Facility Layout Design Tools Comparison: A Case Study of a SME in Electronic Industry

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Abstract

Designing and/or redesigning a proper layout of a small production line it is not an easy task to a company. Usually this is performed using empirical methodologies and according to space availability. Mainly due to the latter, the layouts are not very efficient and optimized. This case study portrays a Small and Medium-sized Enterprise (SME) in the electronics industry, which, taking advantage of the need to introduce a new product in the production, intends to redesign the layout of a production line, whose efficiency has been decreasing. To this end, three methods were applied - Empirical Model, Systematic Layout Planning and Lean Facility Layout System. The results prove that the Lean Layout Facility System method achieved better results by reducing both lead time and the workers movement time and distance.

Keywords
Layout Design, Systematic Layout Planning, Lean Manufacturing

1. Introduction

As global markets become increasingly more competitive, the uncertainties and difficulties associated with the development of a new product increase alongside with the pressure to keep up with the demand in product innovation (Gupta and Wilemon 1990). Therefore, innovation is considered critical for a company to obtain a dominant position in the market and to gain higher profits (Cheng et al. 2010). Time management, more specifically, the reduction of lead times, will result in a competitive advantage, allowing manufacturing companies to gain an edge over the creation and production of new products (Tersine and Hummingbird 1995). Manufacturing companies have to adapt to this innovation rhythm if they want to survive, and for that, the production lines for new products must be well planned before implemented in the shop floor. Several problems occur when this implementation is not supported by a careful planning and solid study, thus risking lowering the efficiency of the production lines.

According to Kiran (2019), plant layout deals with the orderly and proper arrangement of manufacturing facilities and the use of available resources, including workforce, money, machines, tools, materials, and production processes.

Depending on the production processes properties, like the production volume and products variety, the layout should be organized in different ways. The four main layout types are: fixed-position layout, process layout, cell layout, and product layout.

Considering the existing layout types, the shop floor should be designed so that the manufacturing processes can be achieved in an effective and efficient manner (Åkerman 2016).

The placement of the facilities in the plant area, often referred to as ‘‘Facility Layout Problem”, is known to have a significant impact upon manufacturing costs, work in progress, lead times and productivity (Drira et al. 2006). A well-organized layout of machines or departments and a suitable transportation paths create an efficient plant (Bock and

Hoberg 2006). In addition, a good plant layout keeps costs low and reduces unnecessary material handling while maintaining the product flow through the facility (Khan and Tidke 2013). Due to its important role, manufacturing companies have to continuously pay attention to this problem since there are several reasons why the layout might need to be redesigned, such as a change in the product design, new products added to the existing production lines, new departments added to the enterprise, the need to reduce the amount of work-in-progress (WIP), the need to minimize bottlenecks, etc.

During the last decades, several studies with different approaches to solve the facility layout problem were published. (Singh and Sharma 2006) presents the current and future trends of research on facility layout problems including formulations, solutions methodologies, and developments of different software packages.

Some of these methodologies are: Empirical Model, Systematic Layout Planning (SLP) and Lean Facility Layout System (LFLS). De Carlo et al. (2013), presents a case study of a small batches production line using these three approaches, where LFLS achieved better results. The SLP method, developed by Richard Muther (Muther 1973), combines a flow with an activity analysis to develop a relationship chat and, from it, a relationship diagram (Sule 1991). Using this relationship diagram, the manufacturer's workstations/sections are placed in a plant, close to each other, according to their use frequency and logical relationships (Suhardini et al. 2017). This method is widely used in layout design in various small and medium enterprises (Ali Naqvi et al. 2016), being already proven by several successful studies of its application (Ali Naqvi et al. 2016; Eliud, Muchiri, and James 2018; Fahad et al. 2017; Wiyaratn, Watanapa, and Kajondecha 2013). The term Lean Manufacturing (LM) became known in 1988, having its origin in the Toyota Production System (TPS). Alukal, (2003) states that LM helps organizations to reduce costs, cycle times and unnecessary activities without added value, resulting in a more competitive, agile, and responsive company to the market. The characteristics of the LM philosophy can be applied to the Layout Planning Problem - Lean Facility Layout System. This methodology has been successfully applied in several works (Jia et al. 2013; Putri and Dona 2019).

This case study takes place in a SME in the electronics industry, which has seen a significant reduction in the efficiency of one production line. In addition, it also needs space to introduce a new production line for a new product. The need to reorganize the space in the manufacturing plant presented a perfect opportunity to optimize the layout of this production line. To achieve this goal, three different methods were applied and their implementation and comparison in terms of efficiency are presented in this paper.

