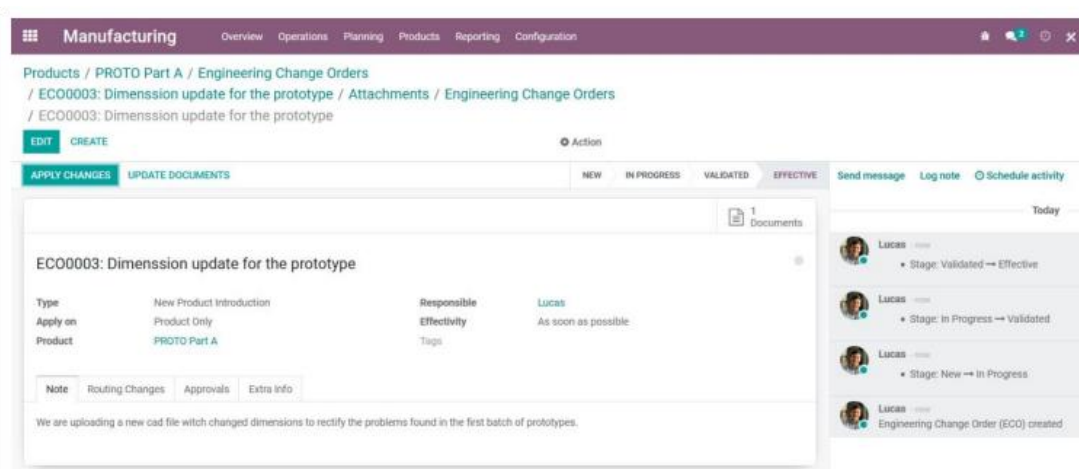


Figure 50 Depiction of the validation of the ECO

The validation procedure basically is set to ask for validation of someone with proper access permissions or specific personnel. In this case, the master account was used to validate and make effective as can be seen from the log in the right side of the image. Once the change 55 is applied you can see that the product item version has been iterated to version 2 as well as a new ECO has been added to the list of ECOs linked to the item (Figure 51).

驗證程式基本上設置為要求驗證某人具有適當的訪問許可權或特定人員。在本例中，主帳戶用於驗證並使其有效，從圖像右側的日誌中可以看出。一旦改變 55 應用后，您可以看到產品項版本已反覆運算到版本 2 以及與該專案相關的 ECO 清單中添加了一個新的 ECO（圖 51）。

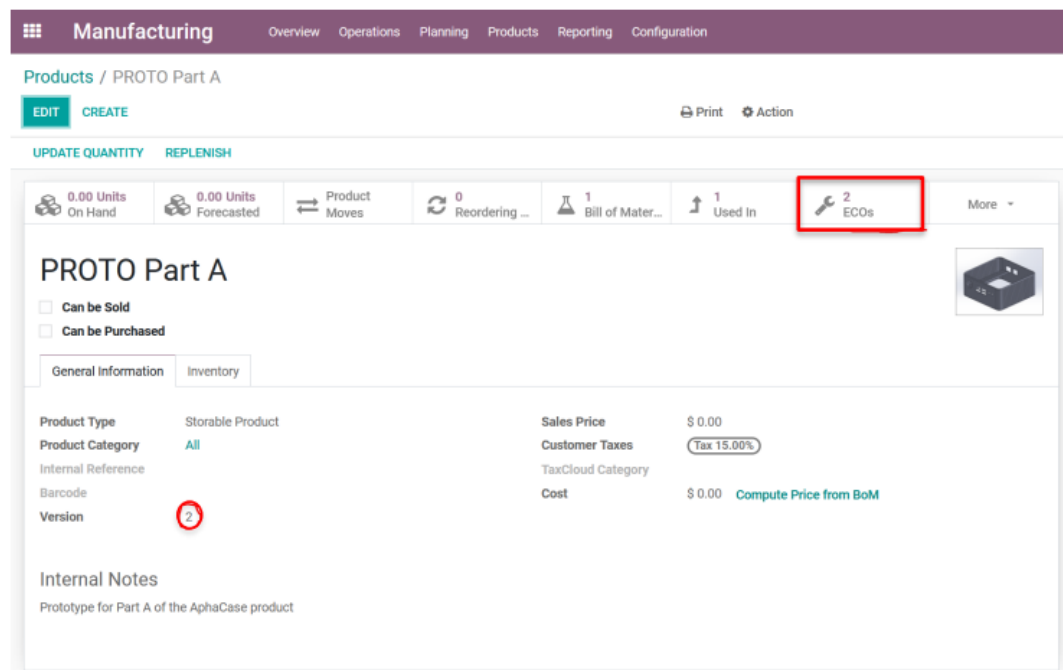


Figure 51 Depiction of changes provoked by the ECO to product item

Now that the prototype phase is complete the focus will shift to the process. As established before, it was decided to separate the prototype products from the final product item to isolate the product from the production process during the development. This way many aspects of development of the product could be evaluated in an ordered manner. Now that the process is been developed it seems reasonable to create the product items that will represent the final products since the product of a successful run of the process will be the production ready samples of it (Figure 52).

現在原型階段已經完成，重點將轉移到流程上。如成立之前，決定將原型產品與最終產品專案分開進行隔離產品從生產過程中的發展。這樣，許多方面都是如此產品的開發可以有序地進行評估。現在這個過程已經開發出來，創建代表最終的產品專案似乎是合理的產品自產品成功運行以來，將做好生產準備它的樣本（圖 52）。

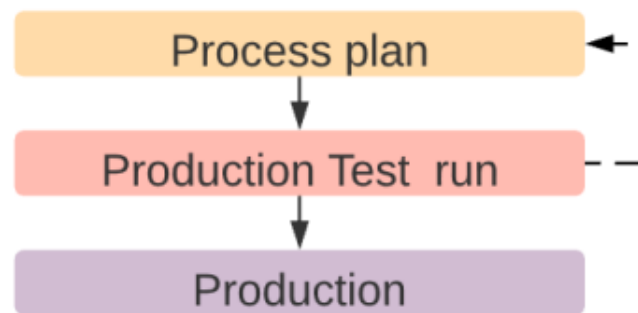


Figure 52 Sectioned diagram regarding Process development

Other product items that created were the raw materials for the injection molding (which are plastic pellets that are fed into the machine to be melted and injected). All that was done in identical manner to when we create the prototype products with the exception that the Alpha case (Figure 53) now is marked as sellable and its sale costs are now relevant (Figure 54).

創建的其他產品項目是注塑成型的原材料（其中是送入機器進行熔化和注射的塑膠顆粒）。一切都已完成與我們創建原型產品時的方式相同，不同之處在於 Alpha 案例（圖 53）現在被標記為可銷售，並且其銷售成本現在是相關的（圖 54）。



Figure 53 Render of how the final product should look like

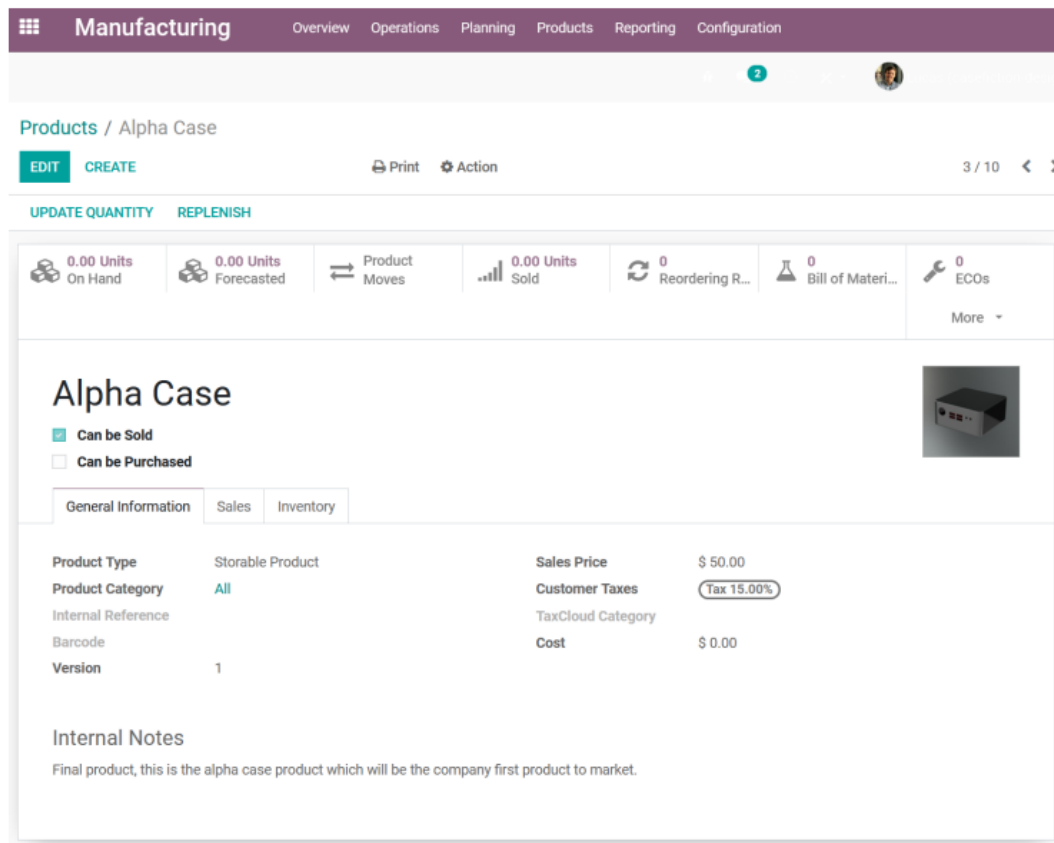


Figure 54 Product Item of the Alpha Case

Once the product items are taken care of, we need to go back to what aspect of the process will be tracked using Odoo in the context of this simulation. As it was hinted previously when talking about injection molding the key aspect of change regarding the process are the molds used by the machines to create the parts. For this simulation it was considered that the mold development will follow a very similar procedure of the development of the product, this should be more clear from the following diagram (Figure 55).

