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MASTER THESIS

TITLE:

Process improvements in a material handling activity by applying lean production techniques

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Overview

This Master Thesis is about one of the most nowadays topics: Optimization in processes and methods applying the Lean philosophy. With the pursuit of improvements in logistics and resources companies' efficiency, Lean Manufacturing is acquiring an important role in the current business society.

The main objectives of this document are the study, proposal, achievement and analysis of improvements about packaging processes in *Talleres Bellvitge,* the place where the entire project has been done. Getting these improvements, using the initial resouces, it is obtained some benefits, adding more production and easiness to work in general. Also there is an improvement in terms of quality.

Lean Manufacturing is focused on reduction of the seven wastes in order to improve overall customer value, but there are varying perspectives on how this is best achieved. By eliminating waste, improving quality and production time and costs are reduced.

To make the project, gather data tools have been used. Applying these tools and formats, an initial study has been made and then proposal improvements.

After analyze the results, it is possible to show positive conclusion using Lean Manufacturing as an optimization method, because currently, there is more space, less time used and better quality in the final product.

Titulo: Mejora de procesos en material manipulado aplicando técnicas de producción Lean

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Resumen

Esta Tesis de Master trata sobre uno de los temas de mayor actualidad, la optimización de procesos y métodos mediante la filosofía Lean. Intentado mejorar la logística y la rentabilidad de los recursos de las empresas, Lean Manufacturing ha adquirido un papel muy importante en la sociedad empresarial actual.

Los principales objetivos de este documento son el estudio, la propuesta, la realización y el análisis de mejoras en los procesos de empaquetado que se realiza en Talleres Bellvitge. Obteniendo estas mejoras se consigue optimizar los recursos disponibles, añadiendo mayor producción y facilidad a los trabajos. También una mejora por lo que respecta a la calidad.

Lean Manufacturing trata de reducir los siete tipos de desperdicios (sobreproducción, tiempo de espera, transporte, exceso de procesado, inventario, movimiento y defectos) en productos manufacturados. Eliminando el despilfarro, la calidad mejora y el tiempo de producción y los costes se reducen.

Para realizar el proyecto se han utilizado herramientas Lean para recopilar datos. Mediantes estas herramientas y formatos, se ha hecho un primer estudio para luego proponer mejoras.

Tras el análisis de los resultados obtenidos, se puede llegar a una conclusión positiva puesto que la optimización de métodos y procesos mediante Lean Manufacturing nos ha aportado más espacio, mejores tiempo de producción y mayor calidad en el producto final.

Quisiera agradecer todo el apoyo prestado
por mi tutor de proyecto, Jordi Olivella y a
Néstor Gavilán, que con su orientación,
paciencia y ayuda han hecho posible
este trabajo. Y por supuesto a
Talleres Bellvitge y toda su gente.

A mi familia y amigos, sin los cuales
nada de esto existiría.

CONTENTS

INTRODUCTION, MOTIVATIONS AND OBJETIVES 1

CHAPTER 1. LEAN MANUFACTURING..... 5

1.1. Introduction 5

1.2. Wastes in Lean Manufacturing 5
1.2.1. Muda 6
1.2.2. Muri 7
1.2.3. Mura 7

1.3. Stages and tools 8

CHAPTER 2. WORK PLACE: *TALLERES BELLVITGE*..... 11

2.1. Introduction 11

2.2. Improvement projects done 12

2.3. Current situation 13

CHAPTER 3. PROCESS IMPROVEMENTS PLAN 17

3.1. Introduction 17

3.2. Current situation 18
3.2.1. Select a specific family process 18
3.2.2. Understand what the client wants 19
3.2.3. Carry out the process flow 19
3.2.4. Carry out the material flow 21
3.2.5. Carry out the information flow 23
3.2.6. Calculate the working cycle (Lead-time) 25

3.3. Future VSM 27

CHAPTER 4. IMPLEMENTATION 31

4.1. Introduction 31

4.2. Improvement implementation 31
4.2.1. Stage 1: 5s 31
4.2.2. Stage 2: New work places 37
4.2.3. Stage 3: Task panel 42
4.2.4. Stage 4: Input material position 44
4.2.5. Stage 5: Input material separation 47

CHAPTER 5. CONCLUSIONS 51

5.1. Project conclusions 51

5.2. Personal conclusions 52

BIBLIOGRAPHY **53**

ANNEXES **55**

A1. Wastes in Lean **55**

A2. Gather data **57**

A3. Future Talleres Bellvitge map **67**

INTRODUCTION, MOTIVATIONS AND OBJETIVES

Introduction

During last years companies invert more money and resources to improve. They want to optimizate their money, time and space.

Therefore the different improvements tools help organization to optimize its processes to achieve more efficient results.

The organization or company can be a private business, a non-profit organization or a government agency. Most improvement techniques were developed during the Manufacturing era, and nowadays many of the methodologies have been successfully adapted to work in the services business. Altough there are different challenges in every type of industry, in fact the main objective is to be able to apply in all industries and functions these methodologies and tools.

It should be taking into account that the improvement tools are focused on "doing things right" more than "doing the right thing". In general, they attempt to reduce variation and/or wastage in processes and activities.

Lean Manufacturing, or lean production, is the optimal way of producing goods through the removal of waste and implementing flow, as opposed to batch and queue. Lean manufacturing is a generic process management philosophy derived mostly from the Toyota Production System (TPS) [12].

Toyota's development of ideas that later became Lean may have started at the turn of the 20th century with Sakichi Toyoda, in a textile factory with looms that stopped themselves when a thread broke, this became the seed of *autonomation* and Jidoka.

Apart from these advantages, Lean Manufacturing methodology also has technical and functional challenges, always to find the best performance.

Motivations

Lean phylosophy is renowned for focus on reduction of the original Toyota seven wastes in order to improve overall customer value, but there are varying perspectives on how this is best achieved. The steady growth of Toyota, from a small company to the world's largest automaker, has focused attention on how it has achieved this.

In other words, Lean Manufacturing can be used:

- To significantly improve overall productivity.
- To increase market share.
- To improve speed-to-market with new products.
- To reduce manufacturing and engineering labor costs.
- To eliminate non-value-added operations and processes.

Therefore, it is obtained more benefits with the same or less time, money and space.

Lean Manufacturing is a philosophy with well-known and tested results that everyday is more common and used around the world.

Objetives

Lean implementation is focused on getting the right things, to the right place, at the right time, in the right quantity to achieve perfect work flow while minimizing waste and being flexible and able to change. Lean aims to make the work simple enough to understand, to do and to manage.

The objective of this Master Tesis is to carry out a study, proposal, achievement and analysis of improvements about packaging processes in *Talleres Bellvitge*. Getting these improvements, it is obtained some benefits, adding more production and easiness work and also an improvement in terms of quality.

Talleres Bellvitge is a non-profit organism that works in the job insertion to physically handicapped people. The company works in handling and packaging, printing and delivery service for the purchase bought in municipal markets.

To make this project, it has been carried out four different chapters and one more for the conclusions.

In the first chapter there is a small introduction to understand better the Lean Manufacturing and the different tools used. The second chapter shows the working place, the different Lean Manufacturing projects done and the current situation. This chapter permits to observe and define the possible improvement points.

Therefore, in the third chapter is specified the process improvement plan. In other words, it shows the different steps to arrive to possible improvement that

can be done in *Talleres Bellvitge*. In the fourth chapter is specified the improvements implementations done and the results about this changes.

Finally, there are some conclusions to finish this entire Master Thesis.

CHAPTER 1. LEAN MANUFACTURING

1.1. Introduction

During many years companies have been creating and using tools to identificate and eliminate waste during a process to improve the quality production time and to reduce the process cost.

To solve the problem of waste, Lean Manufacturing has several tools. These include continuous process improvement, the *Five Whys* and mistake-proofing. In this way it can be seen as taking a very similar approach to other improvement methodologies.

Lean implementation is therefore focused on getting the right things, to the right place, at the right time, in the right quantity to achieve perfect work flow while minimizing waste and being flexible and able to change. Lean aims to make the work simple enough to understand, to do and manage.

1.2. Wastes in Lean Manufacturing

Lean manufacturing is a process management philosophy. It is the production of goods using less of everything compared to mass production: less waste, less human effort, less manufacturing space, less investment in tools and less engineering time to develop a new product.

Lean manufacturing is a generic process management philosophy derived mostly from the *War Manpower Commission* which led to the *Toyota Production System (TPS)* and also from other sources. It is renowned for focus on reduction of the original Toyota '*seven wastes*' in order to improve overall customer value but has some new keys perspectives on how to do this.

Lean is often linked with *Six Sigma* because of that methodology's emphasis on reduction of process variation and Toyota's combined usage (with the TPS). Toyota's steady growth from a small player to the most valuable and the biggest car company in the world has focused attention upon how it has achieved this, making ‘Lean’ a hot topic in management science in the first decade of the 21st century.

The elimination of waste is the goal of Lean philosophy. While the elimination of waste may seem like a simple and clear subject it is noticeable that waste is often very conservatively identified. This hugely reduces the potential of such an aim. Toyota defined three types of waste:

- ***Muda* (or nonvalue-added work):** Muda is discovered after the process is in place and is dealt with reactively. It is seen through variation in output.

- ***Muri* (or overburden):** It is focused on the preparation and planning of the process, or what work can be avoided by design.

- ***Mura* (or unevenness):** It focuses on implementation and the elimination of fluctuation at the scheduling or operations level, such as quality and volume.

1.2.1. Muda

Muda is traditional general Japanese term for activity that is wasteful and does not add value or is unproductive.

A process adds value by producing goods or providing a service that a customer will pay for. A process consumes resources and waste occurs when more resources are consumed than are necessary to produce the goods or provide the service that the customer actually wants. The attitudes and tools of the TPS heighten awareness and give whole new perspectives on identifying waste and therefore the unexploited opportunities.

Muda has been given much greater attention as waste than the other two which means that whilst many Lean practitioners have learned to see muda they fail to see in the same prominence the wastes of *Mura* and *Muri*. Thus while they are focused on getting their process under control they do not give enough time to process improvement by redesign.

One of the key steps in Lean and TPS is the identification of which steps add value and which do not.

The expression "Learning to see" comes from an ever developing ability to see waste where it was not perceived before. The following Seven Wastes (see Annexe 1) identify and classify resources which are commonly wasted.

- ***Overproduction**:* Production ahead of demand.
- ***Transportation**:* To move products that is not actually required to perform the processing.
- ***Waiting***: Waiting for the next production step.
- ***Inventory**:* All components, work-in-progress and finished product not being processed.
- ***Motion***: People or equipment moving or walking more than is required to perform the processing.
- ***Over-Processing**:* Due to poor tool or product design creating activity.
- ***Defects**:* The effort involved in inspecting for and fixing defects.

1.2.2. Muri

Muri is traditional general Japanese term for overburden or unreasonableness.

Muri can be avoided through standardised work. To achieve this standard condition or output must be defined to assure effective judgement of quality. Then every process and function must be reduced to its simplest elements for examination and later recombination. The process must then be standardised to achieve the standard condition. This is done by taking simple work elements and combining them, one-by-one into standardised work sequences.

In manufacturing, this includes:

- ***Work Flow:*** Logical directions to be taken.
- ***Repeatable Process Steps and Machine Processes:*** Rational methods to get there.
- ***Takt time:*** Maximum time allowed producing in order to meet demand.

When everyone knows the standard condition, and the standardised work sequences, the results observed are:

- Employee morale is heightened
- Higher quality is achieved
- Productivity is improved
- Costs are reduced.

1.2.3. Mura

Mura is traditional general Japanese term for unevenness. Waste reduction is an effective way to increase profitability.

Mura is avoided through the *Just in Time Systems*. It is based on little or no inventory, by supplying the production process with the right part, at the right time, in the right amount, and first-in, first out component flow. Just in Time systems create a pull system in which each sub-process withdraws its needs from the preceding sub-processes, and ultimately from an outside supplier. When a preceding process does not receive a request or withdrawal it does not make more parts.

This type of system is designed to maximize productivity by minimizing storage overhead.

If parts or material defects are found in one process, the Just in Time approach requires that the problem be quickly identified and corrected.

1.3. Stages and tools

When a Lean Management is implemented some stages are needed. It is possible to distinguish three different stages.

- 1st Stage: Diagnosis and improvement opportunities
- 2nd Stage: Improvement implementations
- 3rd Stage: Evaluation

The first stage is useful to observe and know the different movements and waste. Then a diagnosis and improvement opportunities can be defined.

Second stage starts when a planning is finished and now, it has to try to implement the improvement opportunities defined before.

Finally, when the project is finished, it is very important to check and review how the activity works with the new modifications. This stage is the third one. When this stage is finished, it has to start all stages another time. That is the reason why it is known as continuous improvement methodology.

To apply the different stages and, in general, the Lean philosophies thecniques there are several tools. The most important tools are:

- **Value Stream Mapping (VSM)**: Used to analyse the flow of materials and information currently required to bring a product or service to a consumer.

- **5S**: It is a reference to a list of five Japanese words (Seiri, Seiton, Seisō, Seiketsu and Shitsuke). 5S is a way of organizing and managing the workspace and work flow with the objective to improve the efficiency by eliminating waste, improving flow and reducing process unreasonableness.

- **Quality Function Deployment (QFD):** Method to transform user demands into design quality, to deploy the functions forming quality, and to deploy methods for achieving the design quality into subsystems and component parts, and ultimately to specific elements of the manufacturing process.

- **Total Productive Maintenance (TPM):** Way of looking at maintenance, or conversely, a reversion to old ways but on a mass scale. TPM is a proactive approach that essentially aims to prevent any kind of variation before occurrence.

- **Kanban:** It is an effective tool to support the running of the production system as a whole. In addition, it is an excellent way for promoting improvements because reduces the number of kanban in circulation highlighted problem areas.

- **Single Digit Minute Exchange of Die (SMED):** It provides a rapid and efficient way of converting a manufacturing process from running the current product to running the next product. Performing faster change-overs is important in manufacturing, or any process, because they make low cost flexible operations possible.

CHAPTER 2. WORK PLACE: *TALLERES BELLVITGE*

2.1. Introduction

Talleres Bellvitge is the company where this entire project has been carried out, from the study to the implementation and testing.

Talleres Bellvitge is a non-profit-making organism that was borned in 1968. This company works in the job insertion to physically disabled people in *Hospitalet de Llobregat (Barcelona)*.

The company works in handling and packaging, printing and delivery service for the purchase bought in municipal markets.

Fig. 2.1 Talleres Bellvitge

Altought there are several floors, this project has tried to improve only one floor, where handling and packaging works is done. The implementation of improvement process in the rest of floors will be part of other future projects.

2.2. Improvement projects done

This project is not the first process improvements done in *Talleres Bellvitge*. In academic course 2006-2007, Néstor Gavilán with other university student from Girona University made the first Lean production techniques to improve the company.

In this period of time some changes were made to produce new work places and material location. Above all, space to locate material, input material and output material. Therefore the main objectives were:

1. Increase the productivity and make every section more efficiency.

2. Make more spaces for workers and new works.

3. To approach the atention from workers to a deternited way to optimizate the carried out work.

In this first improvement objective some shelves where eliminated, tables were moved to new places and new works places were created.

Fig. 2.2 New way of working and new working location

Finally, Néstor Gavilán made some test about table improvements. To make this improvement were used ramps and small slides, but it is not currently implemented in *Talleres Bellvitge*.

Fig. 2.3 Method using ramps

Apart from that, some changes were made since 2007 thanks to *Instituto Lean*, because Jordi Olivella, Comunication Director, Oriol Cuatrecasas and Néstor Gavilán, both Development Lean Director, made a first study and prepare the first changes.