The paper is divided as follows: in section 2, the case study is presented, as well as the production line description and the developed approach to the layout design. In section 3, the obtained results are showcased and commented on. Finally, in section 4 conclusions on the comparison of the effectiveness of the solutions are provided as well as future work remarks.

2. Case Study - Problem description and characterization

The practical case under study takes place in a SME belonging to a group in the electronic industry. This group develop and produce efficient, sustainable, and suitable solutions for the Smart Cities/Utilities, Smart Buildings/Installations, and Smart Homes/Appliances. The company is dedicated to the production of Smart Cooking Boards, LED Lights and, more recently, a new product, that for the sake of disclosure, will be reference thought of this paper as MWM.

To start the production of MWMs, the company faces the problem of lack of free space to accommodate the new production line. Simultaneously, there is another problem, related to the optimization of an existing production line, whose efficiency has been decreasing. So, the need to transfer the existing production lines due to the lack of space is an excellent opportunity to study in detail the possibility of considering a new plant layout, in order to improve the performance of this production line.

The LED Lights production line was observed to detect the flaws that might have caused a decrease in production efficiency. The following problems were detected:

- Excessive movement of workers and parts: the production line was divided over two floors. There was a lot of movements between floors during the production, being these movements the one of the main causes of the existence of non-conformities in the products.
- Lack of space: the space available to the production line is limited.
- Unidentified workstations: there is no workstations identification or dedicated spaces to specific tasks. The tasks were performed according to what the workers find it most convenient.
- Disorganized tools: there is no dedicated place to store the tools on each workstation. Whenever a random tool is needed, workers spend a lot of time looking for it.

2.1 Production Process Description

This study considers the production line of three families of LED lights, that will be denoted in this paper as Ic, IE and L. These products share the same production line, being this the production line that presented a noticeable decrease in production efficiency. Table 1 has information on some Key Performance Indicators (KPIs) that characterize the performance of this production line.

Table 1. KPIs of the LED Lights families production line.

KPI	IE	Ic	L
Lead Time (s)	52507,5	52300,5	552600,5
Workers Moving Time (s)	384,2	614,2	404,2
Workers Moving Distance (m)	438,6	649,7	461,0

Currently, the production of these LED Lights is divided into two floors. Production is started on floor 0, goes to floor 1, and the final product returns to floor 0 to be dispatched to the client.
To deal with one of the identified production line efficiency bottleneck - the excessive movement between floors - an extensive analysis was made regarding the lower floor (floor 0). The study concluded that it would be possible to bring the whole production line into floor 0, thus reducing the movement between floors to zero.
In order to understand the production line configuration, a brief description of this three family products production process is presented next. This description will be only of the processes carried out in floor 1, because it is the part that will be relocated to floor 0.

<u>IE Family Production:</u>
IE LED Lights is a product that consists, in a simplified manner, of Illuminating Matrix Modules (IMMs), which are, printed circuits with built-in LEDs, devices with movement sensors denominated by RF, power supplies (PS), lenses, lighting fixtures, covers and wiring.
All these components arrive to floor 1, where the manufacturing sequence presented in Figure 1 begins. Each process is performed in a workstation and Table 2, portrays the necessary resources in each of the workstation.

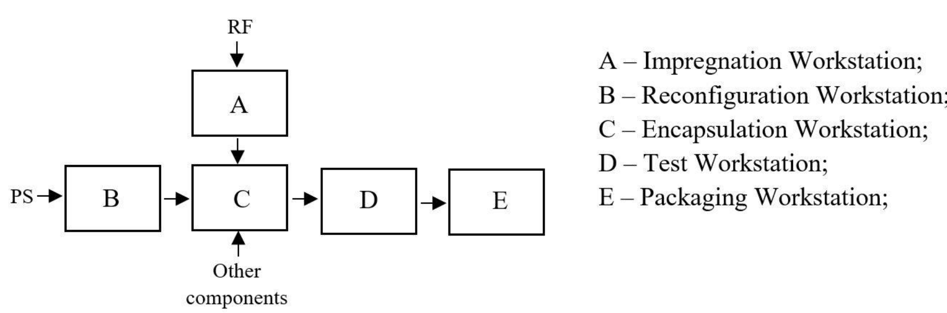


Figure 1. Production process flowm of IE family lights.

All the LED Lights must pass through an endurance test. If any of them fails the test, it goes through a rework process. In the end of production, the IE returns to floor 0 to be dispatched.
Another important consideration is, due to the process characteristics, the impregnation workstation must be kept away from all the others. As such, it will not be considered in the layout design.

Table 2. Resources required for each workstation in the IE family production.

Resource	Quantity	WS	Observations
Reconf. Countertop	1	Reconfiguration	Preference to be close to the production countertops.
Product. Countertop	2	Encapsulation	It must be placed at 1m from each other to facilitate the production of the largest LED Lights.
Support Countertop	1		It must be close to the production countertops. Shared countertop with other families.