一旦處理完產品項目，我們需要回到流程的哪個方面將在此模擬的上下文中使用 Odoo 進行追蹤。正如之前所暗示的那樣談論注塑成型過程中變化的關鍵方面是模具被機器用來製造零件。對於該模擬，認為模具開發將遵循與產品開發非常相似的程序，這從下圖（圖 55）應該比較清楚。

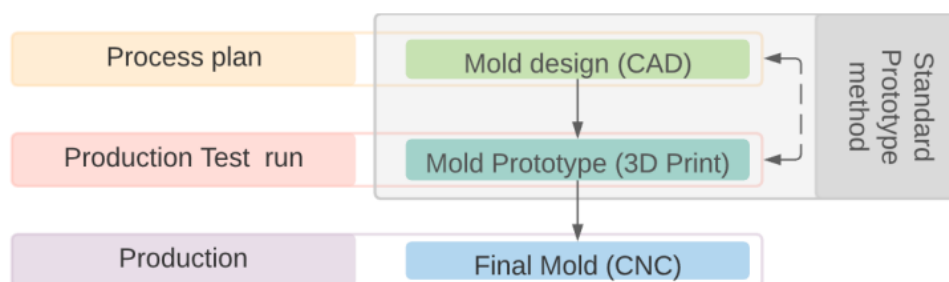


Figure 55 Diagram regarding process development for mold

The production of a prototype mold by 3D printing follows the same standard procedure for prototyping used for the product. So far, the mold is considered a product like any other, this reveals another small weakness regarding Odoo ability to represent the totality of the process. The reader will notice that although the mold is been treated as a product (because it is been manufactured) it should in fact be considered a tool or piece of equipment as well.

通過 3D 列印生產原型模具遵循相同的標準程式用於產品的原型設計。到目前為止，模具被認為是與其他任何產品一樣的產品，這揭示了 Odoo 代表整體能力的另一個小弱點過程。讀者會注意到，雖然模具被視為產品（因為它是製造的）它實際上也應該被視為一種工具或設備

Although Odoo does makes this distinction between equipment and products, it has no integration regarding the situations where one is both. In addition, as explained before, there is no way of uploading CAD files to an equipment item or linking an equipment to a range of tools. I.e. Odoo does not consider a vertical drill with x number of drill bits to make different size holes. The closest it can do from the perspective of equipment/maintenance is consider the vertical drill a workstation and each drill size a separate equipment within the station with an assigned set up time. This is ok if you ignore that the drill bit is a product.

儘管 Odoo 確實對設備和產品進行了區分，但它沒有關於兩者兼而有之的情況的整合。此外，如前所述，還有無法將 CAD 檔上傳到設備專案或將設備連結到範圍的工具。即 Odoo 不考慮製造具有 x 個鑽頭的垂直鑽頭不同尺寸的孔。從設備/維護的角度來看，它能做的最接近的是將垂直鑽頭視為工作站，將每個鑽頭尺寸視為單獨的設備。具有指定設置時間的網站。如果您忽略鑽頭是產品，這是可以的。

All of this is reasonable from the perspective of an ERP system but not ideal from the perspective of PLM because it shows gaps in between items that should represent the same thing. In production from the manufacturing application what is set is the work center station not the equipment (see Figure 41). In the maintenance app there is no connection to the fact that the tool is a consumable product, you can consider a maintenance schedule and even make a useful life parameters but because it is an equipment you can't have reserve tools like drill bits in inventory like consumables.

從 ERP 系統的角度來看，所有這些都是合理的，但從 ERP 系統的角度來看並不理想。PLM 的透視圖，因為它顯示了應該代表相同項目之間的差距東西。在製造應用的生產中，設置的是工作中心站而不是設備（見圖 41）。在維護應用程式中，與事實沒有聯繫該工具是消耗品，您可以考慮維護計劃，甚至做一個有用的壽命參數，但因為它是一個設備，你不能有儲備工具就像庫存中的鑽頭一樣，就像消耗品一樣。

The result is that it becomes very difficult to represent testing with a prototype mold. If you do as the software is designed for you need to create a separate ECO to apply every operation for each different iteration of the mold development to the necessary BOMs and make a test run (Figure 56). At this point, considering the maintenance aspect of the mold as a tool just does not make sense because it would entails filing in metadata in the maintenance App by hand for every prototype mold iteration all without causing any difference from the manufacturing perspective. The PROTO mold item ends up been used only for the sake of tracking material and holding files as the mold is improved.

結果是，用原型模具進行測試變得非常困難。如果您可以按照軟體的設計來做，您需要創建一個單獨的 ECO 來應用每個對模具開發的每個不同反覆運算進行必要的 BOM 操作，以及進行測試運行（圖 56）。在這一點上，考慮到模具的維護方面一個工具是沒有意義的，因為它需要在維護中歸檔元數據每個原型模具反覆運算都手動應用，而不會造成任何差異製造業視角。PROTO 模具項目最終僅用於在模具改進時跟蹤材料並保存檔

The screenshot displays a web-based Manufacturing ERP interface. At the top, a navigation bar includes 'Manufacturing' and several menu items: Overview, Operations, Planning, Products, Reporting, and Configuration. Below this, a breadcrumb trail reads 'Products / PROTO Part A / Engineering Change Orders'. The main header area shows the specific ECO: '/ ECO0004: Update of process to test the prototype molds'. On the left, there are buttons for 'EDIT' and 'CREATE'. On the right, an 'Action' dropdown menu is visible. Below the header, a progress bar indicates the status of the ECO: 'NEW' (highlighted), 'IN PROGRESS', 'VALIDATED', and 'EFFECTIVE'. To the right of the progress bar, there are icons and counts for '1 Documents' and 'BOM Revision :2'. The main content area displays the details of 'ECO0004: Update of process to test the prototype molds'. It includes a table with the following information:

Type	New Product Introduction	Responsible	Lucas
Apply on	Bill of Materials	Effectivity	As soon as possible
Product	PROTO Part A	Tags	
Bill of Materials	PROTO Part A		

At the bottom of the main content area, there are four tabs: 'Note', 'Routing Changes', 'Approvals', and 'Extra Info'.

Create Operations

Operation: Test injection with prototype mold part A

Work Center: Injection station 1

Sequence: 101

Bill of Material:

Duration Computation: ☐ Compute based on tracked time ☒ Set duration manually

Default Duration: 60:00 minutes

Work Sheet: ☐ PDF ☐ Google Slide ☒ Text

Description: Make sure the 3D printed prototype mold is well installed to the plastic injection equipment than turn on the machine.

SAVE & CLOSE SAVE & NEW DISCARD

Figure 56 ECO example of update procedure of BOM

Taking this in consideration, in simulation it will be produced one 3D printed mold for each part of the alpha case. Then ECOs for the prototype parts of the case will be created to be applied to the parts BOMs updating the operation from 3D printing to injection molding test run with prototype molds.

考慮到這一點，在類比中，它將生產一個 3D 列印模具 Alpha 案例的每個部分。然後，將創建案例原型部件的 ECO 以應用於零件 BOM，將操作從 3D 列印更新到注塑成型使用原型模具進行試運行

At this point we could differentiate the product prototype from the test run prototype by making a new prototype product item, however considering our rapidly growing list of product items (Figure 57) it was concluded that it would be just better for depiction in this work to modify the previously produced product prototypes (made with 3D printing) and just 60 use the same items. We can do this because those prototypes have already served their purpose.

在這一點上，我們可以通過以下方式將產品原型與試運行原型區分開來製作一個新的原型產品專案，然而考慮到我們快速增長的清單產品專案（圖 57）得出的結論是，在這種情況下描述會更好修改以前生產的產品原型（用 3D 列印製成）並只是 60 使用相同的專案。我們可以做到這一點，因為這些原型已經為他們的目的。