2.3. Current situation

Nowadays *Talleres Bellvitge* has three clients, all of them need handling activites. All these works are done in this floor 0.

Therefore, for this two clients there are working thirty two people in eight different tables apart from one specific table for one client and one place to apply a temporary job for another client. Moreover some workers use a hand pallet truck and electric walkie pallet truck.

In figure 2.4, a general floor map is showed. In this map is possible to see the location of the different tables, material and floor office.

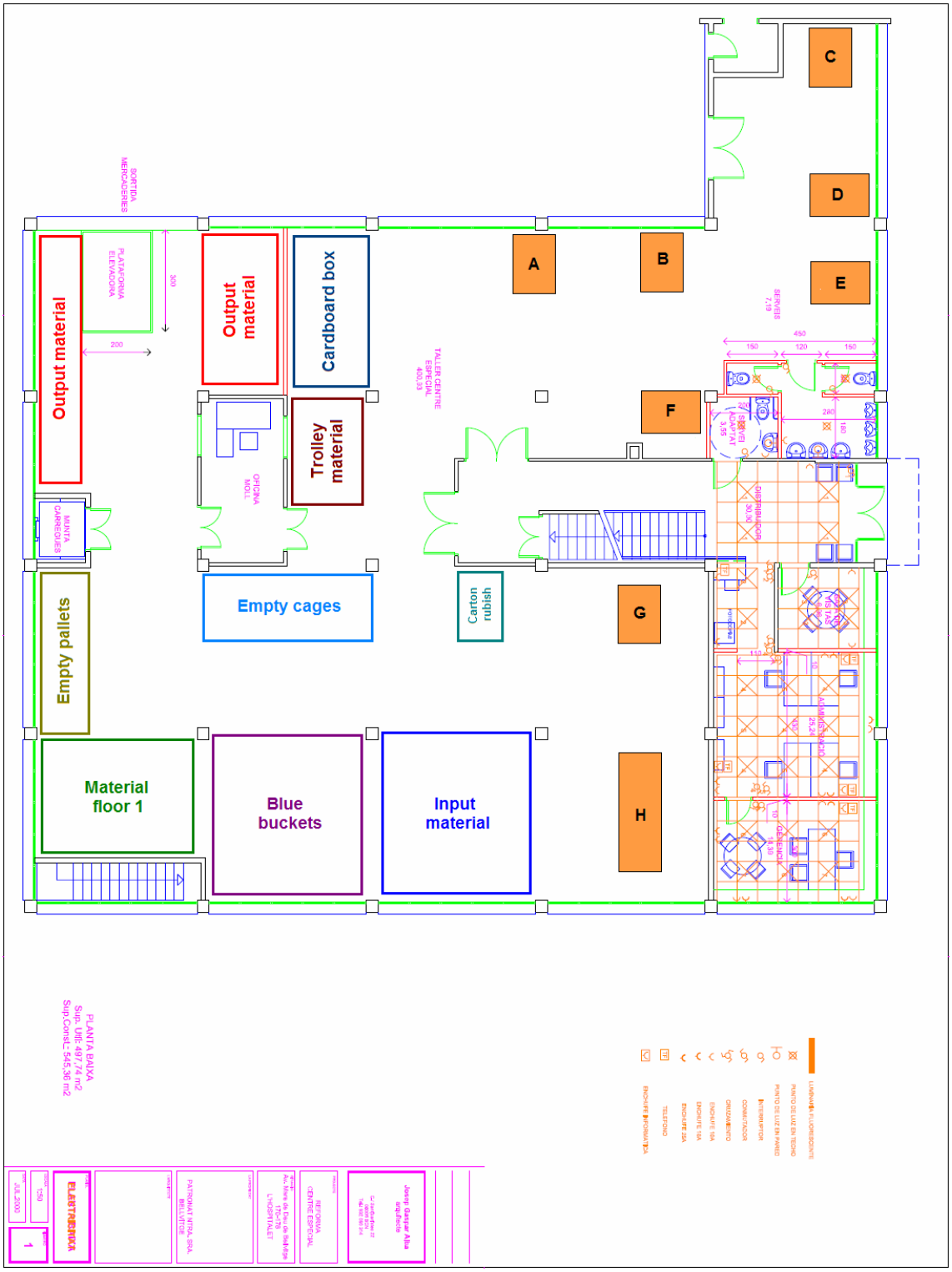

Fig. 2.4 Current Talleres Bellvitge floor 0 map

During the week, at least twelve trucks take about sixteen pallets. Moreover, after unload all these pallets the output material, finished material, is loaded in the same truck.

Therefore, everyday, apart from Tuesday and Thursday that there are usually three, two trucks come with sixteen new pallets.

Depending on the month, there is more work or a little bit less. The months with heavy load are during the summer station, Juny, July and Agust, that there are more than twelve trucks per week. That is the reason why with the space available is not enough to locate all the material and work places necessary.

Nowadays there are eight tables with different sizes and a no standarized process to locate the input material. Nowadays there are 25 m^2 for one client and 20 m^2 for the other client. When all this space is full of pallets, the new input or output material is located in the corners or corridors. This situation produces untidiness, less productivity and innecessary movements.

CHAPTER 3. PROCESS IMPROVEMENTS PLAN

3.1. Introduction

To understand which process can be improved it has used the Lean techniques of Value Stream Mapping and Standarization.

Value Stream Mapping is a Lean technique used to analyse the flow of materials and information currently required to bring a product or service to a consumer. At Toyota, where the technique originated, it is known as "Material and Information Flow Mapping".

To carry out a VSM is necessary to understand all stages in every process, separating between the actions with add value and without it. Apart from distinguish the different processes, it has to find and know the different flows, in other words, all the different stages of the process, material and information flows.

To create a new VSM is necessary to understand, firstly, the current VSM. All these works permit to obtain information about Process flow, Material flow and Information flow.

The objectives to create the current VSM are to:

- Create a unic source of information.
- Visualize the three flows (Process, material and information).
- Identify, easily, the waste in every process.
- Analize the current situation to make a list of activities to improve with priorities.
- Define how to start and the line to follow.

Also, it is important to take into account that this document has to live. It has to change during the process improvement and change objectives if it is necessary.

To carry out the current VSM, and later to carry out a future VSM, six points have done:

(1) Select a specific family process
(2) Understand what the client wants
(3) Carry out the process flow
(4) Carry out the material flow
(5) Carry out the information flow
(6) Calculate the working cycle (Lead-time).

All these points take part from de Standarization.

3.2. Current situation

As it is known, to make a VSM and standardization is necessary to follow six specific points. Here it is shown the different points and how they have been done.

All this process has been done to be able to improve the current situation in *Talleres Bellvitge*.

To make all this study it was necessary to gather some data. There is availables in Annex 2.

3.2.1. Select a specific family process

In this company, it is possible to separate two different works working in: Pallet truck or Handling work. Inside these two processes, there are new and specifics work groups.

Therefore, workers doing pallet truck activities can be separated in two new groups: Hand pallet truck and electric walkie pallet truck. Although could seem to be one only word different, the activities that these group have to carry out are different. All this separation is shown in figure 3.1.

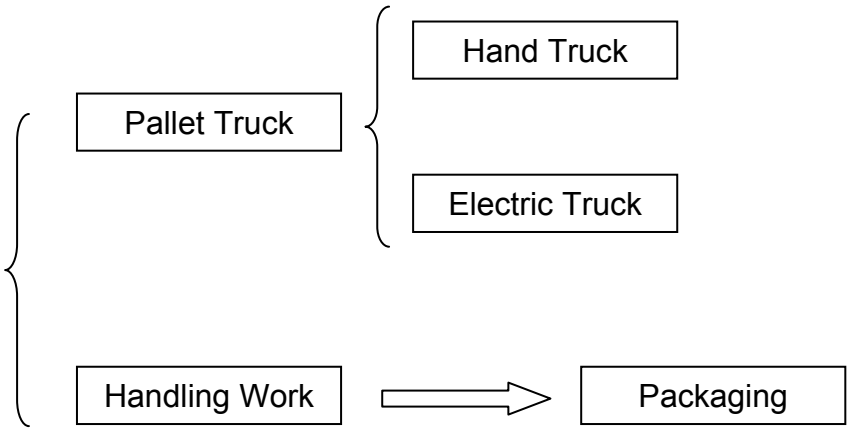

Fig. 3.1 Talleres Bellvitge processes

On one hand, people working with the electric walkie pallet truck have to carry the input material from the lorry to the input material place. Moreover, has to do the opposite activity, carry the output material from the output material place to the lorry.

On the other hand, hand pallet truck workers have to distribute the input material to the different handling work places. Moreover they have to carry the empty pallet to leave the output material that it is finished. Finally, they have to move the finished pallets from the tables to the output material place.

Finally, the last work group makes the hadling activity (packaging). This work is carried out by people working in tables where input material is taken. They have to carry out the actual add value to the process.

The easier process to improve is the first group, pallet truck activities, because has less variation and also has a big volum.

3.2.2. Understand what the client wants

In this second point, understand what the client wants means to know the quantity of components or pieces are needed to supply the customer.

Therefore it has to be a production control to supply every week or month, apart from an historical daily or monthly production.

To do that is necessary to calculate the Takt Time. The Takt Time is the rate at which must operate our plant to meet demand client.

$$Takt\_Time = \frac{Available\_time}{Client\_demand}$$

In *Talleres Belvitge*, the worst case is when from the input material arrived to the output material departure takes two days. Therefore, there are twenty four pallets in every lorry, obtaining a total number of pallets of fourty eight.

Therefore,

$$Takt\_Time = \frac{48h}{48\,pallets} = 1\,{}^{hours}\!/_{pallet}$$

3.2.3. Carry out the process flow

In this point it has to identify the stages and the charactheristics of them. Therefore, it is important to separate the different stages and find the number of workers, cycle time and important characteristics of every process station.

In *Talleres Bellvitge* there are different stages between the beginning and the final of the chain.

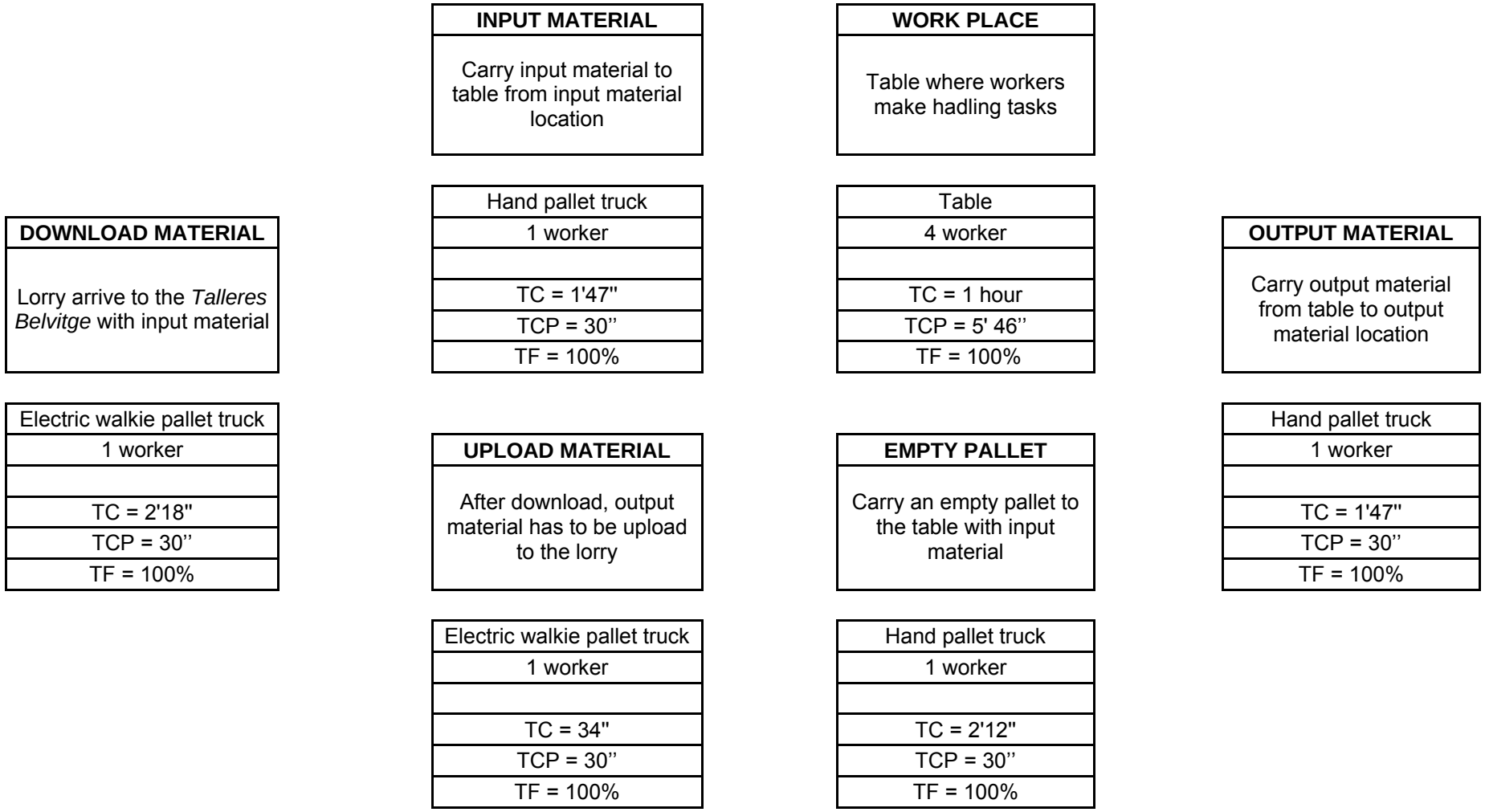

Fig. 3.2 Process flow map

3.2.4. Carry out the material flow

Now it is time to know the behaviour of the material flow, where is the stocktaking and how much. Also it must to undertand how the material arrives and how often goes to the client.

In the next figure, Fig. 3.3, it is possible to se the material flow map. In this map it is identified how the material arrives and what are the different steps before to leave the company.

Therefore, it is possible to separate in two groups, the same groups specified in section 3.2.1, pallet trucks and packaging activities.

Moreover, although in theory there is a material flow, it is usually to find work wave and places where the material does not flow. These places have to be found and analize what it is happen.

In this material flow map is possible to see four movements of material from the arrival to the departure of this packaging material.

The electric truck worker moves the input material one time to the input place. Then this worker has to upload the handled material to the lorry. In other words, the output material.

Moreover the hand truck worker has to move, at least to times:

- From the input material place to the working table
- From the working table to the output material palce

This situation happens in the best case, because when there is no space or a fix location to the material, the hand or electric truck worker can move the material several times before to leave *Talleres Bellvitge*. This situation also happens if the input or output material is not located in the correct place or order and they have to move some pallet behind other material.

This waste is one of the seven important wastes that Lean Manufacturing tries to remove (see Annex 1).