Encaps. Shelf	1		It must be close to the production countertops. It can be shared with another family.
Pack. Countertop	2	Pack.	Preference to be close to the test platform.
Pack. Shelf	1		Preference to be close to the Packaging countertop. Shared by the three families.
Test Platform	1	Test	Test platform shared with Ic and L LED Lights

Ic Family Production:
Ic LED Lights consists of IMMs, RFs, PSs, lighting fixtures, covers and wiring. The production process of Ic is similar to the IE. The main difference being that Ic Lights do not go through the reconfiguration process. The other differences are related to their design and, consequently, the way which operation is carried out. The manufacturing sequence, that occur in the floor 1, can be seen in the Figure 2, and Table 3 portrays the necessary resources at each workstation.

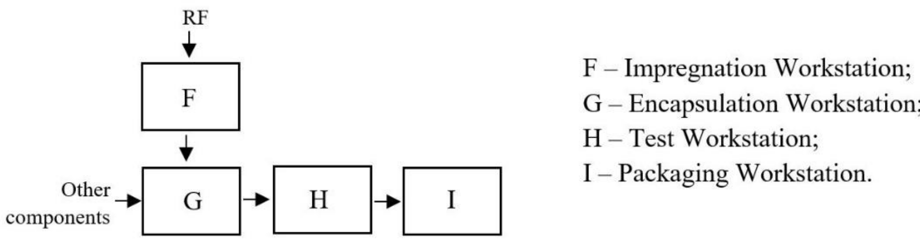
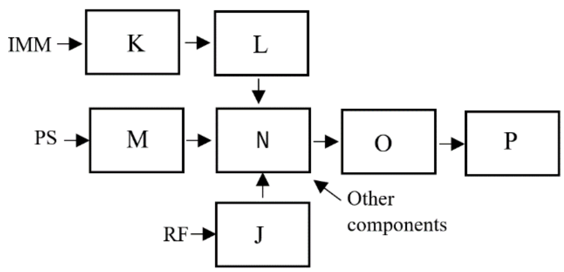


Figure 2. Production process flow of Ic family lights.

Table 3. Resources required for each workstation in the Ic family lights production.

Resource	**Quantity**	**WS**	**Observations**
Prod. Countertop	2	Encapsulation	It must be placed at 1 m from each other to facilitate the production of the largest LED Lights.
Support Countertop	1		It must be close to the production countertops. Shared countertop with other families.
Encaps. Shelf	1		It must be close to the production countertops. It can be shared with another family.
Pack. Countertop	2	Pack.	Preference to be close to the test platform.
Pack. Shelf	1		It must be close to the production countertops. It can be shared with another family.
Test Platform	1	Test	Preference to be close to the Packaging countertop. Shared by the three families.

L Family Production:
L LED Lights consists of IMMs, RFs, PSs, LED Light hoops, diffusers, acrylics, and wiring. The L production process differs considerably from the other LED Lights families. All the previously mentioned prefabricated components arrive at floor 1. The following diagram shows the workflows identified between workstations, and the Table 4 resume the resources needed for them to work normally.



J – Impregnation Workstation;
K – Gluing Workstation;
L – Welding Workstation;
M – Reconfiguration Workstation;
N – Encapsulation Workstation;
O – Test Workstation;
P – Packaging Workstation.

Figure 2. Production diagram of the L family lights.

Table 4. Resources required for each workstation in the L family production.

Resource	**Quantity**	**WS**	**Observations**
Gluing Platform	1	Coll.	It must be close to the welding countertop.
Hoops Support	1		It must be close to the gluing platform.
Welding Countertop	1	Weld.	It must be close to the gluing platform.
Reconf. Countertop	2	Reconf.	Preference to be close to the production countertops.
Production Countertop	2	Encaps.	They have to be put together to have a larger work countertop.
Support Countertop	1		It must be close to the production countertops. countertop shared with the other families.
Encaps. Shelf	1		It must be close to the production countertops. It can be shared with another family.
Pack. Countertop	1	Pack.	Preference to be close to the test platform.
Pack. Shelf	1		Preference to be close to the packaging countertop. Shared by the three families.
Test Platform	1	Test	Shared platform with IE and Ic.

2.2 Current Layout Analysis

As previously mentioned, the main objective is to transfer the portion of the production line being currently run on floor 1, into floor 0. Figure 4 depicts the current layout of the reserved space for the LED Lights production on the upper floor, which is comprised of approximately 54m^2.