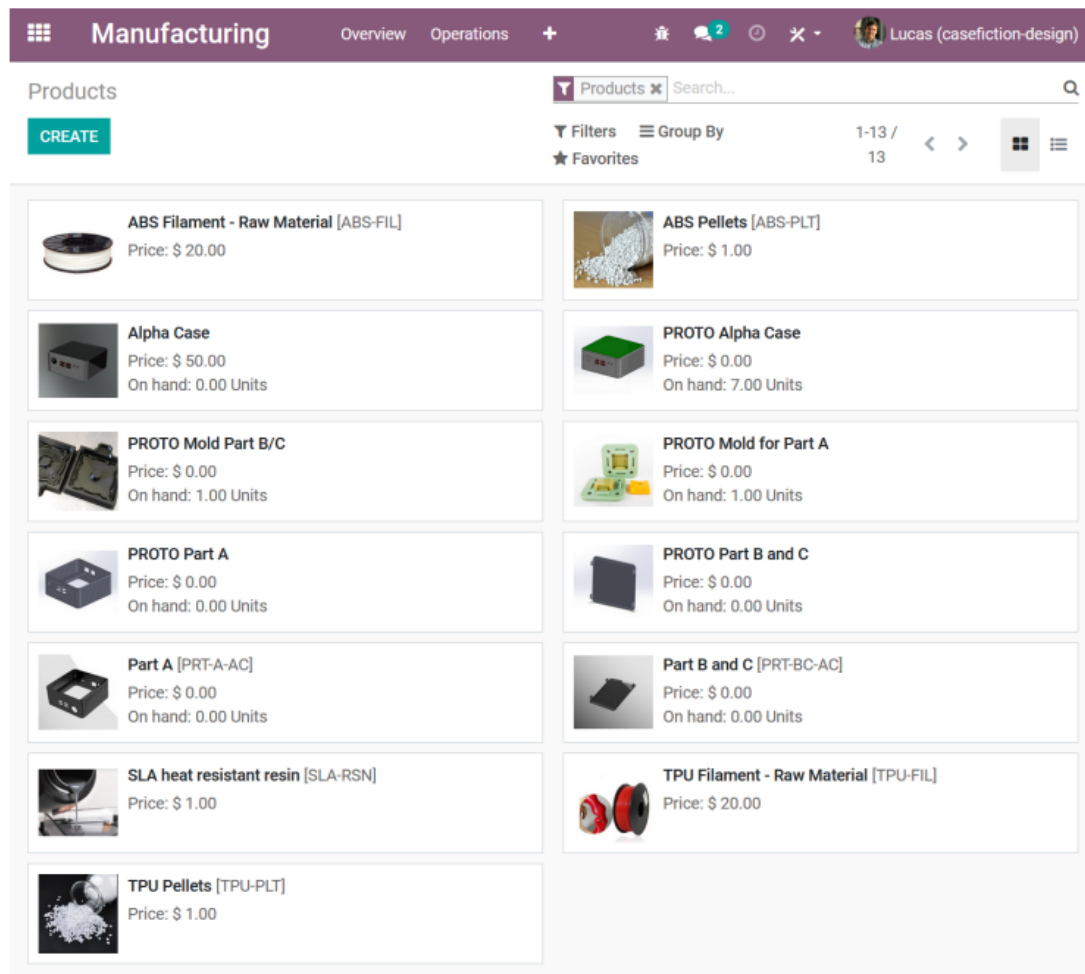


Figure 57 Overview of product items at this stage of the simulation

After the mold have been created and the BOMs for the prototypes are updated to include the injection stations and the proper operations (specifying the use of the molds) the next step is to do a production test run of prototype. Again that is done by emitting the MO completing the generated WOs (see Figure 46 and Figure 47 of previous section).

創建模具並更新原型的 BOM 以包括注射站和正確的操作（指定模具的使用）
 下一步就是做一個原型的生產試運行。同樣，這是通過發出 MO 完成來完成的
 生成的 WO（參見上一節的圖 46 和圖 47）。

The result of the production is used to check for dimension and fitting, if correction is needed the ECOs would be emitted again as seen in Figure 56, and a new iteration of production and testing would be carried out. This process would repeat until the product is satisfactory enough to justify the production of the CNC machined molds that would be used in mass production.

生產結果用於檢查尺寸和擬合度，如果校正如圖 56 所示，需要再次發射 ECO，並且將進行生產和測試。此過程將重複，直到產品足以令人滿意地證明生產將要使用的 CNC 加工模具是合理的在大規模生產中。

Since in this simulation it was chosen that the final mold (made of aluminum) would also be produced in house, this is the next step of development. Procedure is basically the same as before except that it is needed to create product items for both the raw material (aluminum block) and the CNC molds prior to their manufacturing. Creating BOMs and uploading relevant files.

由於在此模擬中選擇最終模具（由鋁製成）也將內部生產，這是下一步的開發。流程基本相同與以前一樣，只是需要為原材料（鋁）創建產品項目塊和製造前的 CNC 模具。建立 BOM 並上傳相關文件。

Finally, the actual production on the new molds can begin. To represent that a manufacturing order of 100 Alpha Cases were created. This marks the end of the main path of development from idea to production (Figure 58).

最後，新模具可以開始實際生產。來表示一個創建了 100 個 Alpha Case 的製造訂單。這標誌著主路徑的結束從創意到生產的開發過程（圖 58）。

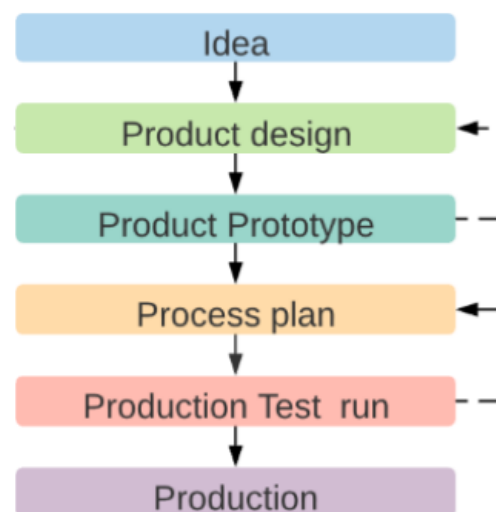


Figure 58 Main path of development from idea to production

5.4.3. Process upgrade procedure 製程升級流程

The previous sections were about the procedure that would be necessary to use the Odoo software to track change during the main development of product. As such, most of what was described focused in the use of PLM and the standard procedure of creating and utilizing items like Products, BOMs, ECOs, MOs, WOs and Operations. This section will be different in the sense that now we have a production being carried out and the idea is to test Odoo in its capabilities of performing upgrades (Figure 59 and Figure 60). In other words, performance and feedback of information (and of course MES) becomes the main subject.

前面的部分介紹了使用 Odoo 所需的程序用於追蹤產品主要開發過程中變化的軟體。因此，大部分內容都是重點描述了 PLM 的使用以及創建和使用的標準流程產品、BOM、ECO、MO、WO 和營運等項目。此部分將有所不同從某種意義上說，現在我們正在進行製作，我們的想法是測試 Odoo 其執行升級的能力（圖 59 和圖 60）。換句話說，訊息的表現和回饋（當然還有 MES）成為主要課題。

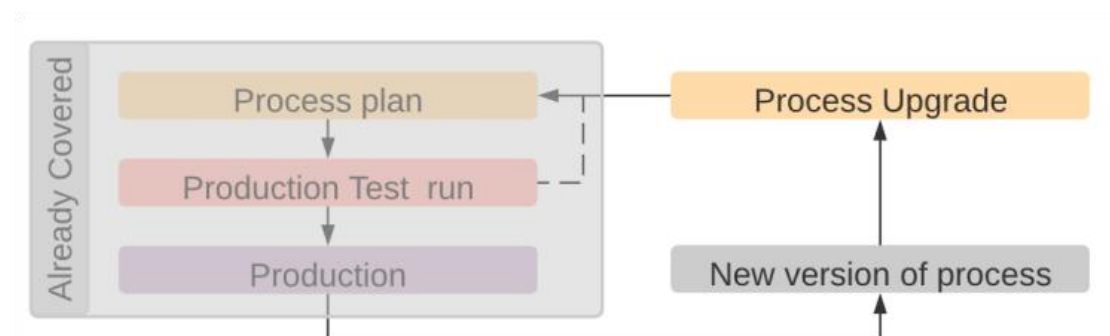


Figure 59 Sectioned diagram regarding Process upgrade procedure

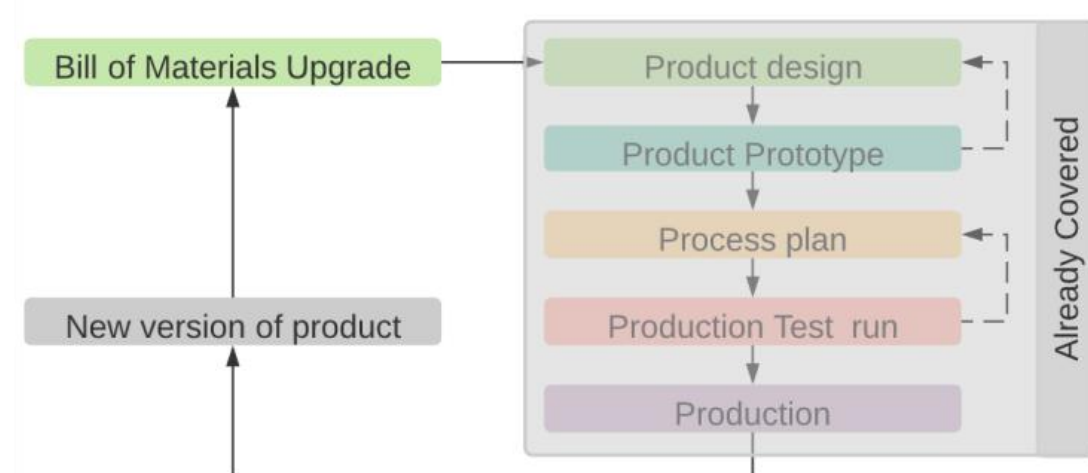


Figure 60 Sectioned diagram regarding Process development

Change is always enacted using the ECO functionality even in this case. To remind the reader the situation in which this change will be applied (Figure 61) is the product overview of the relevant product items. Every product item in that list (that is not a raw material) poses at least one BOM and two ECOs already applied to them in order to signify the initial state of every product item (Figure 62). The first ECO of every item affects the product and it holds the initial related files, the second is applied to the BOM of the product in order to hold files related to the initial state of the process as well as record the initial state of the BOM. Without these ECOs (Figure 62), when we ever applied an improvement, the initial state of the product files or BOMs would be lost.