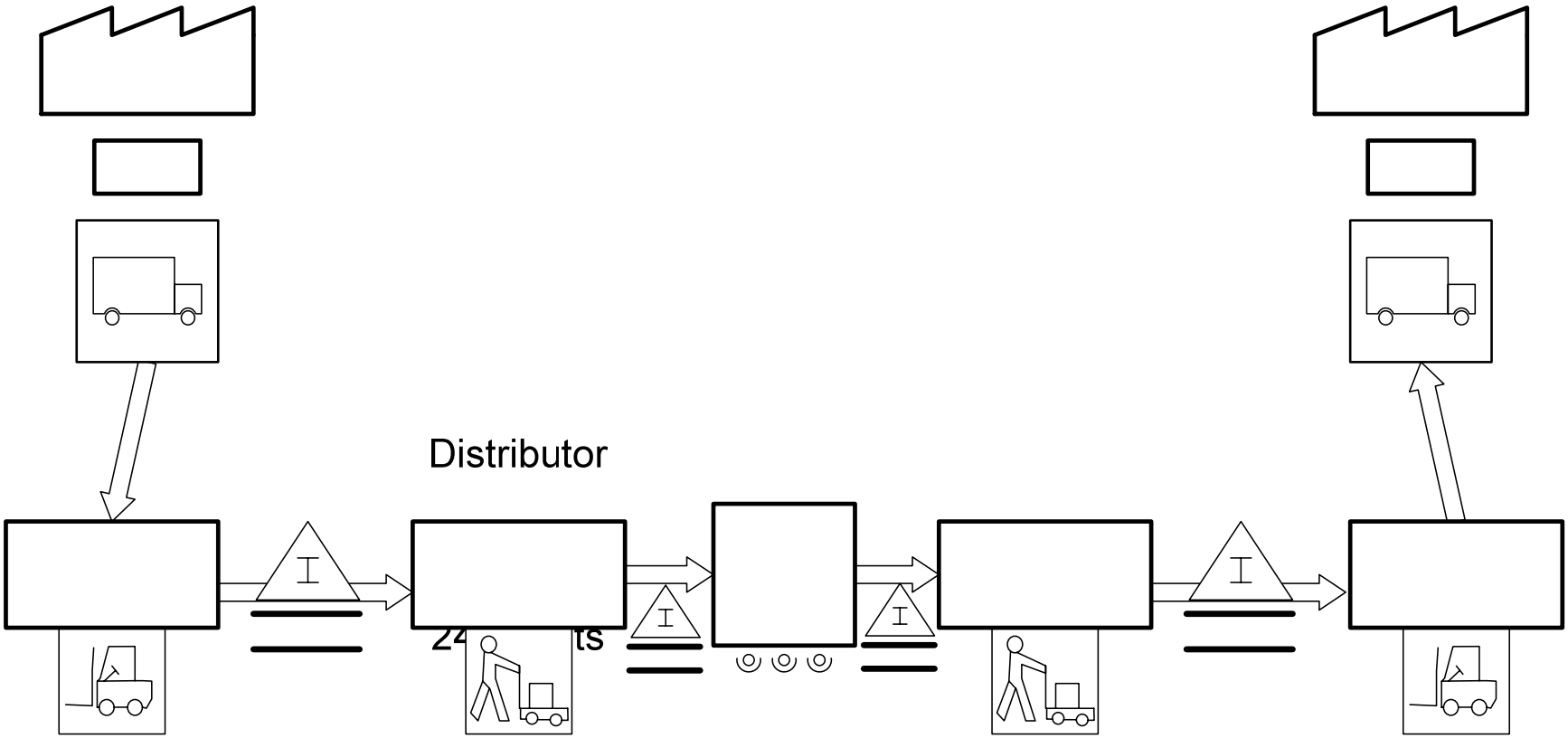

Fig. 3.3 Material flow map

3.2.5. Carry out the information flow

In this step, the main objective is to know (When and How) the logistics orders. This flow map shows the transmition of information.

In *Talleres Bellvitge* there are two different sources of information:

- The company that distribute the different pieces
- The floor manager

On one hand, the company that distribute the material is a different company that the final company. When the distributor sends some material to *Talleres Bellvitge*, they send also and e-mail specifying all the input material that arrives. Thanks to this information it is possible to carry out a control and checking about the input and output material.

On the other hand, the floor manager distributes the input material when it is carried with the lorries. Moreover, the informatic, accountant and material manager receive the input information from the e-mail and then check the input and output material that arrives and leaves *Talleres Bellvitge*.

In the information flow map below, it is possible to identify the different information flows that there are in *Talleres Bellvitge*.

Nowadays the floor manager has to check the input material and distribute how to locate in the warehouse. Moreover, every time that an input material is asignted to one work table, this task has done by the floor manager.

Also, the table workers usually ask him about how to carry out this task and how they have to carry out the output material pallet.

When an output pallet is finished, the hand truck worker goes to the computer to obtain a sticker to put in the output pallet. This sticker indicates what type of material is. Then, the floor manager has to decide where to locate this output material depending on the type of material.

Therefore, currently the floor manager is involved in all processes (see Fig. 3.4). Finally the accountant and material manager marks the output material done to send an e-mail and check the input and output material done.

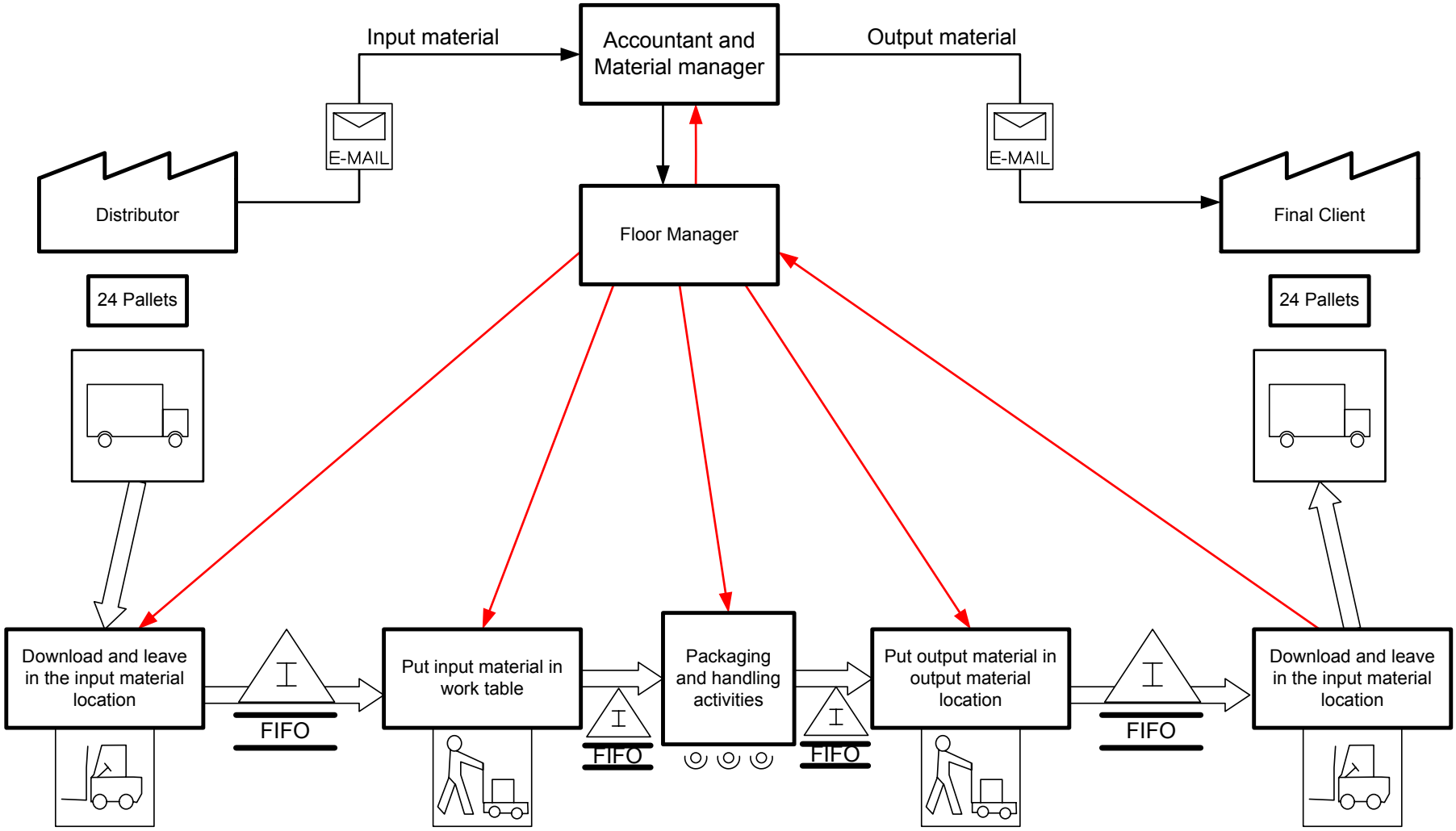

Fig. 3.4 Information flow map

3.2.6. Calculate the working cycle (Lead-time)

Lead-time is known as the average time that it takes for one unit to go through the entire process - from start to finish - including time waiting between sub-processes. In practice, the term Lead Time usually means Production Lead Time.

Now it is possible to put all the previous sections together and obtain the current Value Stream Map. This VSM shows (see Fig. 3.5) all the process, material movements, times and information flows.

Therefore this section shows the diagnosis about the processes. Now it is possible to find the improvements and carry out a future VSM.

The total time obtained (realizing some processes) is one hour, six minutes and thirteen seconds. Moreover there are some times of waiting about one day and a half.

The total time from the beginning to the end is about two days. But it is known that the maximum time for an input material is two day. Therefore it is near to this time. The main problem is to have during around one day material in stand by in the warehouse because. It is important to carry out an improvement for the hand and electric truck workers, moreover to the working groups in table to reduce this day with the material stopped.

Despite of obtaining this Lead time, it is important to take into account that this lead time is the worst case. Not during all packaging pallets the time used will be one hour.

In any case it is important to reduce the wastes produced by innecessary movement, asking or changing the type of work.

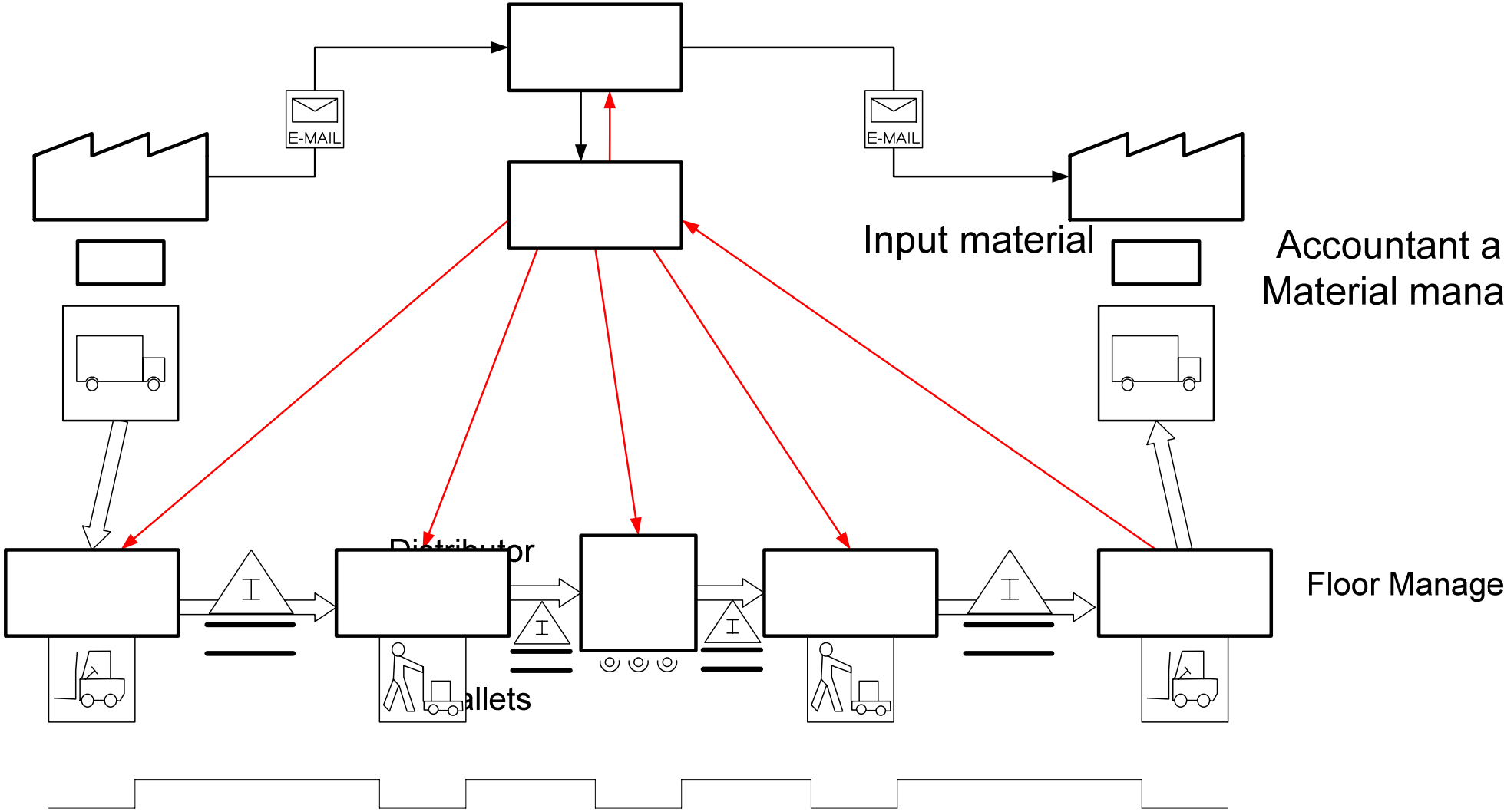

Fig. 3.5 Lead-Time map

3.3. Future VSM

To carry out the future VSM, Lean indicates to follow six different steps:

- Production when there is stock (demand)
- Knowing the inventory necessary
- Where schedule
- Lot Size
- Creation of Pulling
- How to control the processes

Althought these steps are correct and it is important to apply, in this case and taking into account that some of these steps have been done previously this project some stages are not done and specified.

Therefore in this section a future VSM is shown, see figure 3.6, where the objective is arrive to obtain this VSM.