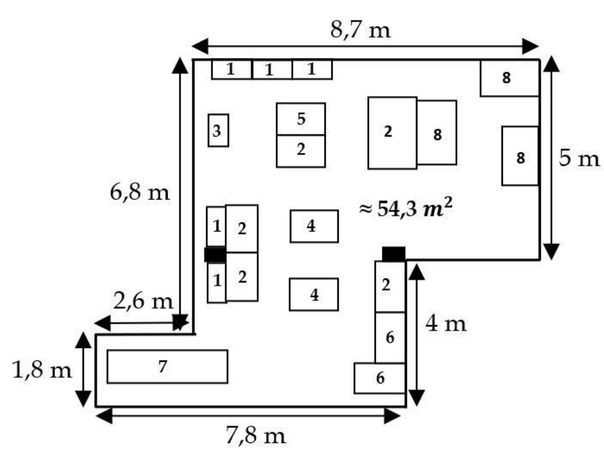


Figure 3. Current layout of the production line under study on the first floor. Legend: 1 - Support shelf; 2 - Support countertop; 3 - Gluing platform; 4 - Encapsulation countertop; 5 - Reconfiguration and welding countertop; 6 - Packaging countertop; 7 - Test platform; 8 – Impregnation countertop.

An analysis of the current layout shows that the three LED Lights production share the available resources, which makes the simultaneous production of different light families unfeasible. When simultaneous production is needed, the workers used resources not allocated to this production line. Furthermore, the production space is quite small.
As mentioned before, it is possible to allocate space for the new layout on floor 0, doubling the space previously available to the production line (Figure 5).

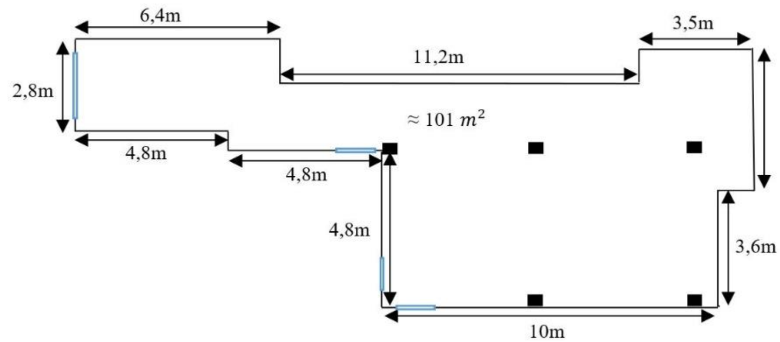


Figure 4. Space available in the lower floor for the new production line layout.

2.2 Design of Layout Solutions

The layout solutions were achieved using three different methodologies. The first was an empirical model based on observation and the remaining are two well known methodologies - System Layout Planning and Lean Facility Layout System - which include engineering and optimization techniques.

Empirical Model:
The empirical approach was applied with the aim of eliminating or reducing the previously identified problems. For that purpose, the main factors considered were:

- Workflows;
- Interaction between workstations;
- Approaching restrictions;
- Visual management;
- Workers' opinions: semi-structured interviews were conducted to understand which layout was considered most suitable by workers with more experience.

According to the information collected, the layout shown in Figure 6 was developed. This figure shows the workstations, the resources positioning, and the LED Lights workflow. The dashed blue line represents the IE, the filled orange the Ic and the dotted green the L family workflows.

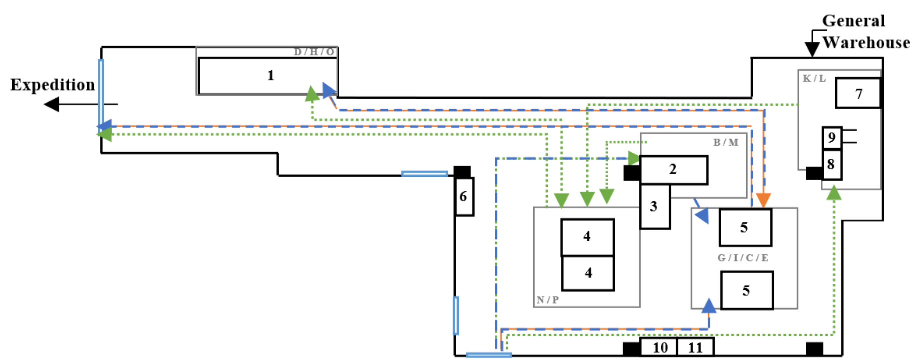


Figure 5. Sections and workflows in the layout resulting from the empirical model. Legend: 1 - Test platform; 2 - Reconfiguration countertop; 3 - Support countertop; 4 - L encapsulation/packaging countertop; 5 - Ic and IE encapsulation/packaging countertop; 6 – Shelf to L tools; 7 - Welding countertop; 8 - Gluing platform; 9 - L hoop support; 10 - Shelf for packaging; 11 - Shelf for Ic and IE tools.