即使在這種情況下，也始終使用 ECO 功能來實施變更。提醒大家請讀者了解將應用此變更的情況（圖 61）是產品概述相關產品項目。此清單中的每個產品項目（不是原材料）構成至少已應用一個 BOM 和兩個 ECO 以表示初始狀態每個產品項目（圖 62）。每個項目的第一個 ECO 都會影響產品，並且它保存初始相關文件，第二個應用於產品的 BOM 以保存與流程初始狀態相關的文件以及記錄 BOM 的初始狀態。如果沒有這些 ECO（圖 62），當我們應用改進時，初始狀態產品檔案或 BOM 將會遺失。

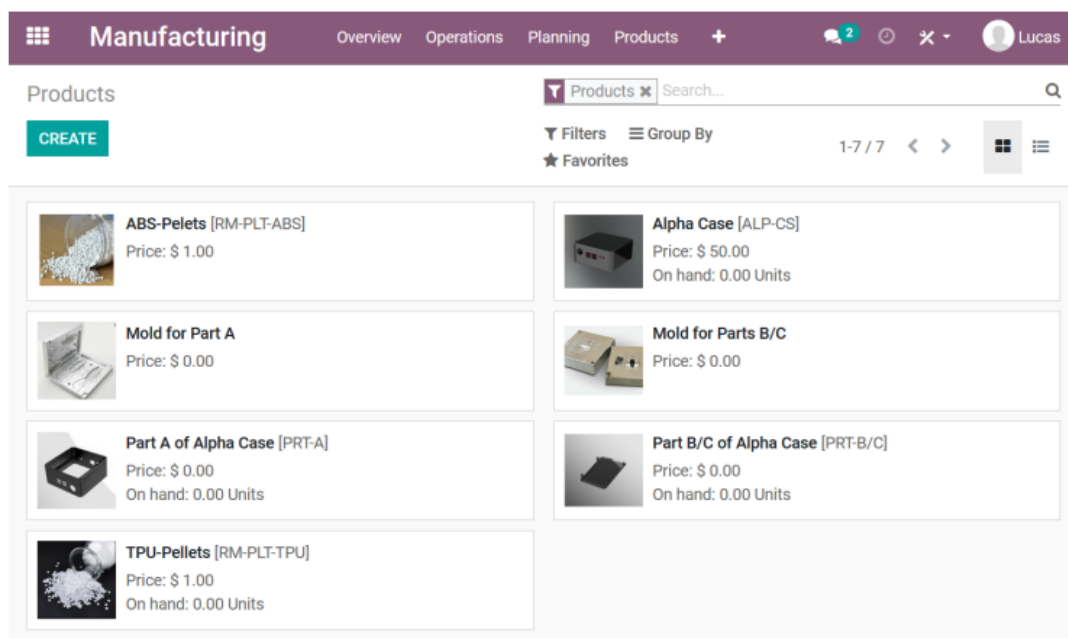


Figure 61 Relevant product items overview

Reference	Bill of Materials	Responsible	Effectivity Date	Stage
<input type="checkbox"/> ECO0001: Files Upload		Lucas		Effective
<input type="checkbox"/> ECO0006: Initial BOM	[ALP-CS] Alpha Case	Lucas		Effective

Figure 62 Example of ECOs of a product item

This time around the production duration and the estimated duration of the process is something that need to be taken in consideration so we can perceive how that applied change on the process affect production. To this end a MO of 50 units of Alpha Case will be created with each operation being estimated to take 30 seconds (15s for parts B/C because there is the need for 2 of them). Meaning that in an ideal situation the total length would be 50 minutes (25 of injection production being done in parallel and 25 for final assembly).

這次的生產持續時間和流程的預期持續時間是需要考慮的事情，以便我們能夠了解如何應用變化對工藝影響生產。為此，將創建 50 個 Alpha Case 單位的 MO 每個操作預計需要 30 秒（B/C 部分需要 15 秒，因為有需要其中 2 個）。這意味著在理想情況下總長度為 50 分鐘（25 注射生產並行完成，25 分鐘用於最終組裝）。

In this simulated manufacturing run it was chosen that the injection operations would take slightly more time to complete to be representative of a suboptimal performance. This is been done to see how Odoo reacts and informs in real time the situation in hand.

在此模擬製造運行中，選擇注射操作需要稍微多一點的時間來完成代表次優效能。這這樣做是為了看看 Odoo 如何反應並即時告知當前情況。

The first phase of the production in the injection process that is carried out in parallel for parts A and B/C on the injection stations 1 and 2. The following (Figure 64) shows how in the beginning of the process the overview of the productions stations indicate with green circles. These circulars signaling in known as Andon and although it is not always considered part of MES it is commonly an integrated feature in many MES systems. After the production process have been carried out with a little delay the circle turned gray and overall efficiency has been marked red on the station tabs (Figure 64).

第一階段的生產在注射過程中並行進行注射站 1 和 2 上的 A 和 B/C 部分。下圖（圖 64）顯示如何流程開始時，生產站概覽以綠色顯示界。這些通告信號被稱為 Andon，儘管並不總是被考慮它是 MES 的一部分，通常是許多 MES 系統中的整合功能。生產後該過程已進行，有一點延遲，圓圈變為灰色，整體效率已在網站標籤上標示為紅色（圖 64）。

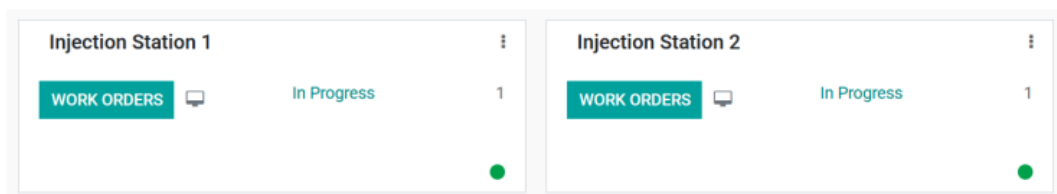


Figure 63 Workcenter overview 1

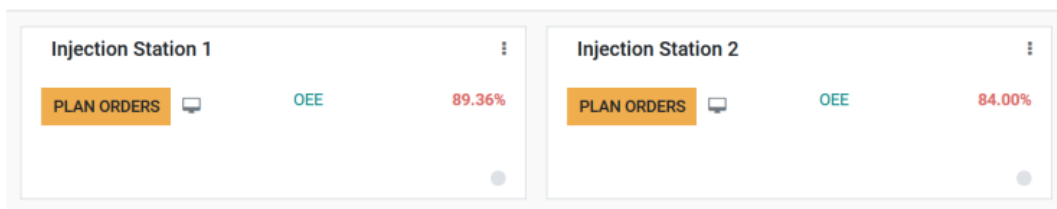


Figure 64 Workcenter overview 2

The production was carried out twice before any improvement was applied. The first improvement to be carried out were on the production process on the operation and the raw materials used. More specifically, a new operation representative of an equipment upgrades on the injection machines and the replacement of the brand of plastic pellets use in the injection process (Figure 65).

在進行任何改進之前，生產進行了兩次。首先需要對生產流程、操作和原料進行改進使用的材料。更具體地說，新的操作代表了設備的升級關於注射機和更換塑膠顆粒使用的品牌注射過程（圖 65）。

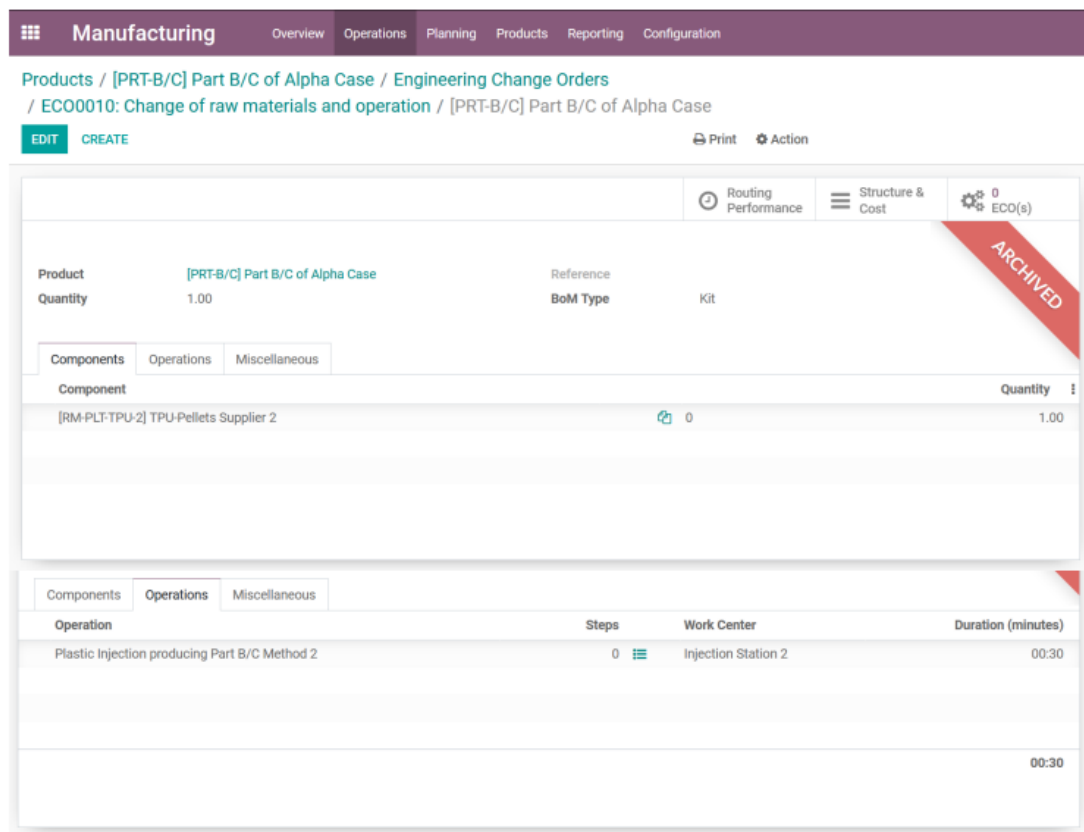


Figure 65 ECO applied to BOM

These upgrades were applied to the BOMs of parts A and B of the Alpha case and production recommenced. After two other MOs producing 50 products each simulating an improvement to the process the following types of data were automatically made available by Odoo (Table 3):