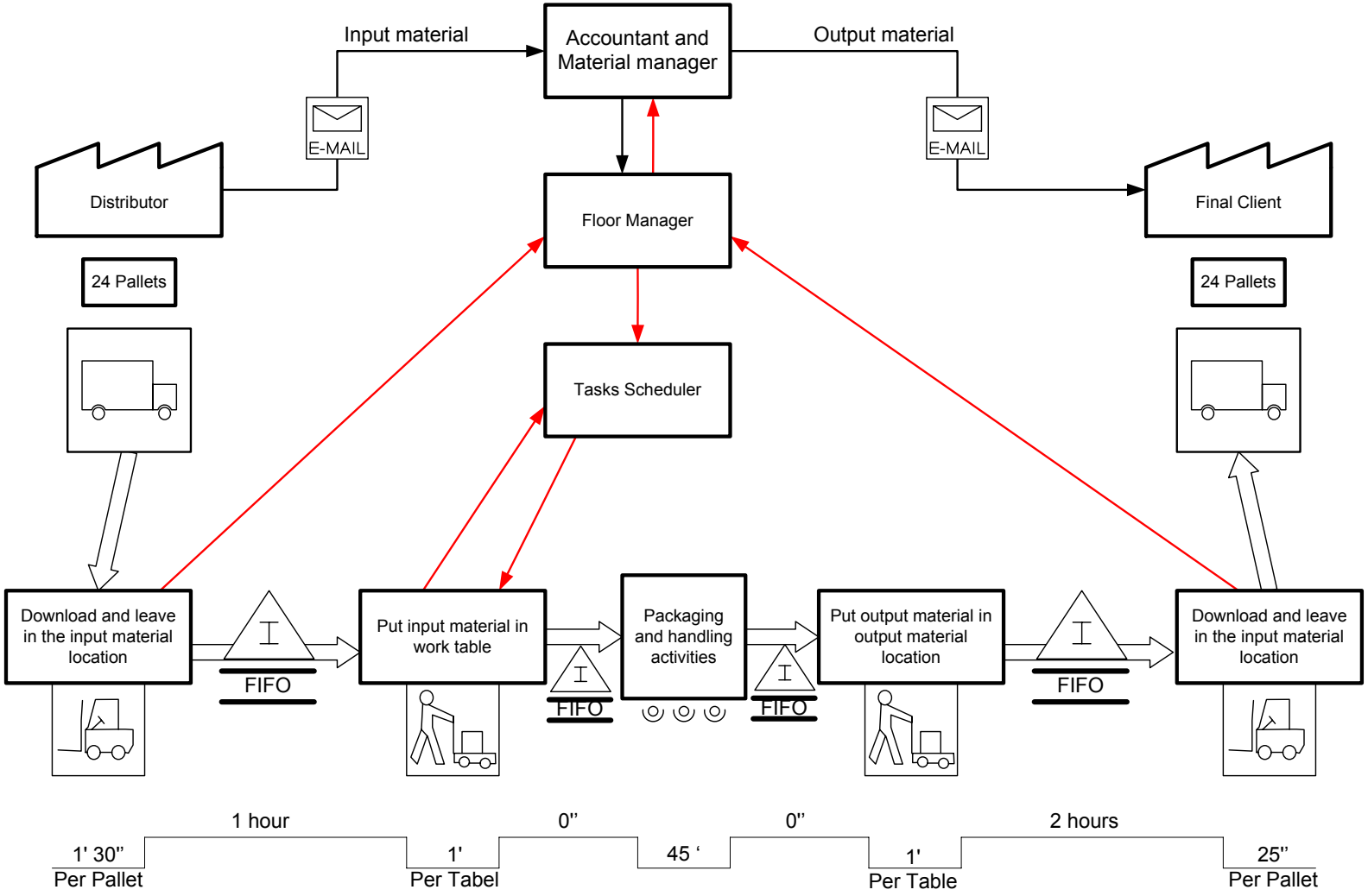

Fig. 3.6 Future VSM

To carry out this VSM it is necessary to make some changes in the floor 0 of *Talleres Bellvitge*. Therefore it was made a future map (Fig. 3.7). Moreover, to obtain this map and all the tries, a scale model was done (see Annex 3).

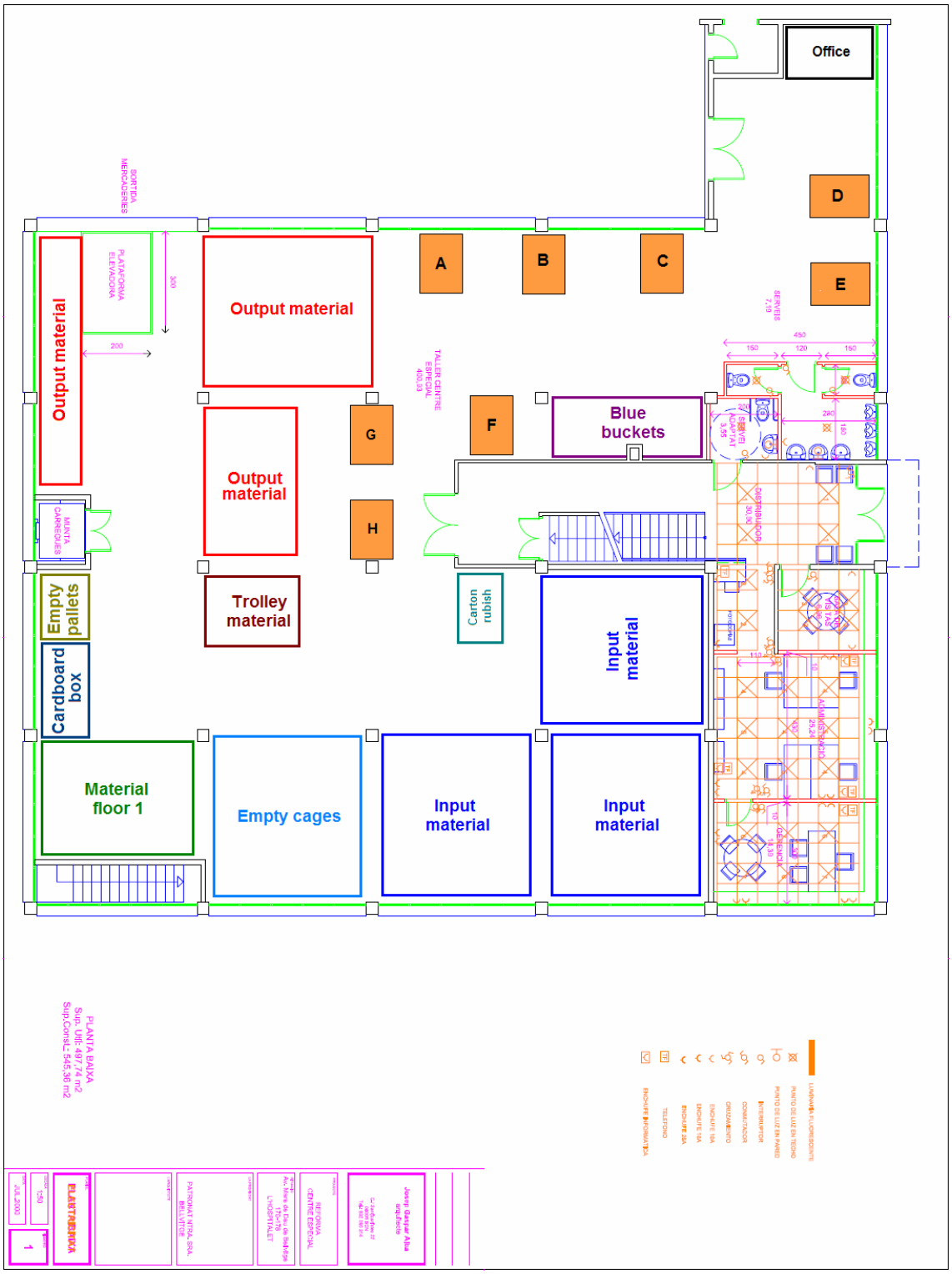

Fig. 3.7 Future *Talleres Bellvitge* floor 0 map

CHAPTER 4. IMPLEMENTATION

4.1. Introduction

Taking into account that there is a time limitation to do this Master Thesis, all the plannification done and all theoretical improvements obtained can not be put in practice.

Therefore, that is the reason why in this chapter, chapter 4, it is shown the different improvement done.

4.2. Improvement implementation

During these several months, there were different modifications to obtain some improvements, from space to time. Therefore, it has been five different improvements implementations.

4.2.1. Stage 1: 5s

One of the Lean tools used to identificate and eliminate waste is the Five S. This tools makes a quality improves while production time and cost are reduced.

This tool has to be, always, one stage in every improvement process. The 5s makes the work easy, because the right thing is in the right place makes the work easier. Moreover for *Talleres Bellvitge* is an important point because allow to the managers to know if there is all the material (staplers, seals, seal machines, etc) necessary available.

Moreover, before to carry out this improvement only every Friday the entire floor was cleaned. The problem of this methodology was not only to have the floor more or less cleaned, but to have some material control and checking.

The main idea, apart from having a clean floor, was to check every day how the material is spent.

To carry out this stage a work timetable was done (Fig. 4.1). The main idea was that every table knows what they have to do fifteen minutes before to finish the working day.

There are defined four different tasks and there are eight different work tables, from A to H. Therefore only half of table groups have to carry out these clean task, check and replacement of material. The other half of table groups must continue with their packaging work.

Fig. 4.1 Work timetable or *Ruleta de la suerte*

The *"Ruleta de la suerte"*, as *Talleres Bellvitge* workers called, change every week, having every table group one week with material and sweep tasks and one week free.

There are two equal tasks, to sweep. The reason of being two groups doing the same task is because *Talleres Bellvitge* first floor is too much big for only four people. That is the reason why there are two table groups to carry out the sweep task. In spite of doing two groups an equal task, the entiere floor was separated in two different zones.

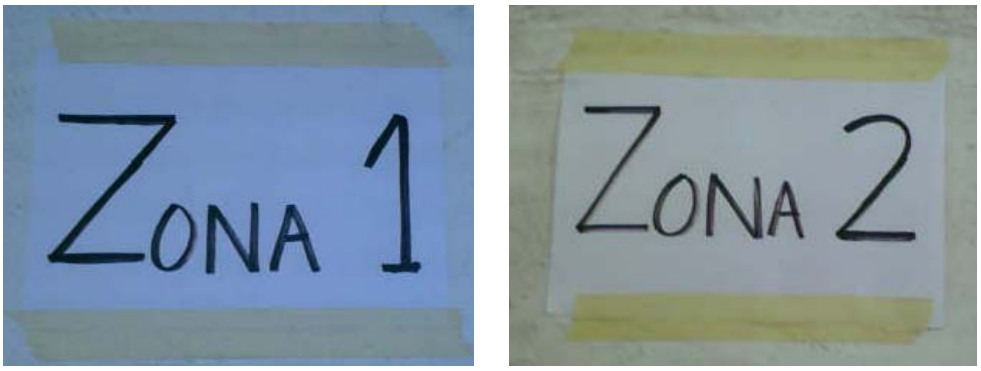

Fig. 4.2 Zone 1 and Zone 2 identifiers

Zone one goes from the loading and unloading dock to the input material place. Zone two is the rest of the floor, from the input material place to the emergency exit door. In the next figure, 4.3, is possible to see the separation in the floor map.

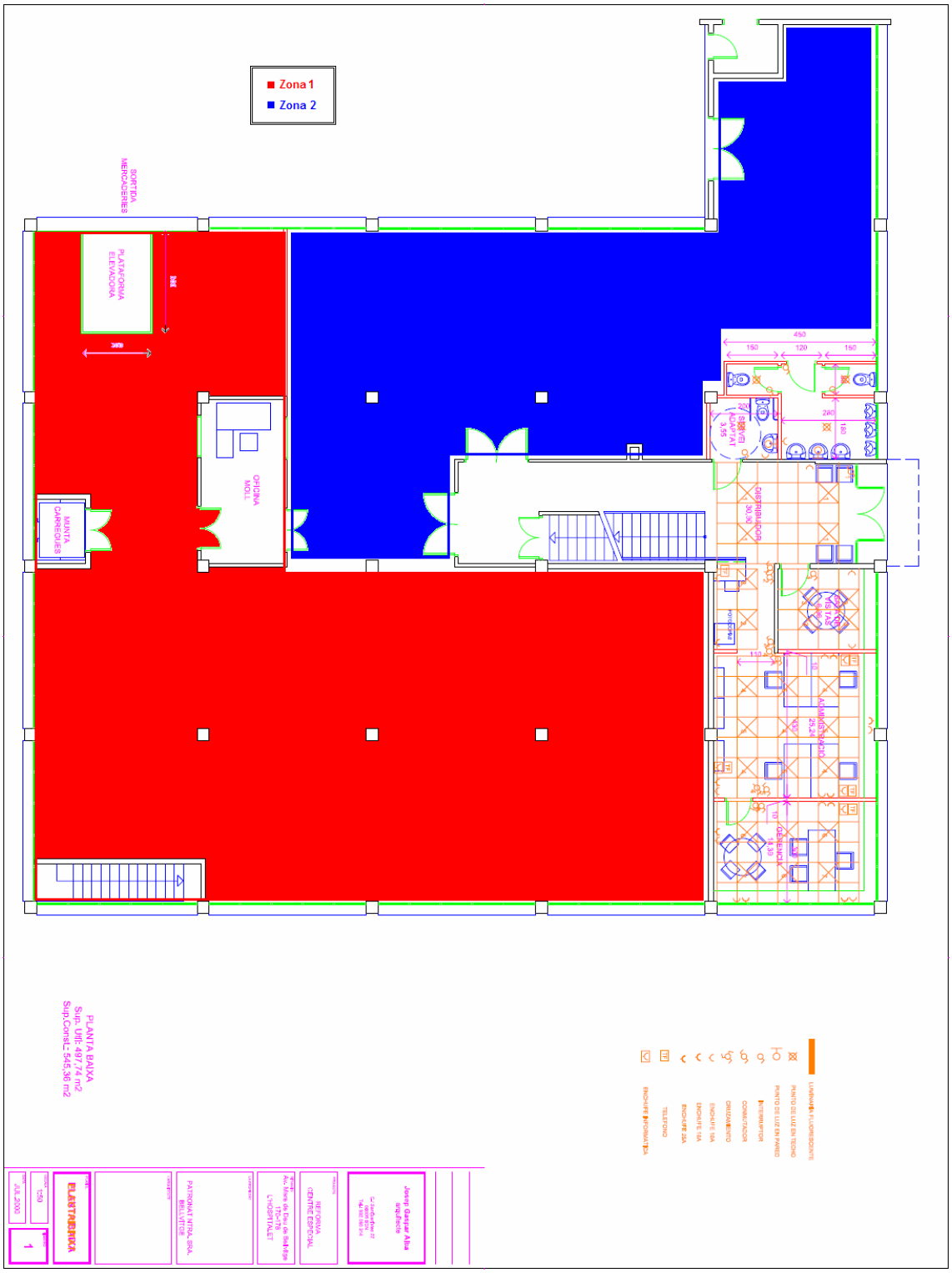

Fig. 4.3 Sweep zones

Apart from sweep tasks, there are two more different tasks. Both are about material.

On one hand Material 1 refers to individual material that every table has to have (Fig. 4.4) available.

Fig. 4.4 Material per table (Material 1)

On the other hand, Material 2 refers to shared material which all working tables can use. At the end of the working day, or packaging task, this material has to be in the determined place to be used the next day, or by another table group. It is important to make this control in order to avoid the waste of time looking for the material.

Fig. 4.5 Shared material (Material 2)

Realizing this stage it was possible to control and check the different material available. Also it was the process necessary to know how often it is necessary to buy or replace material.

Fig. 4.6 Material 1 and 2 tasks

Finally, it was a good stage to spend less time looking for some material and asking where is the material located.

4.2.2. Stage 2: New work places

In this second stage, the objective was to create new working places. To do this implementation was necessary to eliminate one big shelf located in one wall indicated in the map. Also, there was another shelf that was no useful and decreased the work space in table E (see Fig. 4.7).