Systematic Layout Planning (SLP):
This methodology can be divided into three major steps: collection and analysis of production processes information, layouts design and selection of the most suitable layout.
In the first step, all the information that characterizes the workstations/resources is collected. This information is used to build, the relationship chart. The relationship charts highlight the desirability levels of adjacency between pairs of resources belonging to the various workstations and also depicts the reason for the respective degree of proximity (with a code from 1 to 3). After the relationship charts elaboration, the respective relationship diagrams are drawn. This diagram shows the resources connected through lines, and their characteristics - thickness and color - are dependent on the desirability levels of adjacency between the resources. The SLP second phase involves the creation of layouts options, considering the developed relationship diagram. It is necessary to consider the available space and the desirability levels of adjacency between the resources to be allocated. Finally, in the third phase, the developed layouts are analyzed, and the most suitable one, according to the settled KPIs, is chosen to be implemented and tested. Since the layout has to consider three products production, it would be necessary to develop a relationship chart for each one. However, analyzing the processes and resources incorporated in each product production, it is easily perceived that the Ic and IE families have 3 processes in common and both need the same resources. That said, only a relationship chart will be made for these two families and another one for the L family. Figure 7 and Figure 8 show the relationship charts obtained for the families under study. With the relationship charts developed, the respective relationship diagrams were elaborated (Figure 9).

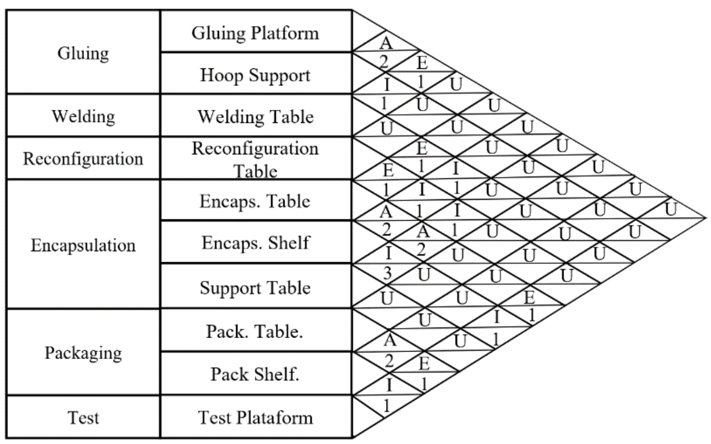


Figure 7. Relationship chart of the L family of LED Lights. Legend: A - Absolutely necessary; E - Especially important; I - Important; O - Ordinary; U - Unimportant; X - Undesirable. Code: 1 - Workflow; 2 - Resources used in the same task; 3 - Resources from the same workstation.

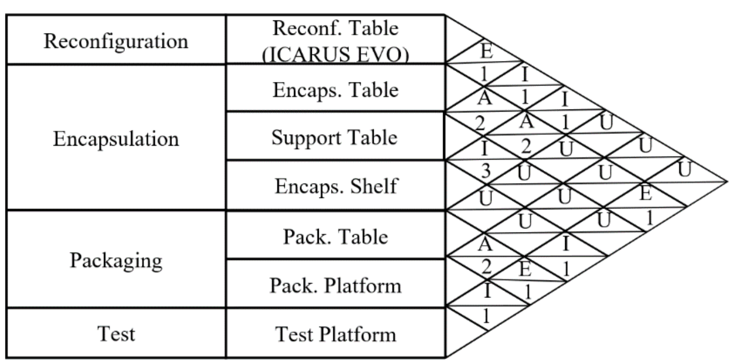


Figure 8. Relationship chart of the Ic and IE families of LED Lights. Legend: A-Absolutely necessary; E-Especially important; I-Important; O-Ordinary; U-Unimportant; X-Undesirable. Code: 1 - Workflow; 2 - Resources used in the same task; 3 - Resources from the from the same workstation.