這些升級應用於 Alpha 外殼的 A 和 B 部分的 BOM，以及重新開始生產。在另外兩個 MO 生產 50 個產品後，每個 MO 類比流程改進 自動提供以下類型的數據由 Odoo（表 3）：

Table 3 Types of data output

Regarding WOs:	Regarding MOs:	Overall Effectiveness:	Equipment
<ul style="list-style-type: none"> -Duration deviation -Duration per unit -Expected duration -Quantity -Real duration 	<ul style="list-style-type: none"> -Backorder sequence -Extra cost -Quantity to produce -Total quantity 	<ul style="list-style-type: none"> -Quantity 	

It should be commented that the data regarding MOs is unfortunately captured in a monthly basis as opposed to the other two categories that process data per order executed. This means that since this simulation is using a trial version of the software that lasts only 14 days the graphical representation of that data offers an unimpressive view of a single point or a single column. In the long run this is a great way to display performance over time but in the case of this simulation not so much (Figure 66).

應該指出的是，不幸的是，有關 MO 的數據被捕獲在每月，而不是處理每個執行訂單數據的其他兩個類別。這意味著，由於此類比使用的是僅持續 14 的軟體試用版天 該數據的圖形表示提供了單個點的不起眼的視圖或單列。從長遠來看，這是顯示性能隨時間推移的好方法，但是在這種模擬的情況下，情況並非如此（圖 66）。

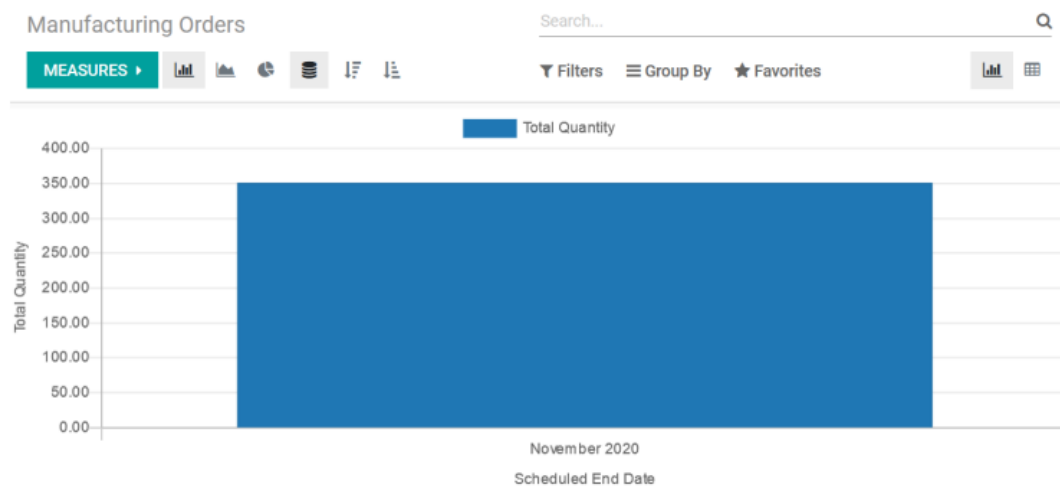


Figure 66 Total quantity regarding MO

All the data available can be seen in the form of bar charts, line charts or pie charts automatically generated after the time performance is registered (which happens at any moment an action is performed in a work order). Figure 67, Figure 68 and Figure 69 are examples of the results of the 5 production runs:

所有可用的數據都可以以條形圖、折線圖或餅圖的形式查看在註冊性能后自動生成（在任何在工作訂單中執行操作的時刻）。圖 67、圖 68 和圖 69 分別是 5 次生產運行的結果範例：

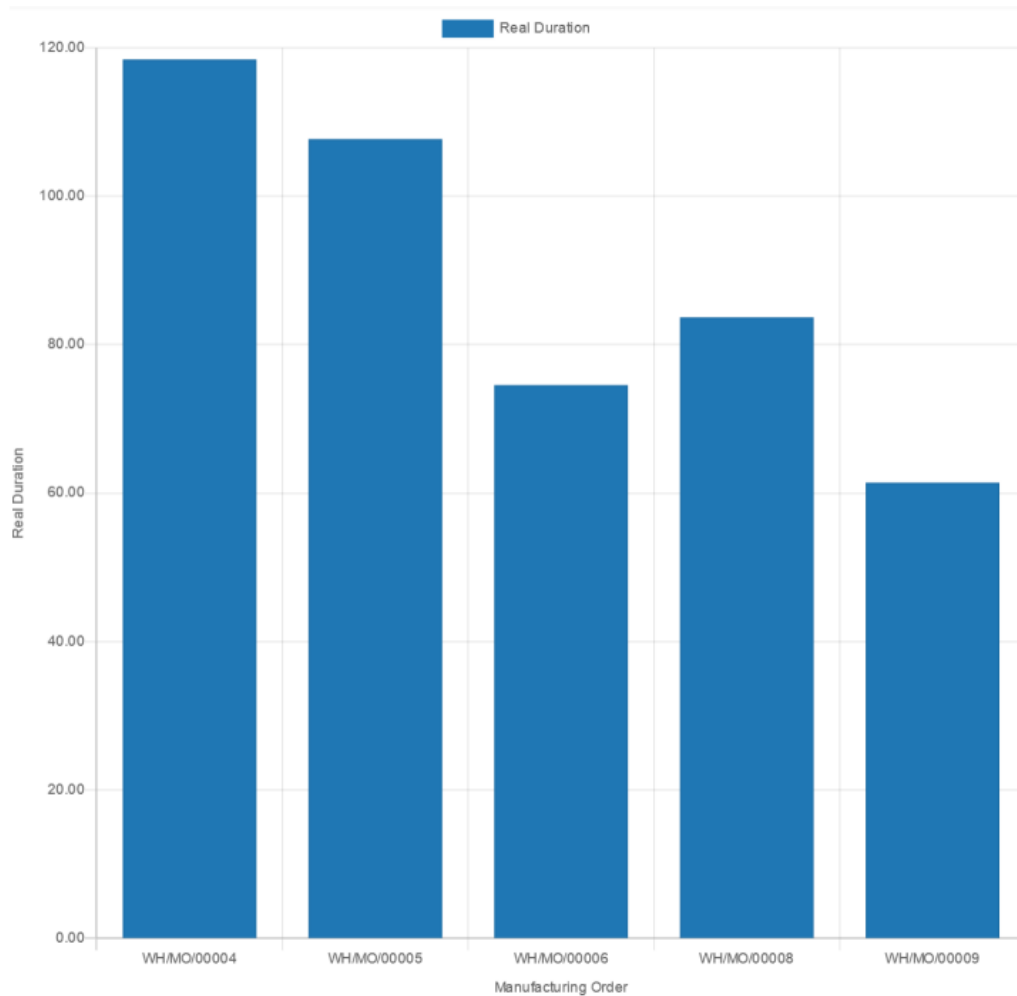


Figure 67 Real duration regarding work orders

Something worth mentioning here is that whenever Odoo mentions quantity or duration it is referring to amount per workorder summed (the system does not care if the operations are being carried in parallel). So, on our simulation, making 50 units using 3 operations that should take 30 seconds each the estimated “duration” to be recorded ideally here is 75 minutes per MO.

這裡值得一提的是，每當 Odoo 提到數量或持續時間時它指的是每個工單的總和金額（系統不關心操作是否並行進行）。因此，在我們的類比中，使用 50 個操作製作 3 個單元每個應該需要 30 秒，估計要記錄的“持續時間”，理想情況下，這裡是 75 每 MO 分鐘數。