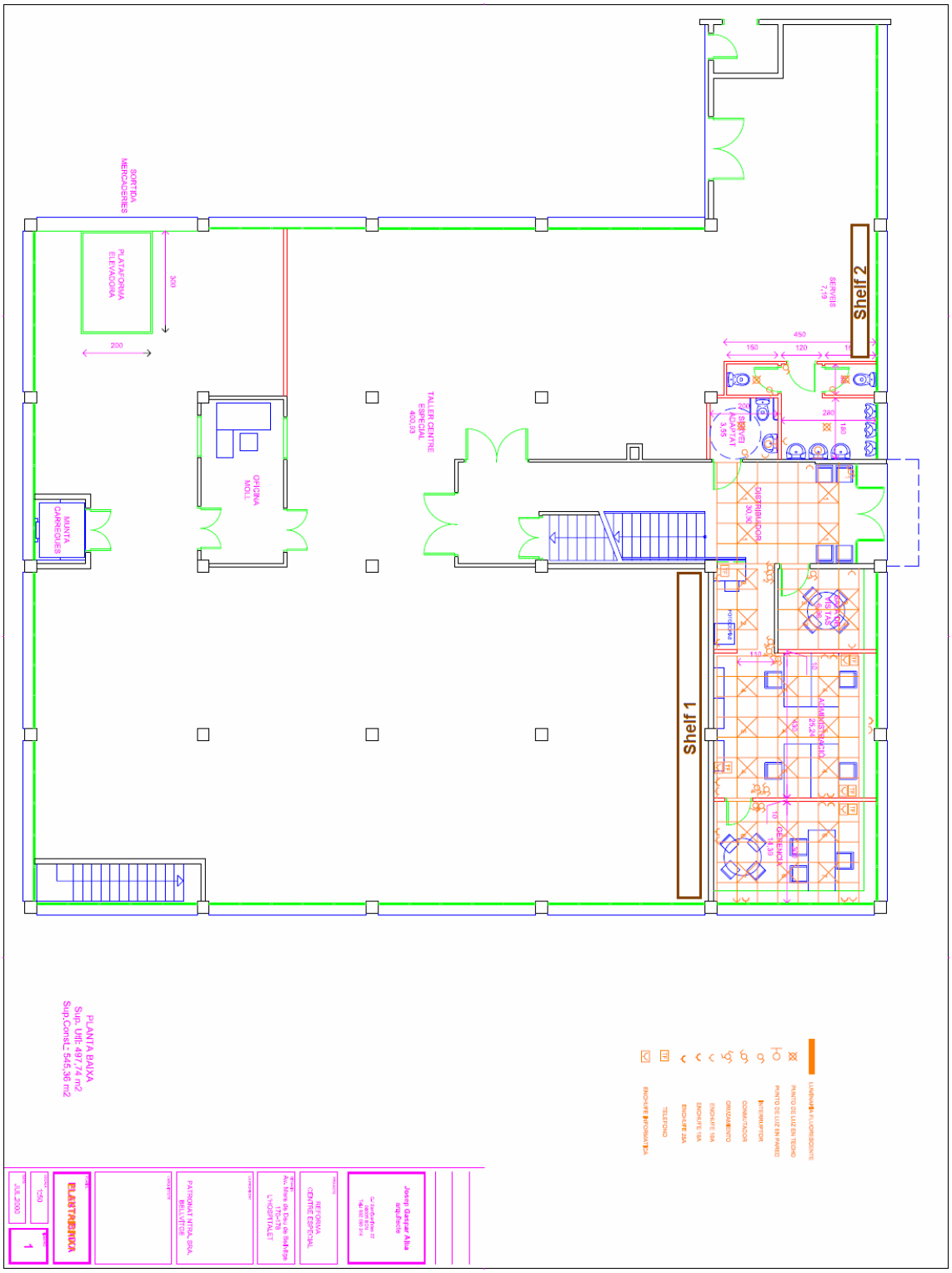

Fig. 4.7 Shelves location

Sometimes, to create new work places do not mean to hire new workers, having more workers in the company. Taking into account the lead time in every process it is normal to see that every process has a different duration. Therefore, in the *Talleres Bellvitge* case, the hand pallet truck and electric

walkie pallet truck workers have a smaller working time than packaging workers in a table.

That is the reason why if it is wanted to optimizated the tasks carried out by the hand pallet truck and electric walkie pallet truck workers, they have to do other tasks. It is important also that hand pallet truck and electric walkie pallet truck workers can not do what they want, because there are a specific number of pallets and material in the tables, work places, until it is finished.

Also, when a table has finished their output material pallet, exists a time that the hand pallet truck worker needs to put new task and take the output material to the correct location.

With numbers, the time needed for the hand pallet truck worker to carry out all their movements required is:

INPUT MATERIAL		EMPTY PALLET		OUTPUT MATERIAL	
Carry input material to table from input material location	+	Carry an empty pallet to the table with input material	+	Carry output material from table to output material location	= 5' 46''
Hand pallet truck		Hand pallet truck		Hand pallet truck	
1 worker		1 worker		1 worker	
TC = 1'47"		TC = 2'12''		TC = 1'47"	

If there are eight different tables, the total time needed is 46’ 08’’. If it is compared this time with the Takt Time, calculated in Chapter 3, one hour per pallet, it is possible to increase the number of tables to increase the 46’ 08’’ near to one hour.

Therefore, creating one new work place the total time used by the hand pallet truck worker is 51’ 54’’, with two new tables 57’ 40. This time is very near to the Takt Time.

After to calculate these times, the idea was to create two new work places to use the space obtained with the no shelves. Moreover, the orientation of the tables was also important. Therefore, the location and orientation applied is showed in the next figure, Fig. 4.8.

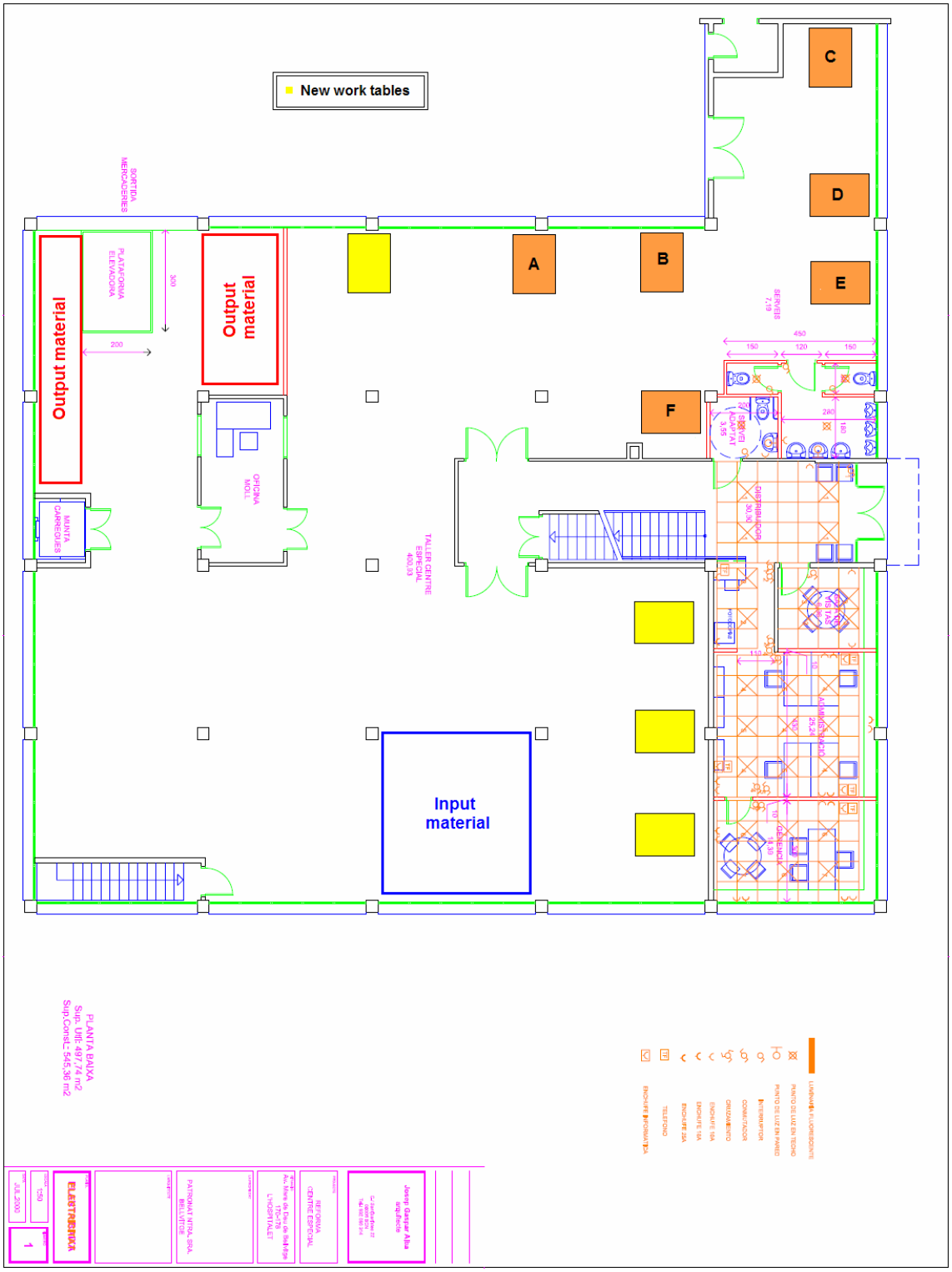

Fig. 4.8 New work tables location

Having this location and a number of static work places, it is easy for the hand pallet truck worker, because he has to do the same way looking and checking if all work places have material to work.

Moreover there is more space in the input material place, because some material is in the ten tables available.

Finally, the new layout that the hand pallet truck worker has to do is the route showed in figure 4.9.

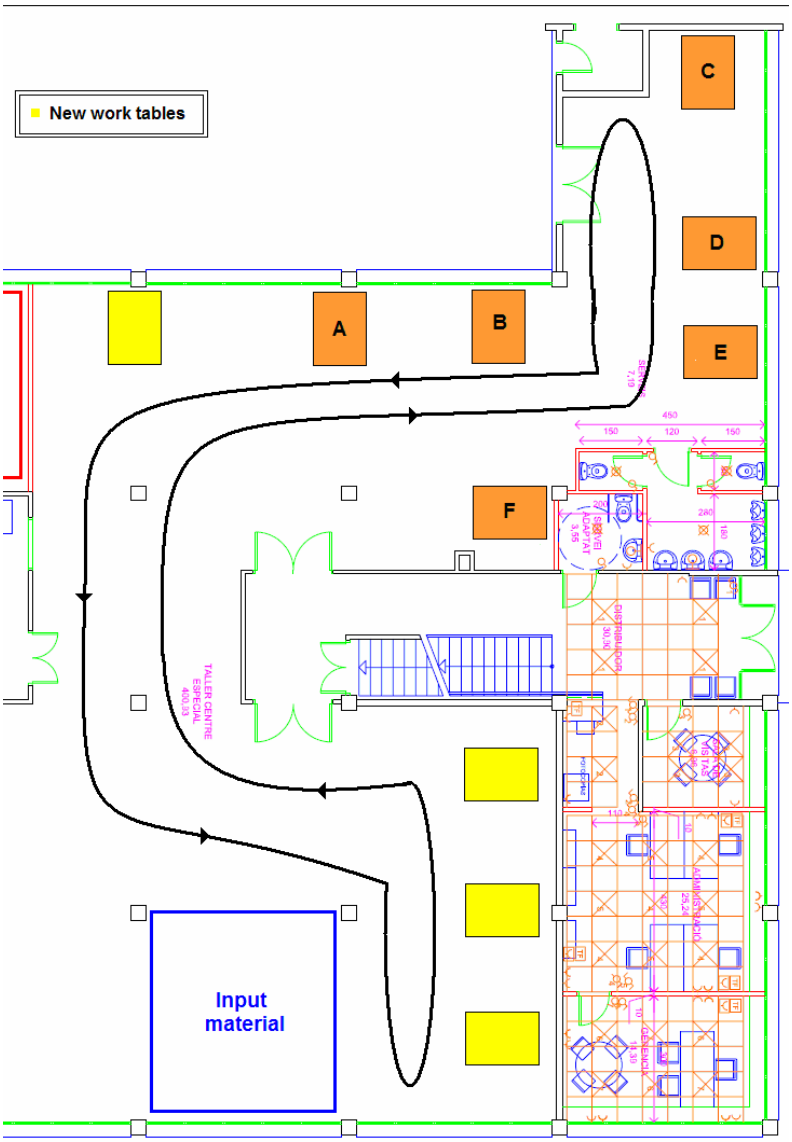

Fig. 4.9 Hand truck worker layout

Thanks to apply this stage, it was passible to obtain lead time more similar between these two different tasks. Altought this stage was created, and it was shown its benefit, after several weeks it was not used because it was necessary more space for input and output material. In spite of eliminating this improvement, it shows that can be process improvement without increase the number of workers to equilibrate the takt time from the different process.

4.2.3. Stage 3: Task panel

Before to implement this stage, in *Talleres Bellvitge* there was a big handicap and an important waste of time. A lot of workers were asking the manager floor the normal questions (What, How, When and Where) before to start, or during, every task.

This situation has been happening during lot of time because the floor manager made all tasks to himself. It has been happening because the floor manager had a lot of task answering the different question to the workers and produce that he had less time to prepare and allocate the pallets in the most efficiency way.

This floor manager has all the task and methodology in his mind. That cause that every worker has to ask him. This situation creates an important waste of time, because it is not only the time asking to de floor manager, also there are moments that the manager is not available. That causes a big delay in every task to be carried out.

To solve this problem, a panel task was created (see Fig. 4.10). This task panel works as a scheduler and task distributor for all workers in *Talleres Bellvitge*.

Fig. 4.10 Panel scheduler and task distributor

This panel has an easy function, but with big changes and results. Every time that some material arrives to *Talleres Bellvitge*, the electric walkie pallet truck

worker put in every input pallet a tag indentification. Every tag indentification has two equal copies. One goes to the new arrived pallets and the other to the panel task.

The tag identification has a specific color, depending on the day of the week, and also has an M or T (*Mañana* – Morning or *Tarde* - Afternoon). Therefore there are five different colors, from Monday to Friday to distribute all pallets during the week and during the morning or afternoon. Every color, or day, has a secuence of number from one to twenty four, the maximal number of palets that can be in the same lorry. Therefore there are twenty four tags identifiers available for the morning material and another twenty four to the afternoon input material.

Fig. 4.11 Tag identifiers

In other words, there are twenty four different tag identifiers to be used in the morning and the same number for the afternoon input material. Fourty eight different tags identifiers for each day and two hundred and fourty different tag identifiers for all the week.

There is no problem with the tag identifiers from one day of the week to the same day in the next week, because the material is going to be two days, in the worst case, in *Talleres Bellvitge*.

Then when the electric walkie pallet truck worker has finished assigning all tags identifier to every pallet, he has to go to the floor manager and give him the rest of tag identifiers. Now, it is when the manager knows how many new pallets

there are in the input material place, because he can see the first number do not used.

Therefore, on the one hand the floor manager has to put in the panel task the order and assignation to the different group tables that it is better, taking into account that there are urgent and no urgent material. The task panel has different lines with letters. These letters are the different tables that there are working.

On the other hand, the hand pallet truck worker only has to look the task panel and see the tag indentification that goes to each table. Also, the panel task has prepared to see the different time used to each pallet, but currently it is not working and being used.

Therefore, the floor manager does not have to be answering all workers questions, because they can look the task panel and then the floor manager can spend his time with other important task.

Moreover, in case that one day he can not come, there is no problem, because the methodology is easy and other floor manager can carry out this task and manager the tag identifiers.

Also, thanks to have an indentification with a number, color and differenciation between morning and afternoon, it is easy to know how many days the pallets are in *Talleres Bellvitge*.

Therefore the floor management has to do this assignation to the task panel at least one time in the morning and another during the afternoon. Two times per day and forget the input material assignation to the different tables, although during the working day it can be changed and modified.

This stage helps *Talleres Bellvitge* to spend less time asking to the floor manager and make workers more independent. Also, it is not good that one company depends on one worker, in this case the floor manager.

4.2.4. Stage 4: Input material position

In this stage, the main objective was to obtain new and more space for the input material. It is important to take into account that during some months the input material that arrives to *Talleres Bellvitge* is a quantity that can be located in 25 m^2. In other words, this material can be leave in the position that was asigned until this stage was done (see Fig. 4.12).