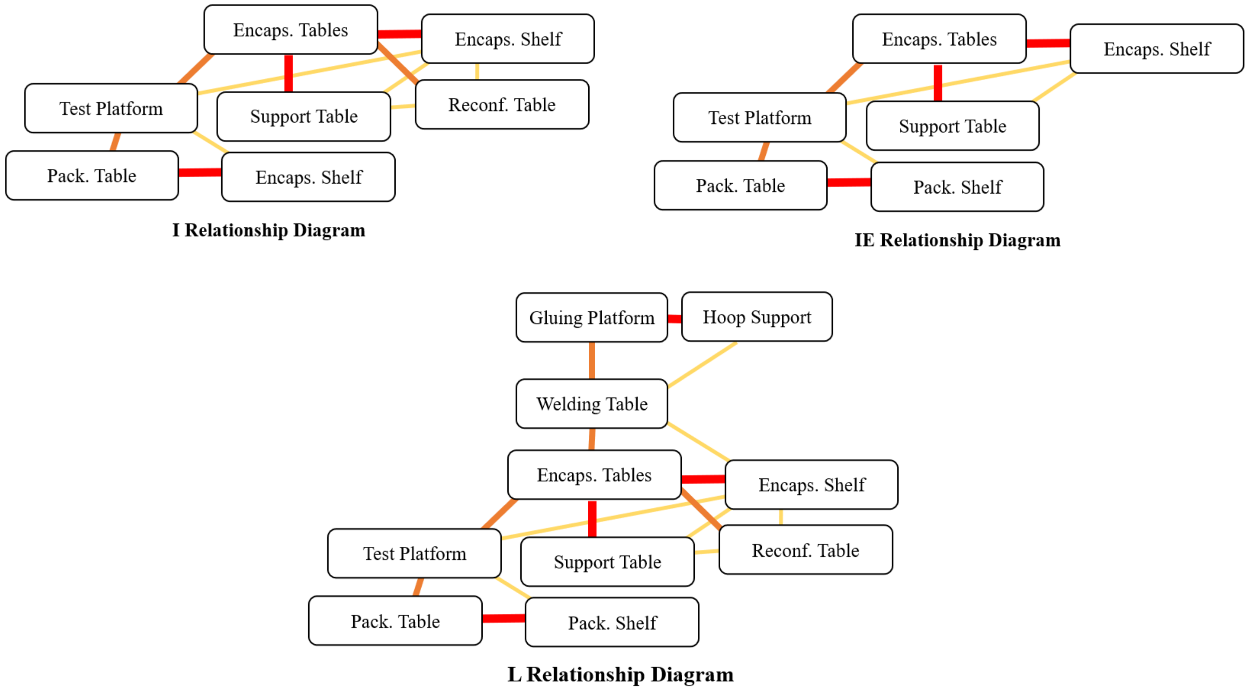


Figure 9. Relationship diagrams only with the relevant connections. Color code legend: Red Line - A; Orange Line - E; Yellow Line - I.

After analyzing the previous diagrams, the layout solution is presented in Figure 10. The dashed blue line represents the IE, the filled orange the Ic and the dotted green the L family workflows.

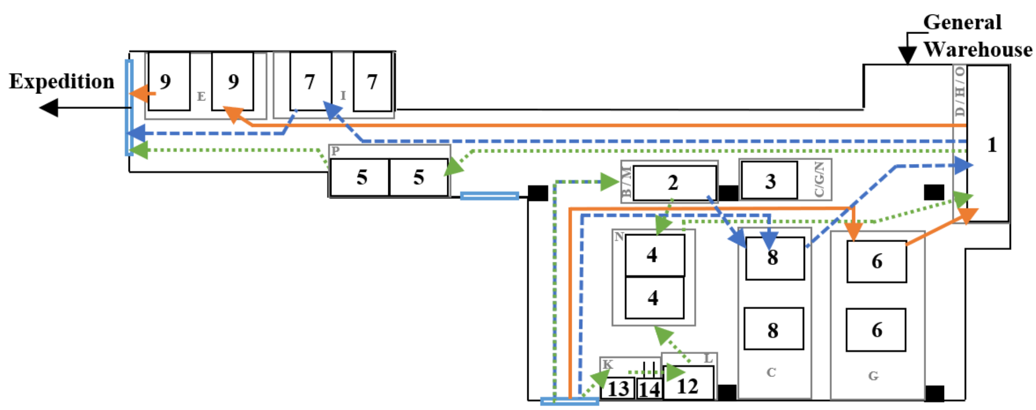


Figure 10. Sections, resources positioning and workflows in the layout resulting from the SLP method. Legend: 1 – Test platform; 2 - Reconf. countertop; 3 – Support countertop; 4 – L Encaps. countertop; 5 – L Pack. countertop; 6 – Ic Encaps. countertop; 7 – Ic Pack. countertop; 8 – IE Encaps. countertop; 9 – IE Pack. countertop; 10 – L Tools shelf; 11 – Ic & IE Tools shelf; 12 – Welding countertop; 13 – Gluing platform; 14 – Hoop support; 15 – Pack. shelf.

<u>Lean Facility Layout System (LFLS):</u>
The Lean concept is based on the waste elimination, also referred as *MUDA*, in order to obtain a continuous flow. The literature identifies seven types of lean waste: transport, inventory, handling, waiting, excessive production, excessive processing, and defects. More recently, an eighth type has been added to the literature: the devaluation of knowledge and experience of human resources.