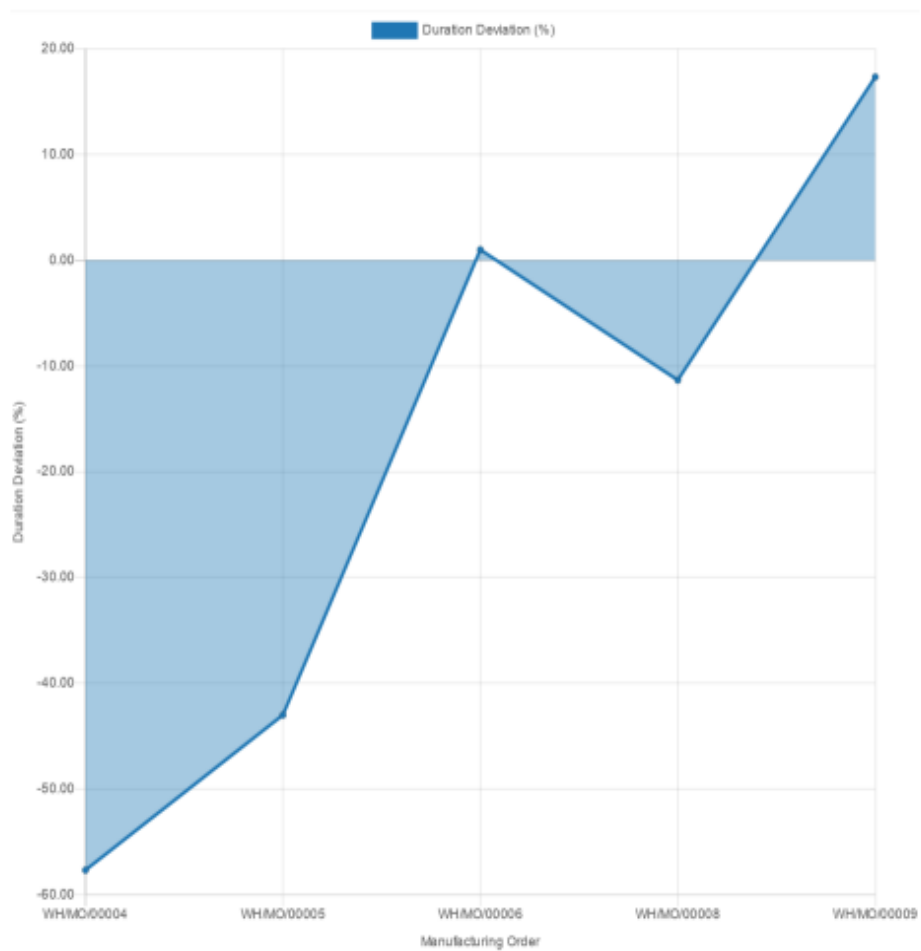


Figure 68 Duration variation regarding work orders

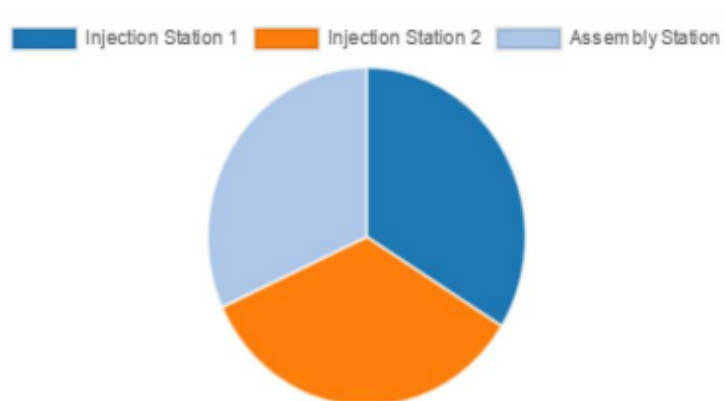


Figure 69 Overall equipment effectiveness

The astute reader will notice that all the data mentioned so far is derived from the time to completion of the operations been carried out, the related amount to the MO and the workcenter utilized. Even so it is impressive how much information can be drawn especially considering that it is all generated automatically.

敏銳的讀者會注意到，到目前為止提到的所有數據都是從完成操作后，相關金額應向 MO 和已使用工作中心。即便如此，可以繪製多少信息還是令人印象深刻，尤其是考慮到它都是自動生成的。

6. CHAPTER 章節

ODOOS ACOMPLISHMENTS REGARDING PLM AND MES

(ODOOS 在 PLM 的成就製造執行系統)

This chapter aims to summarize the strengths and weaknesses of the Odoo software focusing on the questions raised on section 4.2. It will also comment Odoo functionalities or lack thereof noticed throughout the simulation also taking the questions into account.

本章旨在總結 Odoo 軟體的優點和缺點重點關注 4.2 節提出的問題。它還會評論 Odoo 功能或考慮到問題，整個模擬過程中也注意到缺乏這一點。

6.1.How does the software deals with items?

軟體如何處理專案？

Overall, the Odoo software presents the user with a wide variety of digital items that can be used to represent several aspects of manufacturing as well as other aspects of business. This is mainly due to the way the Odoo ERP functionality uses items to track the pull and push actions throughout its use, that is also how automation is achieved in the software.

總體而言，Odoo 軟體為用戶提供了各種各樣的數位項目，可以可用於表示製造的多個方面以及業務的其他方面。這主要是由於 Odoo ERP 功能使用項目來追蹤拉動和在整個使用過程中推動操作，這也是軟體實現自動化的方式。

6.1.1. Are all aspects of the product lifecycle represented?

是否代表了產品生命週期的所有面向？

One of the disadvantages of being derived from a ERP system is that it focus on the primary scope of ERP (Figure 2) ,that is, production and sales. The Items in Odoo reflect that. For instance, the development part of the life cycle during the simulation, although the representation was possible it certainly felt like a stretch of functionalities made for the production phase rather than development is self (Figure 70). When developing prototypes for instance many of the steps like creating an ECO just to carry files in the beginning and going through many steps every time an adjustment in the prototype was made felt too bureaucratic or too much of a workaround.

源自 ERP 系統的缺點之一是它專注於 ERP 的主要範圍（圖 2），即生產和銷售。Odoo 中的項目反映那。例如，模擬過程中生命週期的開發部分，儘管代表性是可能的，它確實感覺像是為生產階段而不是開發階段是自我的（圖 70）。開發原型時例如，許多步驟，例如建立 ECO 只是為了在開始時攜帶文件，每次原型調整時也感覺要經歷許多步驟官僚主義或太多的解決方法。

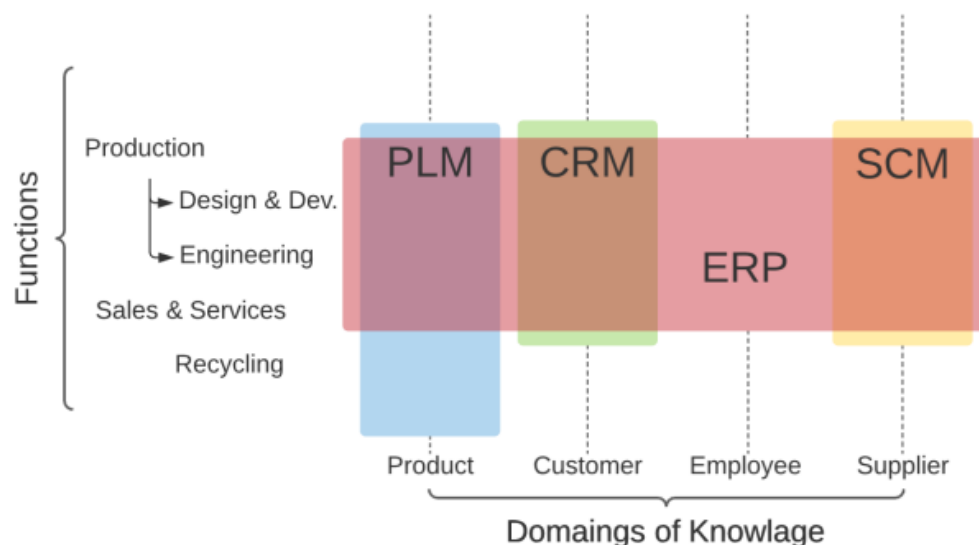


Figure 70 Diagram representing Odoo scope of ERP

6.1.2. How well are each of those items represented?

這些項目的表現如何？

Representation levels of the items vary depending on how the item is used. A good example of that is the material focus of product items. In the sense that everything is considered a product with very little distinction between prototypes or raw materials. The representation of product items or BOM items is very high with a lot of metadata and useful connections to other items. However, even within the manufacturing application there are some items that lack attention. Operations for instance are items that could benefit greatly from more upload capabilities like 3D printing or CNC files. As automation is becoming more widespread in production it is no longer enough to have only PDF or slide instructions. Additionally, other items do not have the ability of holding files not even with the use of ECOs

專案的表示級別因專案的使用方式而異。一個好的例如，產品專案的材料重點。從某種意義上說，一切都是被認為是原型或原材料之間幾乎沒有區別的產品。這產品項或 BOM 項的表示非常高，具有大量元數據且有用與其他項目的連接。但是，即使在製造應用中，也有一些缺乏關注的專案。例如，操作是可以大大受益的專案來自更多上傳功能，如 3D 列印或 CNC 檔。隨著自動化的發展在生產中更為普遍，僅有 PDF 或幻燈片說明已經不夠了。此外，其他項目不具備保存檔的能力，即使使用生態組織

6.2.How easy it is to create a brand-new product?

創造一個全新的產品有多容易？

Product creation is one of the most straightforward procedures in Odoo, it really comes down to using either the Inventory application or the Manufacturing application to create a new Product and then fill in its metadata.

產品創建是 Odoo 中最直接的程式之一，它確實來了直至使用「庫存」應用程式或「製造」應用程式創建 new Product，然後填寫其元數據。

6.2.1. How is the product depicted?

產品是如何描述的？

The product depiction is clear and concise, the product item allows for an image to be uploaded to the item and used as an icon. The ERP nature of the product items in Odoo means that the metadata is reasonably bias toward information that is used to manage storage and inventory (Weight, Volume, Quantity etc.) but the item also allows for written description as well as providing links to the BOMs and ECOs related to the product.

產品描述清晰簡潔，產品專案允許圖像上傳到專案並用作圖示。Odoo 中產品項的 ERP 性質意味著元數據合理地偏向於用於管理存儲的資訊，以及庫存（重量、體積、數量等），但該專案也允許書面描述以及提供與產品相關的 BOM 和 ECO 的連結

6.2.2. How does the product integrate and reference relevant files?

產品如何整合和引用相關文件？

There is surely a reasonable attempt in allowing the most valuable items (Product and BOMs) to be able to manage and reference relevant files. However, Odoo does not implement much more than the bare minimum as far as file management goes. The most it can do is allow for files to be uploaded and download manually. This means that whenever someone makes a change in a file it needs to be manually uploaded in ECO. Integration with most files is inexistent except for operation items because the instruction files can be opened and interacted within Odoo during the production.