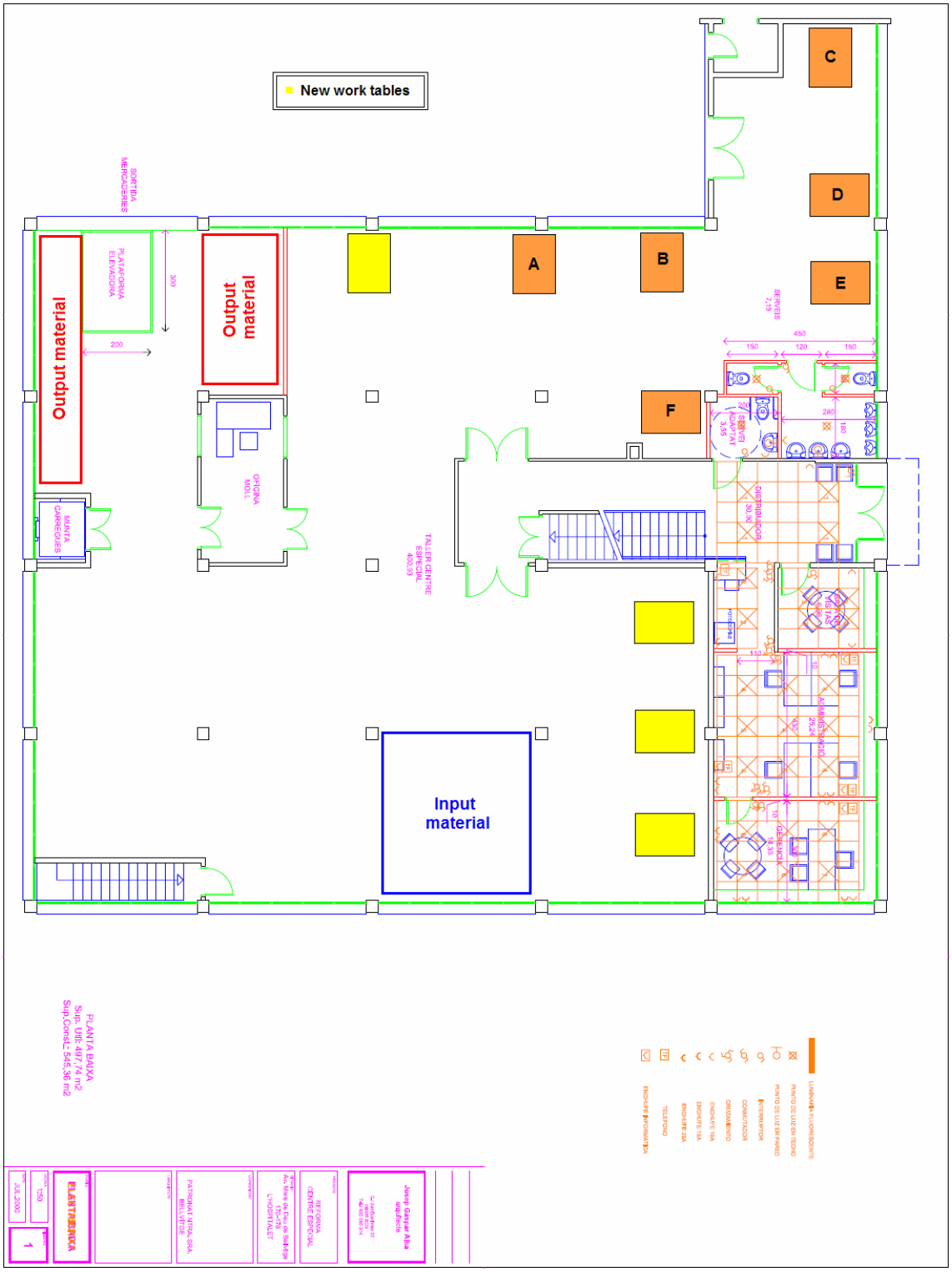

Fig. 4.12 Input material place

Althoght in the second stage more work tables were added, with the past of time, the floor manager decided that was not necessary yet and used eight tables and reuse this space to something more useful.

Therefore and thanks to this space, without shelves, it was decided to increase the input material space. As it is possible to see in figure 4.13, the input material space was increased to the double.

Moreover, it was not necessary to elimitate all new tables, because where relocated some of them too.

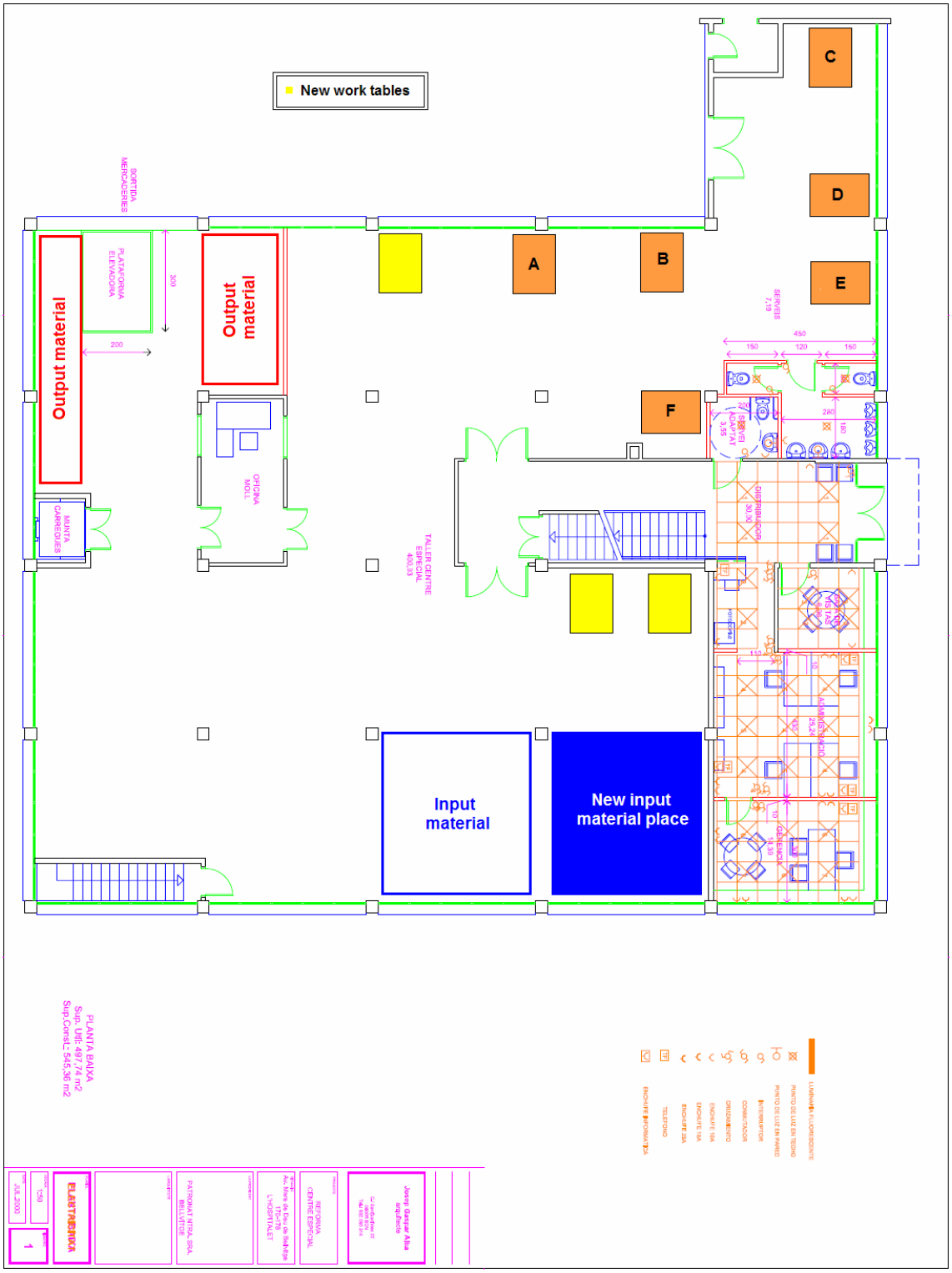

Fig. 4.13 New input material location

Thefeore this new input material space let *Talleres Bellvitge* tolerate the work picks that there are almost six moths of a year (about five moths per year). The worst months, or best month to facturate, are the summer months, from July to September, and during winter station, from the end of November to first of January.

During this period, the number of lorries that take material are not two, but three. Therefore the maximum number of pallets during a working day is not fourty eight, but seventy two.

If there are five lines between two colums, and four pallets in every colum, the maximum number of pallets that can be in input material place are fourty. That is less than seventy two, but these fourty pallets are in one level. Therefore, if it is put pallet over pallet, the total maximum numbers of pallets that Talleres Bellvitge can store are eighty.

In the next chart, 4.1, it is possible to see a comparitson between the previous situation and the new one.

	Before	**Later**
m^2	25 (m^2)	50 (m^2)
Nº of lines	5	10
Pallets per line	4	4
Nº of Pallets	40	80

Chart 4.1 Comparison between previous and new distribution

With this stage, *Talleres Bellvitge* could increase his warehouse and therefore to receive more material to packaging. This stage was one of the main objectives of floor manager and rest of workers in *Talleres Bellvitge*.

4.2.5. Stage 5: Input material separation

As it has been mentioned during this document, in *Talleres Bellvitge* there are two different input material pallets:

- Urgent material
- Normal material (No urgent)

Obviously, urgent material has to be done firstly and does not matter if there is input material from the morning that it is not urgent and the urgent material is from the afternoon. The priority is very clear, first urgent material.

Therefore, it is important for the hand pallet truck and electric walkie pallet truck workers to have in order the pallets in the input material place. The electric

walkie pallet truck worker has to put in order because the hand pallet truck worker has to be able to distinguish the pallets to be done. And obviously the hand pallet truck worker has to put in the tables the material more urgent.

Based on this idea and looking the waste of time done by the electric walkie pallet truck and the hand pallet truck workers, the stage five tried to make the separation easier and spend the less time it was possible.

The methodology was to separate in two different places, urgent a no urgent material places, taking into account that they have to be confortable for the electric walkie pallet truck worker to carry the material from the lorry to this place and also handy to the hand pallet truck worker to carry from these places to the working tables.

Thanks to the previous stage, stage four, there was available around twenty pallets positions in one level, and the same in the second level (pallet over pallet). Therefore, this stage separated the two different input pallet materials in the two big places, separated by colums. This location can be seen in next figure, Fig. 4.14.

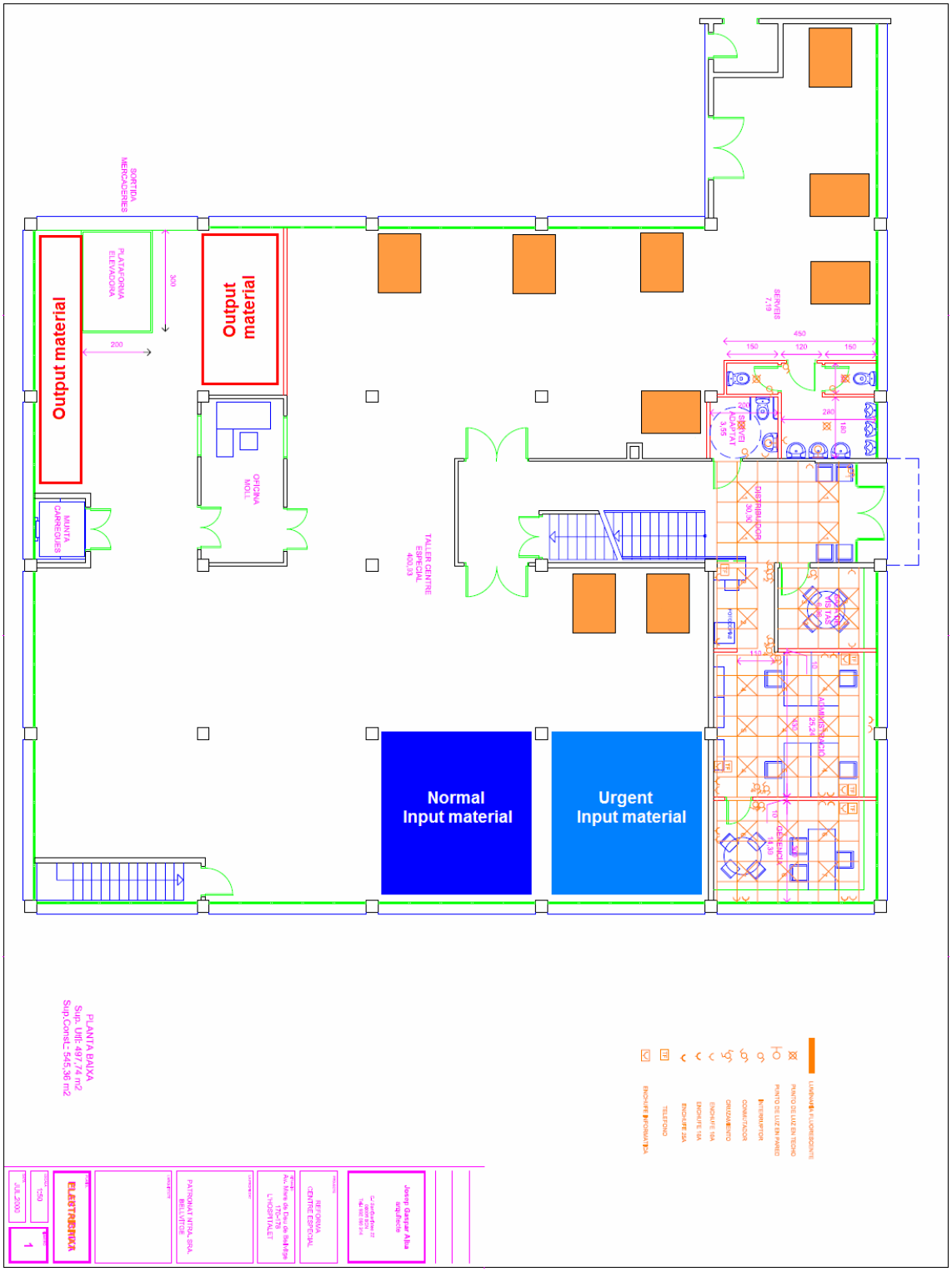

Fig. 4.14 Urgent and Normal input material

As it is shown above, there were two different places to distinguish the urgent and normal input material. Normally, there is more no urgent input material than urgent material. Therefore, it can seem to have no sense to give the same space to urgent and normal input material, but it was not a problem.

Aulthogh sometimes there is more normal input material in *Talleres Bellvitge*, sometimes is the opposite. Therefore, the solution was to start the two places by the opposite sides. In other words, normal input material place has to be hold from the left to the right (looking to the map) and urgent input material from the right to the left, as it is showed in figure 4.15.

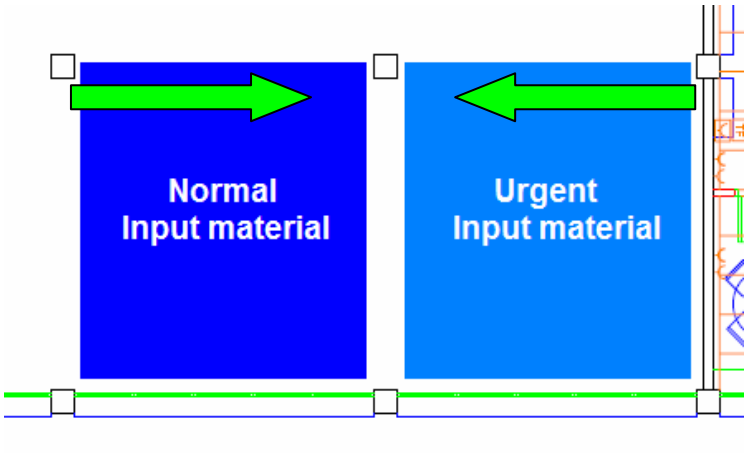

Fig. 4.15 Way of input material ocupation

Therefore, can be moments where some, at the beginning, normal input material can be in urgent input space.

Finally, it is also important do not put material from different lorries in front of other, because the solution will be a LIFO (Last In First Out) system and not a FIFO (First In First Out) system. This second system is what it is necessary is this company.

Doing this stage, it was possible to spend less time for hand pallet truck worker and make easy the control of urgent a normal input material.