The characteristics of lean production can be applied to the layout development, resulting in the Lean Facility Layout System. According to De Carlo et al., (2013), this method consists in four implementation phases:

- Definition of the current state, mapped through the Value Stream Mapping Lean Tool: this phase results in a model that represents the current state - As-Is Model - of the tasks necessary for the development of a given product.
- Waste elimination: lean techniques are applied in this phase in order to eliminate the identified waste in the As-Is Model.
- To-Be Model Development: this model is elaborated considering the waste elimination, or reduction.
- Layout Development: based on the changes and improvements identified in the previous steps, the design of the new facility layout is developed.

The facility layout obtained according to this process has properties and goals similar to the lean manufacturing ideas: it will be oriented towards a waste reduction. De Carlo et al., (2013) applied this methodology, considering transporting time, space and unnecessary workstations as waste that must be reduced.
The current status VSM for this production line - As-Is Model - were developed in order to identify the type of waste to be eliminated or reduced (Appendices A, B and C).
By analyzing the models, the type of waste identified was the transportation time between processes, existing due to the presence of unnecessary movements.
Having this in consideration, the To-Be Models, for this production line was developed (Appendices A, B and C). It should be noted that in the To-Be Models, only the portion of the production line relevant to the lead time was placed in the VSM.
The major differences between the current and the future models are related to the changes in the transport time between processes obtained through the elimination of unnecessary movements.
The Lean layout present in Figure 11 was developed based not only on the To-Be models, but also in the concept of manufacturing cell, when it was considered suitable. Once again, the dashed blue line represents the IE, the filled orange the Ic and the dotted green the L family workflows.

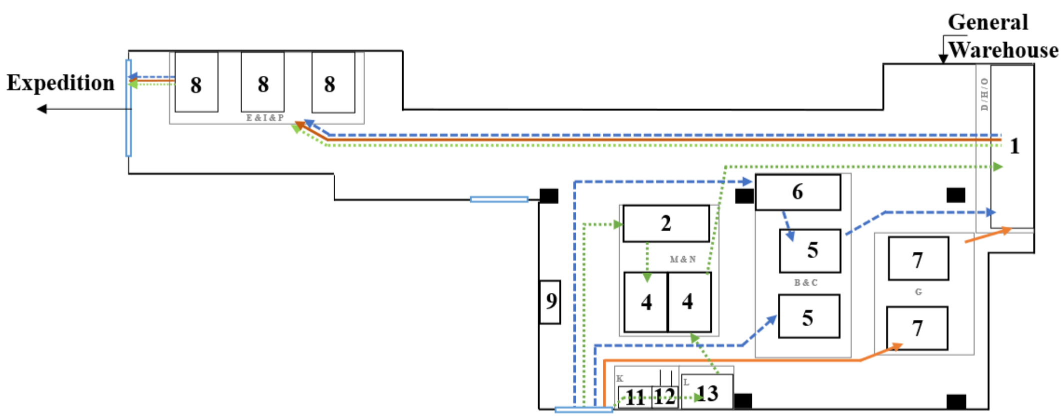


Figure 11. Sections and workflows in the layout resulting from the Lean method. Legend: 1 – Test platform; 2 - L Reconf. table; 3 – Support countertop; 4 – L Encaps. countertop; 5 - IE Encaps. countertop; 6 – IE Reconf. countertop; 7 – Ic Encaps. countertop; 8 – Pack. countertop; 9 – L Tools shelf; 10 – Ic \& IE Tools shelf; 11 – Gluing platform; 12 – Hoops support; 13 – Welding countertop.

The reconfiguration and encapsulation workstations were grouped, forming the reconfiguration & encapsulation cell. In addition, the workstations related to the packaging of the three families were also grouped, creating only one packaging area called the packaging cell. Such was done to optimize the space usage seeing that only two workers do the packing at the same time. Lastly, the test cell was created, which contains the test platform used by all LED Lights families.

3. Results and Discussion

3.1 Empirical model

The layout resulting from the empirical approach mixes concepts such as layout by processes and layout by products. The L family production line uses 4 out of 6 workstations dedicated only to its production - gluing, welding, encapsulation, and packaging - which corresponds to a layout by product. The remaining two workstations - reconfiguration and test - are shared with the rest of the LED Light families, being in this case a layout by process. Regarding the production of the Ic and IE families, both families share workstations, which is why the layout is defined by processes. In this layout, the countertops needed for packaging and encapsulation are the same since the workers consider that this to be an asset. In addition, specific shelves were installed to store the tools needed for production and for smaller raw material.

With the empirical layout, it becomes possible to produce two products from different families at the same time and the useful free space is considerably higher, which will have a positive impact on production efficiency.