肯定有合理的嘗試來允許最有價值的物品（產品和 BOM）能夠管理和引用相關文件。然而，Odoo 並沒有實現就文件管理而言，遠遠超出了最低限度。它最多能做的就是允許手動上傳和下載檔案。這意味著每當有人對需要手動上傳到 ECO 的檔案進行更改。與大多數文件集成由於指令檔可以打開，除操作項外不存在在製作過程中與 Odoo 互動。

6.2.3. Does changing one affects the other?

改變一個會影響另一個嗎？

It does not, files are mostly dealt by Odoo as paperwork for later reference. Anything added file wise that could entail a change in the product or BOM metadata will require someone to be aware of the change and update the information manually.

事實並非如此，檔主要由 Odoo 作為文書工作處理，以供以後參考。什麼添加的檔明智，可能需要更改產品或 BOM 元數據有人瞭解更改並手動更新資訊。

6.3.How easy it is to create a brand-new production process?

創建一個全新的生產過程有多容易？

As mentioned before the item the best represents the process is the bill of materials. This item class requires an existing product to be associated with, other that the BOM is no harder to create than a product item.

如前所述，最能代表該過程的專案是物料清單。這物料類需要與現有產品相關聯，但物料清單並不難創建比產品項。

6.3.1. How the process is depicted? 這個過程是如何描述的？

The process is depicted in the BOM as a list of components (other product items) and operations that are carried out in as specific order to produce a number of end products. This representation seems to sit well with the production procedure. Metadata is kept to a minimum but there is still the capability to offer a text description.

該過程在物料清單中描述為元件清單（其他產品專案）和以特定順序執行的操作，以生產許多最終產品。這代表似乎與生產程式相得益彰。元數據保留在最小，但仍然能夠提供文本描述。

6.3.2. How does the process integrate and reference the product it produces?

流程如何集成和參考產品生產？

The integration between the BOM and the product items is by far the most well done in Odoo. Changes made in the BOM affect production and are directly linked to the product. Whenever metadata changes are possible and said aspect is represented in the product item as well the change of one is inherited by the other.

BOM 和產品項之間的集成是迄今為止做得最好的奧杜。BOM 中所做的更改會影響生產，並與產品直接相關。每當元數據可以更改並且所述方面在產品項中表示時同樣，一個的變化被另一個繼承。

6.3.3. Does changing one affects the other?

改變一個會影響另一個嗎？

As far as inventory and manufacturing is concerned integration is and referencing is well implemented. Production results flawlessly in the resulting changes in inventory and the navigation path of the GUI is very well optimized. It does not take more than 3 or 4 clicks to get from one product to another or to navigate to other relevant items.

就庫存和製造而言，集成是很好的，參考是很好的實現。生產結果在由此產生的庫存變化和 GUI 的導航路徑得到了很好的優化。它不需要超過 3 或 4 次點擊從一個產品轉到另一個產品或導航到其他相關專案。

6.4.How easy is to improve an existing product/ production process?

改進現有產品/生產流程有多容易？

As mentioned previously, all improvements in Odoo are performed using engineering change orders. These are applied to product items or bill of materials. Creating ECOs is quite easy and organized, the ECO is an item on itself that symbolizes a signal given to create change, once effective, it symbolizes an increment on the product or process.

如前所述，Odoo 的所有改進都是使用工程來執行的變更單。這些應用於產品物料或物料清單。創建 ECO 是相當 ECO 簡單而有條理，本身就是一個專案，象徵著創造的信號變化，一旦生效，它象徵著產品或過程的增量。

6.4.1. How easy it is to update its metadata 更新元數據有多容易

It is easy to update any metadata regarding any item in Odoo; however, it is wise to point out that since the ECOs are separate items that are just point by products or BOMs many of the changes are not automatic and require manual intervention. I.e. an ECO will not change the text description of the product for instance. If the new update were to require a change on that description it would require a manual intervention from the user in the product item. Doing that is easy, but it is an extra task that will not be tracked by the ECO.

更新 Odoo 中任何項目的任何元資料都很容易；然而，明智的做法是指出指出，由於 ECO 是單獨的項目，只是按產品或 BOM 來劃分，許多這些變更不是自動的，需要手動幹預。IE。ECO 不會改變例如產品的文字描述。如果新的更新需要更改根據該描述，需要使用者對產品項進行手動幹預。這樣做很容易，但這是一項額外的任務，ECO 不會追蹤。

6.4.2. How easy it is to determine the effects of the change?

確定變革的影響有多容易？

Odoo feedback of information is mainly done in a manufacturing order basis. The information available is clear and ECOs do not affect MOs that are already under way so the effects of an applied ECO would not be hard to notice. However, it is good to point out that in the way the performance information is displayed there is no indication of the product revision or the ECO applied. This means that the user would need to first figure when the ECO was applied, then navigate to the equivalent MO in the data to draw its conclusions. Although not a problem for recent changes this does becomes problematic if someone want to analyze effects of old changes.

Odoo 的資訊回饋主要是在製造訂單的基礎上完成的。這現有資訊很明確，ECO 不會影響已經在進行的 MO，因此應用 ECO 的效果不難注意到。不過，值得指出的是性能資訊的顯示方式沒有任何產品的指示修訂或應用 ECO。這意味著用戶需要先計算應用 ECO，然後導航到資料中的等效 MO 來得出結論。雖然最近的變化不是問題，但如果有人想要的話，這確實會成為問題分析舊變化的影響。

6.4.3. How does the software deals with different product revisions?

軟體如何處理不同的產品版本？

Version control is something well covered by the 1 to N relation between product/BOM and linked ECOs. Every product will have a tab containing all the ECOs applied to it in chronological order effectively working as a timeline representing the item evolution.

產品/BOM 之間的 1 對 N 關係很好地涵蓋了版本控制和連結的 ECO。每個產品都會有一個選項卡，其中包含應用於該產品的所有 ECO 時間順序有效地作為代表專案演變的時間軸。

6.5.How easy is to find data related to product or process?

尋找與產品或流程相關的資料有多容易？

Most of the data related to performance regarding production is concentrated under the reporting tab as mentioned in the previous chapter (Figure 71).

大多數與生產績效相關的數據都集中在上一章提到的報告標籤（圖 71）。

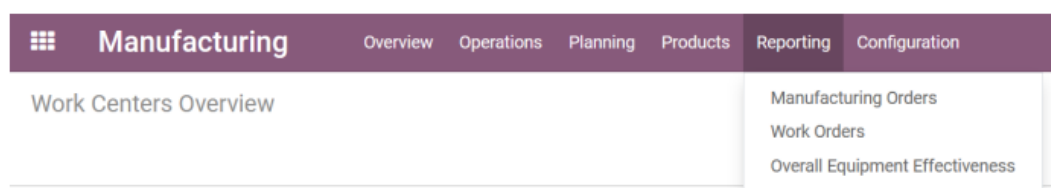


Figure 71 GUI Options of data reporting

This means that as far as performance is concerned it is quite easy to find the data. The previous chapter will show examples of possible information that are available within those tabs.

這意味著就效能而言，查找數據非常容易。這前一章將展示這些內容中可能提供的資訊的範例選項卡。

In addition to using this path the UI of the product item also has a tab that point to the monthly comparison of production volume regarding the product (Figure 72). Which would be more impressive if there was more than one month in the trial version of Odoo.

除了使用此路徑之外，產品項目的 UI 還具有一個指向本產品的每月產量比較（圖 72）。這將如果 Odoo 的試用版有超過 1 個月的時間，那就更令人印象深刻了。

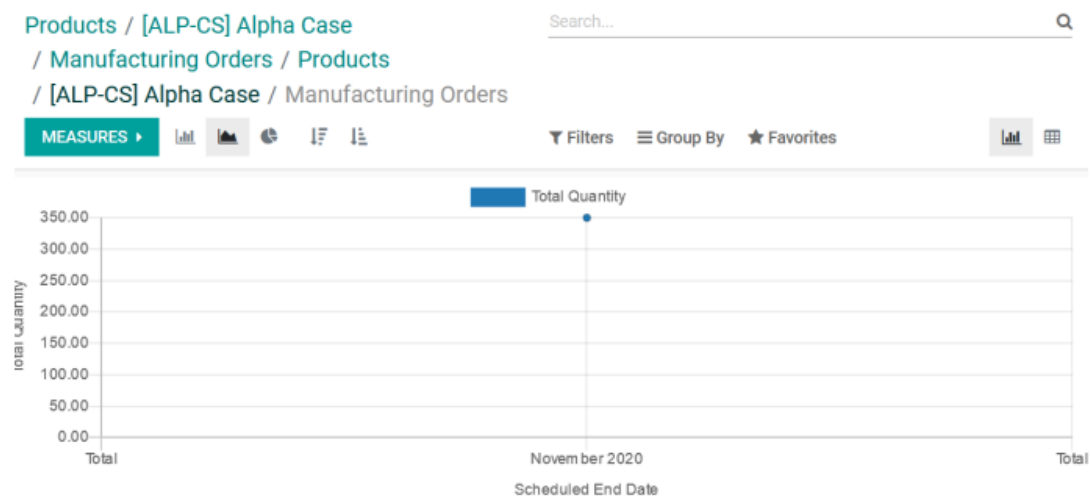


Figure 72 Total quantity regarding MO from product item

6.5.1. How easy is find production numbers?

要找出生產編號有多容易？

In addition to the previously mentioned ways, Odoo also makes available a unit forecast graph that records the ins and outs of the inventory. This is particularly useful to estimate sales and balance storage with demand (Figure 73). This feature is not mentioned to much in this work because supply and demand is not so much a MES functionality, but it is to useful to have an overview of the production.