Fig. 4.16 Urgent and Normal input material location

Moreover, it is more arragned and makes easy the locations of pallets for workers because there are lines separating the different input material colums.

CHAPTER 5. CONCLUSIONS

5.1. Project conclusions

After the realization this entire document, it is possible to extract some conclusions from this Project.

First conclusion is that Lean philosophy works well. In other words, it can improve different aspects from a company, in this case *Talleres Bellvitge*, doing this methodology.

Thanks to Lean Manufacturing, and using its tools, it was possible to obtain more space, less waste of time, where there was asking time, looking for time, etc.

Therefore, although Lean can seem to be something magic, there are several steps necessary to understand and to apply in a correct way the Lean philosophy.

In other words, the stages necessary to carry out this methodology was:

(1) Observe the current situation. Where there is waste?

(2) Extract conclusions. What is it possible to improve? How is it possible to improve? Where is it possible to improve? When is it possible to improve? And, why is it possible to improve?

(3) Standarization. When it is obtained conclusions and it is known how, what, where, when and why it is goning to be done, the standarization make a unic way to carry out the work. All workers are going to do the same work with the same tools, using the same time.

    Also, it is important do not forget observe the situation after realizing any try of improvement and carry out, another time, conclusions.

(4) Layout. Doing the layout it is possible to see the material movement, worker movements, etc.

    Therefore, there are different layouts, and it is necessary to carry out all of them:

    i. Process
    ii. Equipment
    iii. Layout

(5) Information flow. Realizing this final step, it is possible to see the movement of the different point that exists in this company. Therefore, it is possible to undertand where can be improved and it is possible to start, as many time as it is wanted, in the first step.

5.2. Personal conclusions

As personal conclusions, I can say that it has been a wonderful experience. First of all because I could understand better the Lean philosophy, applying the different tools and making this project not only theoretical.

What it is more, I have to thank to *Talleres Bellvitge*, because they give me the opportunity to carry out this entire project, doing the theotherical and practical part.

Also thanks Lean Institute for their material and advices. Therefore, I only can thank them for give me this opportunity.

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ANNEXES

A1. Wastes in Lean

The following seven wastes identify and classify resources which are commonly wasted. They were identified by Toyota's Chief Engineer, Taiichi Ohno as part of the Toyota Production System.

Fig. A.1.1 Seven Lean wastes

Defects

Quality defects prevent the customers from accepting the product produced. The effort to create these defects is wasted. New waste management processes must be added in an effort to reclaim some value for the otherwise scrap product.

Overproduction

Overproduction is the production or acquisition hides the production problems. Overproduction must be stored, managed and protected.

Transportation

Factory layouts can often be the fundamental cause of excess transportation. When appropriate, re-laying out the machines within a factory from a functional to a cellular layout has been found by many companies to help not just reduce transportation waste but also reduce WIP and waiting.

Waiting

Refers to both the time spent by the workers waiting for resources to arrive, the queue for their products to empty as well as the capital sunk in goods and services that are not yet delivered to the customer. It is often the case that there are processes to manage this waiting.

Inventory

Inventory, be it in the form of raw materials, work-in-progress (WIP), or finished goods, represents a capital outlay that has not yet produced an income either by the producer or for the consumer. Any of these three items not being actively processed to add value is waste.

Motion

As compared to Transportation, Motion refers to the producer or worker or equipment. This has significance to damage, wear and safety. It also includes the fixed assets, and expenses incurred in the production process.

Overprocessing

Using a more expensive or otherwise valuable resource than is needed for the task or adding features that are designed in but unneeded by the customer. There is a particular problem with this item as regarding people. People may need to perform tasks that they are over qualified for so as to maintain their competency. This training cost can be used to offset the waste associated with overprocessing.

A2. Gather data

To obtain the different times and maps during the project, it was necessary to carry out a long observation and compile the actions and times needed. To do it, were used a stencil as it is shown below.

In these stencils, there are two workers per action and there are three different actions:

- Download material from the lorry
- Upload material to the lorry
- Hand pallet truck

Moreover it was done a small study in the work tables.

iproducción

HOJA RECOGIDA DE TIEMPOS

CÉLULA	REFERENCIA	Realizado por:	Fecha: FEBRERO '08
FASE:	NOMBRE DEL PROCESO DESCARGAR CAMIÓN (LOBO)		
TURNO	Modelo		

Símb.	Nº	Elemento	Punto Inicial	Punto Final	1	2	3	4	5	6	7	8	9	10	Menor repetido Elemento	Menor repetido Caminar
	1	Coger Pallet Camión	MUELLE	MUELLE	30"	10"	120"	6"	8"	8"					8"	
	2	Movello 1/4 (Pallet)	MUELLE	ZONA SALDAMAT.	7"	3"	7"	8"	16"	7"						7"
	3	Coger Lupe	SALDA MATERIAL	SALDA MATERIAL	14"	15"	13"	16"	15"	16"					15"	
	4	Montar Pallet 3/4	SALDA MATERIAL	ZONA DESCARGA	80"	47"	40"	40"	47"	37"						47"
	5	Volver a Camión	ZONA DESCARGA	MUELLE	22"	19"	20"	21"	37"	22"						22"
	6															
	6	Volver Zona DESCARGA	MUELLE	ZONA DESCARGA	16"											16"
	7	Poner Fecha (etiqueta)	ZONA DESCARGA	ZONA DESCARGA	48"										48"	
	8	Entregar Fichas	ZONA DESCARGA	OFICINA	15"										15"	

Tiempo de ciclo: A 86" B 92"

Nº	Elementos no cíclicos	Frecuencia	Punto Inicial	Punto Final	1	2	3	4	5	6	7	8	9	10	Menor repetido Elemento	Menor repetido Caminar

TOTAL PARA ELEMENTOS NO CÍCLICOS (C) — Tiempo total: C

Media Ponderada ET (A): 86"

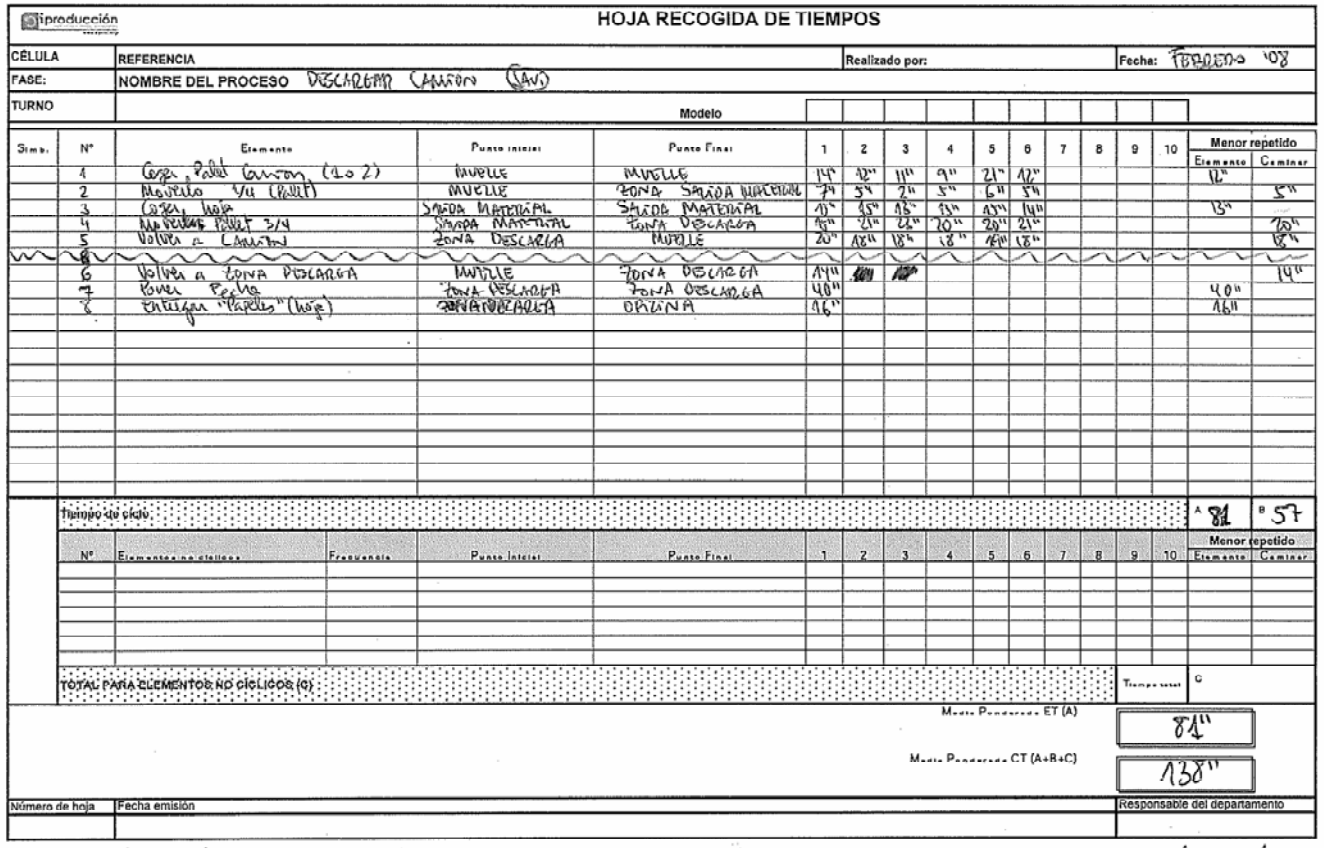
Media Ponderada CT (A+B+C): 178"

Número de hoja	Fecha emisión	Responsable del departamento

⇒ Cuando acaba de descargar, pone las fichas en los pallets descargados.

¡¡CUIDADO QUE NO FALTE NINGÚN PALLET DESCARGADO!!

Fig. A.2.1 Worker 1 – Downloading task



HOJA RECOGIDA DE TIEMPOS

CÉLULA	REFERENCIA	Realizado por:	Fecha: FEBRERO '08
FASE:	NOMBRE DEL PROCESO DESCARGAR CAMIÓN (JAVI)		
TURNO	Modelo		

Simb.	Nº	Elemento	Punto inicial	Punto Final	1	2	3	4	5	6	7	8	9	10	Menor repetido Elemento	Menor repetido Caminar
	1	Coger pallet Camión (1 o 2)	MUELLE	MUELLE	14"	12"	11"	9"	21"	12"					12"	
	2	Movello 1/4 (PALLET)	MUELLE	ZONA SALIDA MATERIAL	7"	5"	7"	5"	6"	5"						5"
	3	Coger hoja	SALIDA MATERIAL	SALIDA MATERIAL	11"	15"	13"	13"	13"	14"					13"	
	4	Movello pallet 3/4	SALIDA MATERIAL	ZONA DESCARGA	15"	21"	22"	20"	20"	21"						20"
	5	Volver a CAMIÓN	ZONA DESCARGA	MUELLE	20"	18"	18"	18"	16"	18"						18"
	6	Volver a ZONA DESCARGA	MUELLE	ZONA DESCARGA	14"	[illegible]	[illegible]									14"
	7	Poner Fecha	ZONA DESCARGA	ZONA DESCARGA	40"										40"	
	8	Entregar "Papeles" (hoja)	ZONA DESCARGA	OFICINA	16"										16"	

Tiempo de ciclo	A 81	B 57

Nº	Elementos no cíclicos	Frecuencia	Punto Inicial	Punto Final	1	2	3	4	5	6	7	8	9	10	Menor repetido Elemento	Menor repetido Caminar

TOTAL PARA ELEMENTOS NO CÍCLICOS (C)	Tiempo total	C

Media Ponderada ET (A): 81"

Media Ponderada CT (A+B+C): 138"

Número de hoja	Fecha emisión	Responsable del departamento

⇒ Cuando hay 2 pallets de material URGENTE, Javi los agrupa para llevarlos juntos!

SIEMPRE HAY INTERRUPCIONES ENTRE MEDIO !!

Fig. A.2.2 Worker 2 – Downloading task

iproducción

HOJA RECOGIDA DE TIEMPOS

CÉLULA | REFERENCIA | Realizado por: | Fecha: Febrero '08

FASE: | NOMBRE DEL PROCESO CARGAR CAMIÓN | Javi

TURNO | Modelo

Simb.	Nº	Elemento	Punto Inicial	Punto Final	1	2	3	4	5	6	7	8	9	10	Menor repetido Elemento	Menor repetido Caminar
	1	Coger Palets (2)	SALIDA MATERIAL	SALIDA MATERIAL	5"	10"	5"	6"	5"	5"					5"	
	2	Mover a Camión	SALIDA MATERIAL	MUELLE	9"	12"	10"	11"	11"	12"						11"
	3	Cargarlo	MUELLE	MUELLE	24"	23"	14"	14"	15"	17"					14"	
	4	Volver nº1	MUELLE	SALIDA MATERIAL	5"	6"	5"	4"	4"	5"						4"

Tiempo de ciclo: A 19 B 15

Nº	Elementos no cíclicos	Frecuencia	Punto Inicial	Punto Final	1	2	3	4	5	6	7	8	9	10	Menor repetido Elemento	Menor repetido Caminar

TOTAL PARA ELEMENTOS NO CÍCLICOS (C) | Tiempo total | C

Media Ponderada ET (A): 19

Media Ponderada CT (A+B+C): 34

Número de hoja | Fecha emisión | Responsable del departamento

Fig. A.2.3 Worker 1 – Uploading task

iproducción

HOJA RECOGIDA DE TIEMPOS

CÉLULA	REFERENCIA	Realizado por:	Fecha: Febrero '08
FASE:	NOMBRE DEL PROCESO CARGAR CAMIÓN LOBO		
TURNO	Modelo		

Simb.	Nº	Elemento	Punto Inicial	Punto Final	1	2	3	4	5	6	7	8	9	10	Menor repetido Elemento	Menor repetido Caminar
	1	Coger pallet	SALIDA MAT.	SALIDA MAT.	3"	8"	8"	6"	10"						8"	
	2	Mover a Camión	SALIDA MAT.	MUELLE	6"	11"	7"	15"	15"							15"
	3	Cargando (Rápido)	MUELLE	MUELLE	14"	21"	17"	23"	24"						24"	
	4	Volver a zona descarga	MUELLE	SALIDA MATERIAL	5"	4"	3"	4"	6"							4"

Tiempo de ciclo: A 32" B 19

Nº	Elementos no cíclicos	Frecuencia	Punto Inicial	Punto Final	1	2	3	4	5	6	7	8	9	10	Menor repetido Elemento	Menor repetido Caminar

TOTAL PARA ELEMENTOS NO CÍCLICOS (C) — Tiempo total: C

Media Ponderada ET (A): 32"

Media Ponderada CT (A+B+C): 51"

Número de hoja	Fecha emisión	Responsable del departamento

→ VARIA MUCHO LOS MOVIMIENTOS !!

Fig. A.2.4 Worker 2 – Uploading task

iproducción

HOJA RECOGIDA DE TIEMPOS

CÉLULA	REFERENCIA	Realizado por:	Fecha: FEBRERO '08
FASE:	NOMBRE DEL PROCESO TRANSPALET (LOBO)		
TURNO	Modelo		

Simb.	Nº	Elemento	Punto Inicial	Punto Final	1	2	3	4	5	6	7	8	9	10	Menor repetido Elemento	Menor repetido Caminar
	1	Buscar TRANSPALET	X	X	10"	10"	9"	10"	14"							10"
	2	Volver a MESA	~~MESA~~ X	MESA	18"	15"	16"	14"	28"							14"
	3	Coger MAT. ACABADO	MESA	MESA	7"	10"	8"	12"	9"						9"	
	4	Poner PEGATINA	MESA	MESA	10"	16"	10"	11"	12"						6"	
	5	MOVERLO A ZONA SALIDA	MESA	ZONA SALIDA	21"	19"	19"	16"	29"							19"
	6	IR A ZONA JAULAS	~~ZONA/SALIDA~~	JAULA/MAT	15"	15"	15"	18"	16"							15"
	7	Coger JAULA/MATERIAL	JAULA/MAT	JAULA/MAT	6"	5"	8"	7"	7"						7"	
	8	PONERLO EN MESA	JAULA/MAT	MESA	14"	18"	14"	14"	15"							14"

Tiempo de ciclo: A 22" B 72"

Nº	Elementos no cíclicos	Frecuencia	Punto Inicial	Punto Final	1	2	3	4	5	6	7	8	9	10	Menor repetido Elemento	Menor repetido Caminar

TOTAL PARA ELEMENTOS NO CÍCLICOS (C) — Tiempo total: C

Media Ponderada ET (A): 22"

Media Ponderada CT (A+B+C): 94"

Número de hoja	Fecha emisión	Responsable del departamento

⇒ ES MUY MUY MUY IRREGULAR EL CICLO DE TRABAJO!!

Fig. A.2.5 Worker 1 – Handing pallet truck

iproducción

HOJA RECOGIDA DE TIEMPOS

CÉLULA	REFERENCIA	Realizado por:	Fecha:
FASE:	NOMBRE DEL PROCESO TRANSPALET (CARLOS)		
TURNO	Modelo		

Simb.	Nº	Elemento	Punto Inicial	Punto Final	1	2	3	4	5	6	7	8	9	10	Menor repetido Elemento	Menor repetido Caminar
	1	Buscar ~~[illegible]~~ Transpalet	X	X	12"	6"	8"	15								10"
	2	Volver a mesa	X	Mesa	23"	19"	18"	18"								17"
	3	Coger Sonda acotada	Mesa	Mesa	10"	10"	9"	10"							10"	
Espera →	4	Pedir Respuesta	Mesa	Mesa	5"	5"	6"	5"							5"	
	5	Movelo a Zona Sauna	Mesa	Zona Sauna	33"	14"	21"	20"								21"
	6	Ir a Zona Sauna	Zona Sauna	Sauna / Material	15"	15"	16"	17"								15"
	7	Coger Sonda / Material	Sauna / Material	Sauna / Material	8"	7"	7"	7"							7"	
	8	Dejarlo en Mesa	Sauna / Material	Mesa	15"	16"	17"	16"								16"

	Tiempo de ciclo														A 22"	B 80"
	Nº	Elementos no cíclicos	Frecuencia	Punto Inicial	Punto Final	1	2	3	4	5	6	7	8	9	10	Menor repetido Elemento	Menor repetido Caminar
	TOTAL PARA ELEMENTOS NO CÍCLICOS (C)														Tiempo total	C	

Media Ponderada ET (A) 22"

Media Ponderada CT (A+B+C) 102"

Número de hoja	Fecha emisión	Responsable del departamento

→ SE PARA CONTINUAMENTE A PREGUNTAR!!

¡¡ NO ENCUENTRA EL TRANSPALET !!

Fig. A.2.6 Worker 2 – Handing pallet truck

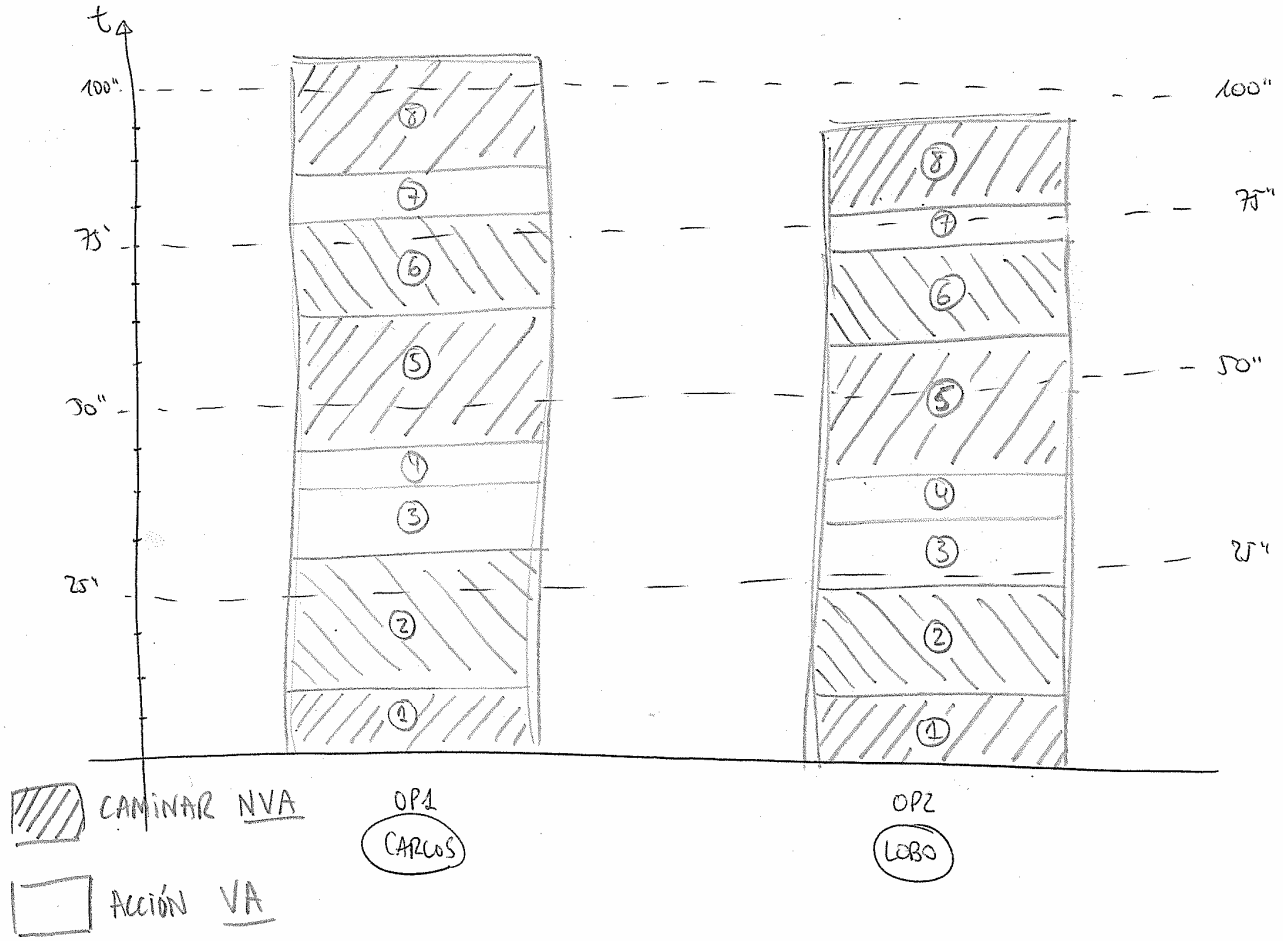


Fig. A.2.6 Handing pallet truck comparison Worker 1 & Worker 2

These two images are the first observations about the work made in the tables. It is important to tnking into account that in *Talleres Bellvitge* there are three different types of pieces:

- Small
- Medium
- Big

These two cases are the observation about small and medium pieces size. Both cases are draft notes.

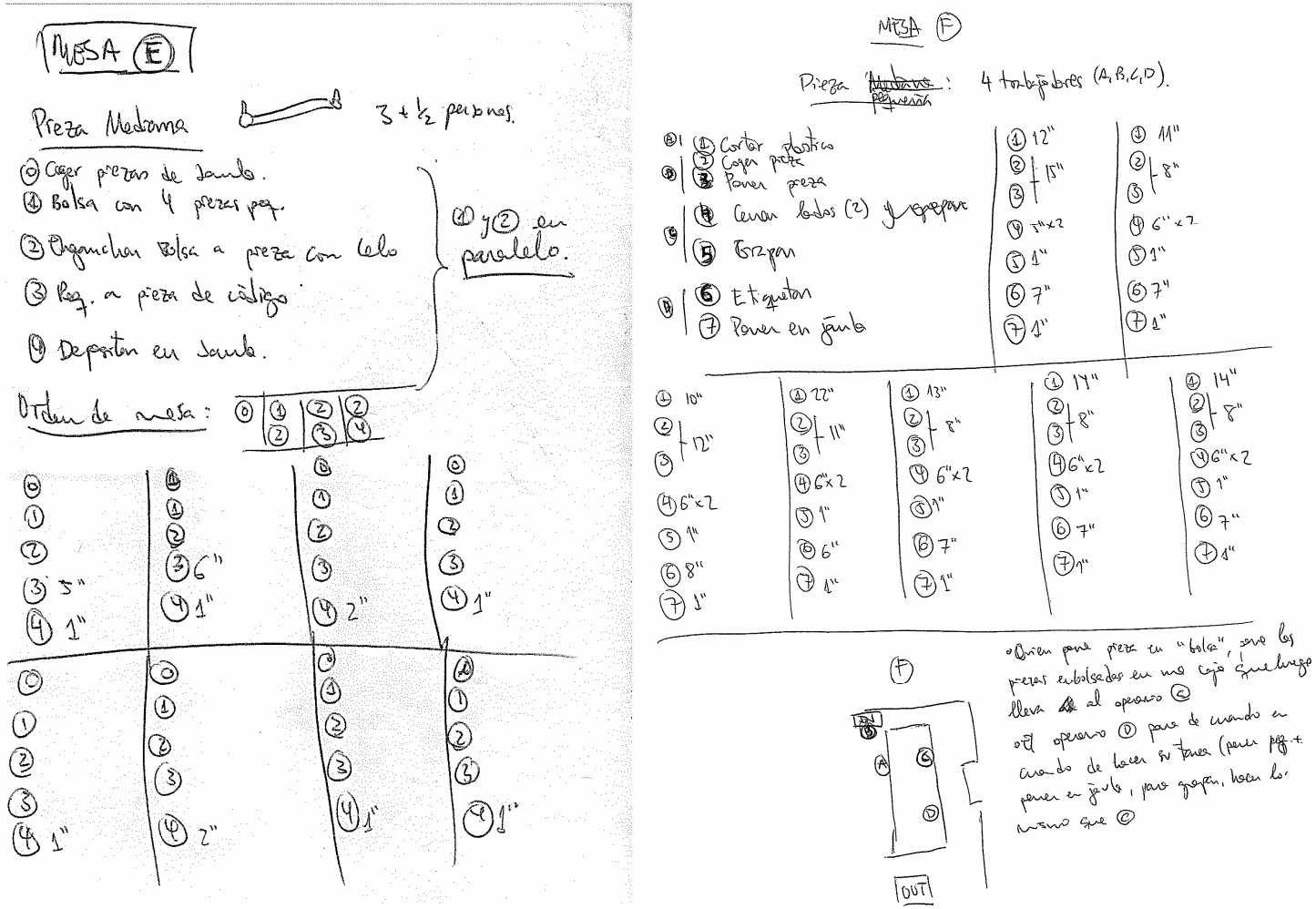


Fig. A.2.7 Work in table draft notes

A3. Future *Talleres Bellvitge* map

To carry out some improvements, some changes have to be done in floor 0. To make this map a scale model was done.

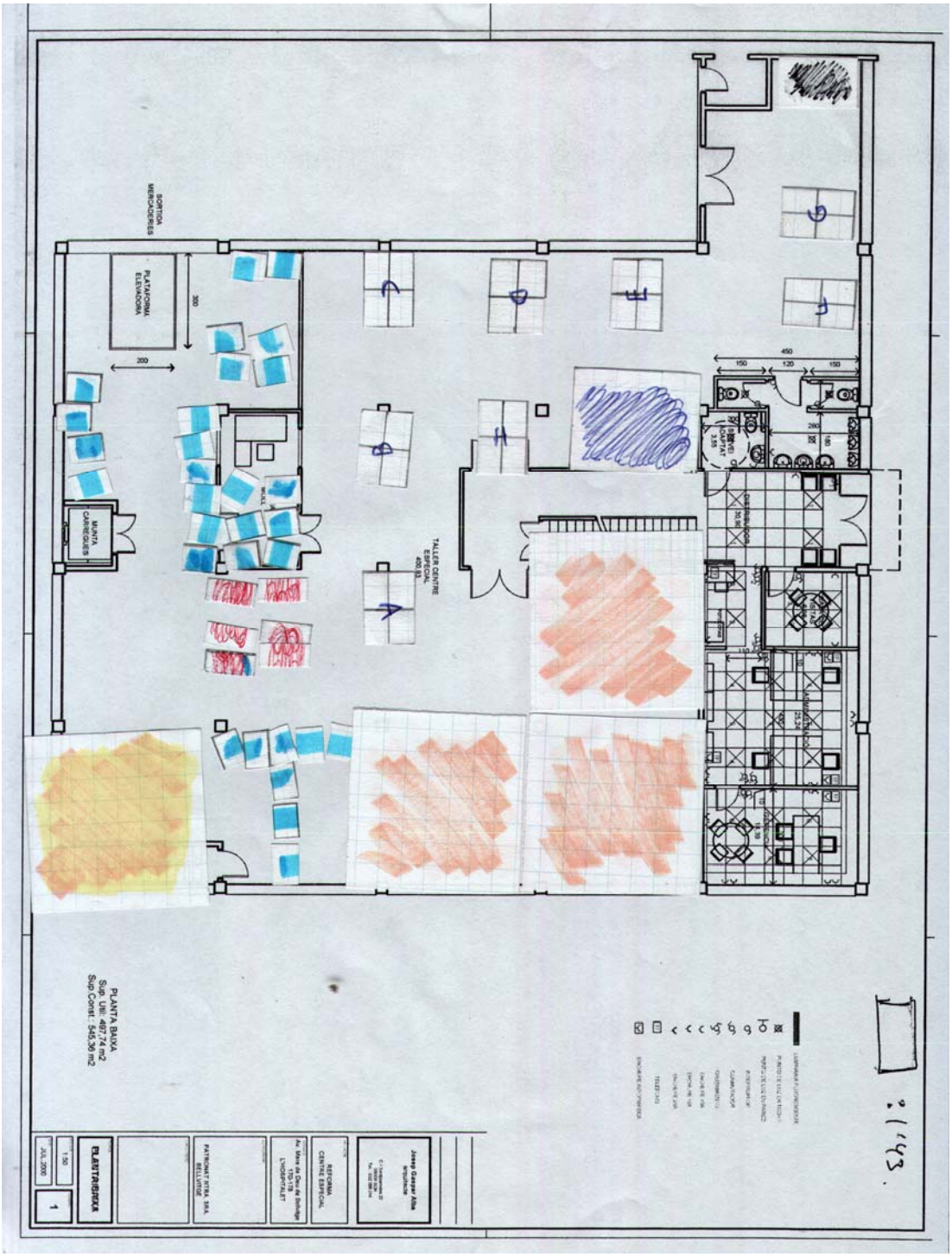


Fig. A.3.1 Model scale Map

Where the sizes and colors are:

Input Material: 25 m x25 m	**Pallet size:** 0,80 m x 1,20 m
Working table: 1,60 m x 2,40 m	**Trolley material:** 1,62 m x 0,72 m
Office: 2,40 m x 1,60 m	**First floor Material:** 25 m x25 m
Blue buckets: 3,20 m x 4,00 m	

Chart A.3.1 Modeling map legend

Finally, it is important to take into account that to implement these improvements a specific order has been done:

(1) Create the input material place
(2) Move the office
(3) Modify the output material place
(4) Relocate some tables
(5) Relocate the blue buckets work