除了前面提到的方法外，Odoo 還提供單位預測記錄庫存進出狀況的圖表。這對於估計特別有用銷售和平衡儲存與需求（圖 73）。這個功能在本文中並沒有太多提及這項工作之所以有效，是因為供應和需求與其說是 MES 功能，但它非常有用了解生產情況。

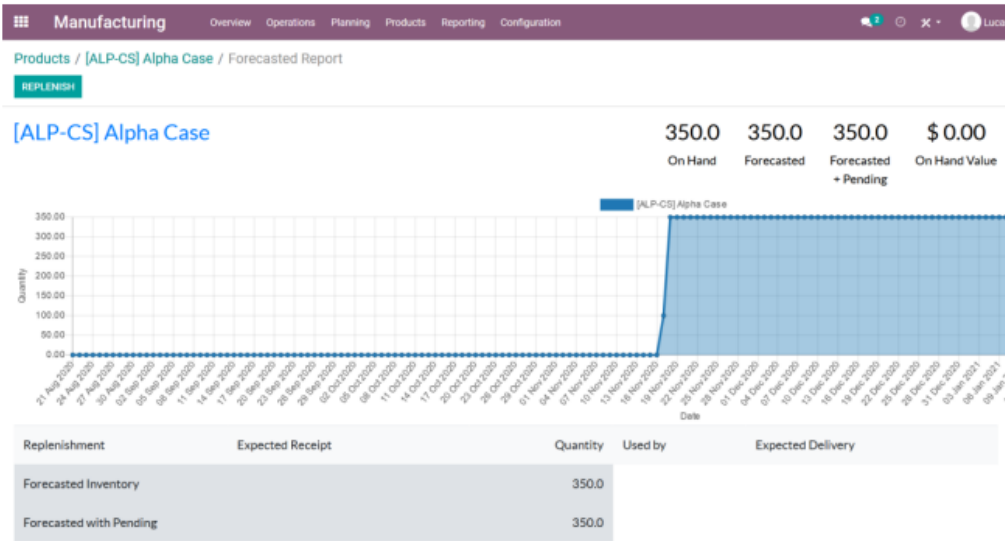


Figure 73 Unit forecast overview

6.5.2. How does Odoo generate performance data? Odoo 如何產生效能數據？

The astute reader will notice that all the data mentioned so far is derived from the time to completion of the operations been carried out, the related amount to the MO and the workcenter utilized. Even so it is impressive how much information can be drawn especially considering that it is all generated automatically.

精明的讀者會注意到，到目前為止提到的所有數據都來自於已進行的操作的完成情況、MO 的相關金額以及使用工作中心。即便如此，我們仍然可以得出如此多的信息，尤其是考慮到它都是自動產生的。

6.5.3. How does the software present performance change as a result of a upgrade? 軟體如何呈現效能變化升級？

In order to identify the change, the user must identify the MOs following the change and see the difference based on that. Ideally it would be nice if the graphical information showed the revision of the product, but this is not present as of Odoo V13

為了識別變更，使用者必須識別變更後的 MO，並且基於此查看差異。理想情況下，如果能顯示圖形資訊就更好了產品的修訂版，但從 Odoo V13 開始不存在

CONCLUSION 結論

In chapter 2 I referenced a diagram that represents a theoretical ideal of how the integration of PLM with other systems should be (Figure 74). In that diagram the reader can notice that ideally PLM would be the center of the system with other systems (Including ERP) attached to it. Different from said diagram the Odoo software takes ERP as the center with other systems attached to it. This work has shown that it is certainly possible to use Odoo for PLM and MES however it has also shown that the PLM and MES implementation presents some weaknesses.

在第 2 章中，我引用了一張圖表，該圖表代表了如何 PLM 應該與其他系統集成（圖 74）。在該圖中，讀者可以請注意，理想情況下，PLM 將是系統的中心，與其他系統（包括 ERP）附加到它。與上述圖表不同的是，Odoo 軟體以 ERP 為中心並附有其他系統。這項工作表明，使用然而，Odoo 用於 PLM 和 MES 的實施存在一些弱點。

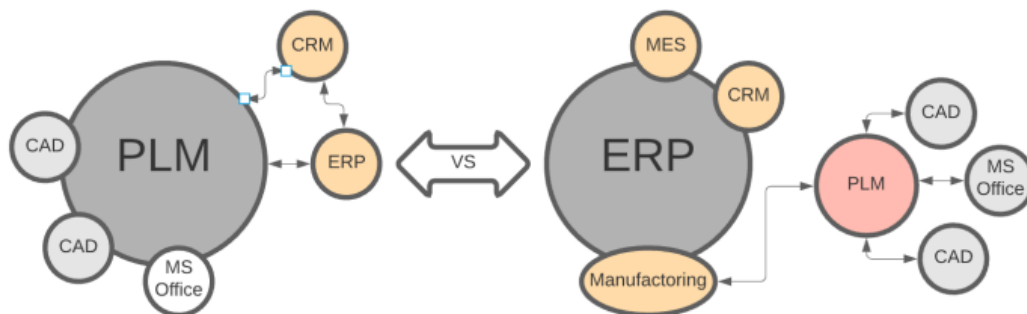


Figure 74 Comparison to the left the adapted diagram as theorized by Saaksvuori, A. and Immonen, A. (2008), to the right Odoo take on how systems interact.

Figure 74 Comparison to the left the adapted diagram as theorized by Saaksvuori, A. and Immonen, A. (2008), to the right Odoo take on how systems interact.

圖 74 左邊的比較是 Saaksvuori, A 理論上的改編圖。和 Immonen, A. (2008), 右邊的 Odoo 對系統如何交互進行了研究。

The lack of file upload support on things like operation items, work centers or equipment is something of some concern especially considering 3D printing or CNC because access to the CAD files would prove helpful to the operators. Also, there is a gap in between the facets of product and tool when the company is taking upon themselves to develop and produce said tooling (similar situation founded when developing the molds in the simulation).

缺乏對操作專案、工作中心或設備等內容的檔上傳支援這是一些值得關注的問題，特別是考慮到 3D 列印或 CNC，因為可以訪問 CAD 檔將對操作員有所說明。此外，刻面之間也存在間隙當公司自行開發和生產時，產品和工具所述工具（在類比中開發模具時出現類似情況）。

In addition, although MES provide detailed graphical representation regarding the dataset that it has, it is limited to data derived from the time to completion of the operations been carried out. For instance, it would be very valuable if graphical representation regarding quality control was easily available as well.

此外，儘管 MES 提供了有關數據集的詳細圖形表示它有，它僅限於從操作完成時間得出的數據進行。例如，如果圖形表示品質控制也很容易獲得。

All that said, applying ECOs to BOMs in Odoo is a procedure deserving of praise. The ECO holds the information until it is ready to be applied and then it updates the BOM automatically once the ECO is validated by responsible personnel. It might not look like something so important now because this simulation is dealing with very simple products, but it becomes exponentially more important as complexity increases. E.g. A car with thousands of parts and hundreds of nested BOMs would be considered a nightmare to control and keep track of change if a system like this was not present.

綜上所述，將 ECO 應用於 Odoo 中的 BOM 是一個值得稱讚的過程。這 ECO 會保留資訊，直到準備好應用，然後更新 BOM 一旦 ECO 由負責人員驗證，就會自動執行。它可能看起來不像現在非常重要，因為這個類比正在處理非常簡單的產品，但隨著複雜性的增加，它變得越來越重要。例如，一輛汽車數千個零件和數百個嵌套 BOM 將被視為控制的噩夢如果沒有這樣的系統，請跟蹤更改。

This software is not perfect for PLM or MES implementation, but it does hold value in the sense of availability and integration with other systems. The functionality is there 76 specially regarding product and process and the software has an extremely interesting integration with its natural ERP functionalities. All this makes up for a system that would suit better:

該軟體對於 PLM 或 MES 實施並不完美，但它確實具有價值可用性和與其他系統的整合感。功能就在那裡 76 特別是關於產品和工藝，軟體有一個非常有趣的與其自然的 ERP 功能集成。所有這些都彌補了一個系統，該系統將更適合：

- Small business that could use PLM and MES in a smaller scale.
- 可以在較小規模上使用 PLM 和 MES 的小型企業。
- Companies that deal with less manufacturing and more assembly or distribution taking advantage of the All in One nature of the software.
- 處理較少製造和更多組裝或分銷的公司利用軟體的多合一性質。

It is important to mention that the limitations of Odoo are not in the complexity of the product itself but in the complexity of the operations that surround its development. All things considered you could track a large and complex assembly if it includes only simple manufacturing operations or if more complex engineering tasks are done by suppliers. I.e. you could track the assembly of a motorcycle with ease in Odoo, but the PLM features are not polish enough to track the full evolution/development of its powertrain. It is certainly possible to do so but it would take too much time and effort from the engineering team to be considered worth it just for the sake of having an all in one solution with ERP features.

值得一提的是，Odoo 的局限性不在於 Odoo 的複雜性。產品本身，但在圍繞其開發的操作的複雜性中。萬物考慮您可以跟蹤大型複雜裝配體，如果它只包含簡單的製造操作，或者更複雜的工程任務由供應商完成。即您可以在 Odoo 中輕鬆跟蹤摩托車的裝配，但 PLM 功能是不夠完善，無法跟蹤其動力總成的完整演變/發展。當然是可以這樣做，但工程團隊需要花費太多的時間和精力僅僅為了擁有具有 ERP 功能的多合一解決方案而被認為是值得的。

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