3.2 SLP

Analyzing the resulting layout of the SLP model, it is easily perceived that, compared to the empirical layout, it uses a greater number of resources, forming a more complex layout. This happens because the resources required for each individual family have been considered, which leads to duplicate resources, avoiding waiting times due to occupied resources. Being, in this case, considered as a layout by product. This layout allows the simultaneous production of the three different families of LED Lights. Additionally, its configuration reduces the distance traveled between workstations by 8%, on average, when compared to the empirical layout.

3.3 LFLS

The layout resulting from the Lean Facility Layout System methodology took advantage of the manufacturing cell concept. Due to this, some workstations were grouped into a cell, which makes the workers work in a smaller area. Consequently, there was a decrease in the workers' movements. This can be reflected in the significant reduction of transportation waste, and by consequence, in the production lead time.

With the lean layout, it is possible to produce three products from different families at the same time, being the space usage optimized, which will have a positive impact on the production efficiency.

The following Table summarizes the results obtained from each model.

Table 5. Results of the three methodologies implemented.

LED Lights Family	**IE**			**Ic**			**L**		
Model	Emp	SLP	LFLS	Emp	SLP	LFLS	Emp	SLP	LFLS
Lead Time(s)	52494,8	52491,5	52487,0	52286,8	52276,2	52276,2	52567,0	52571,0	52571,0
Workers mov. time(s)	306,7	285,1	280,6	489,9	467,4	466,5	315,6	283,2	279,6
Workers mov. dist.(m)	352,4	328,4	323,4	511,6	486,6	485,6	362,6	326,7	322,6

4.3 Layout Results comparison

Consider the three methodologies results, Table 6 summarizes the percentage improvements of the results obtained for the three layouts.

Table 6. Results of the three methodologies implemented.

LED Lights Family	**IE**			**Ic**			**L**		
Model	Emp (%)	SLP (%)	LFLS (%)	Emp (%)	SLP (%)	LFLS (%)	Emp (%)	SLP (%)	LFLS (%)
Lead Time (s)	+ 0,02	+ 0,03	**+0,04**	+0,03	**+0,04**	**+0,04**	+0,06	+0,05	**+0,07**
Lead Time without the endurance test (s)	+0,60	+0,76	**+0,98**	+0,91	**+1,09**	**+1,09**	+1,43	+1,30	**+1,66**

Workers moving time (s)	+20,2	+25,8	**+27,0**	+21,3	+25,1	**+25,3**	+22,0	+30,0	**+31,0**
Workers moving distance (m)	+19,6	+25,1	**+26,3**	+20,2	+23,9	**+24,0**	+21,0	+29,0	**+30,0**

Regarding the lead time of each family, the improvement is not significant. This is due to the processing times being much longer when compared to the transportation times, so the first one has a more significant contribution to the lead time of the products. Regarding the workers' distances and movement times, when directly compared, it is noticeable that there is a substantial improvement, which can reach 30%. Since the movement of intermediate products on the shop floor was considered one of the major causes related to non-conformities, there is a considerable improvement related to product quality. Overall, the Lean Facility Layout System achieves a greater layout improvement over the other methods, and this would be the layout suggested to the SME Executive Direction to be put into practice.

6. Conclusions and Future Work

The efficiency of a production line can be influenced by several parameters, being the layout of the shop floor one of the most important. Considering this, the case study company took advantage of the need to add a new line to the shop floor to make a more in-depth study on three families production line whose efficiency had been decreasing. That said, three methodologies were applied - Empirical Model, Systematic Layout System, Lean Facility Layout System -, and three distinct layouts were obtained. To compare the performance of each layout, both the productive lead time and the workers moving time and distance were used as KPIs.
All developed layouts showed improvements compared to the initial layout. The KPI that achieved the least significant improvement was the lead time. However, this is explained due to the fact that the objective was not to optimize the productive processes but to reduce the waste resulting from excessive movement as much as possible. Regarding the movement of workers, there was a significant improvement, reaching 30%. Although there is no significant reduction in lead time, there is a considerable improvement related to product quality, since the movement of intermediate products on the shop floor was considered one of the major causes related to non-conformities. Taking into account the results, this study proved that the Lean Facility Layout System methodology obtained better results than the other two methodologies, being this layout the one recommended to be implemented.
It is important to note that by changing the initial layout to the proposed one, the space is optimized, however if the company culture does not emphasize the cleaning and organization, quickly the little available space ceases to exist, and consequences will be felt, again, in the productive efficiency. That said, it is necessary to review the layout whenever possible, using different methodologies in order to eliminate another type of waste inserted in the production line. Having this in mind, as future work, it should be test other layout design methodologies to improve the results.

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Appendices

Appendix A: IE VSM - As-Is and To-Be Models

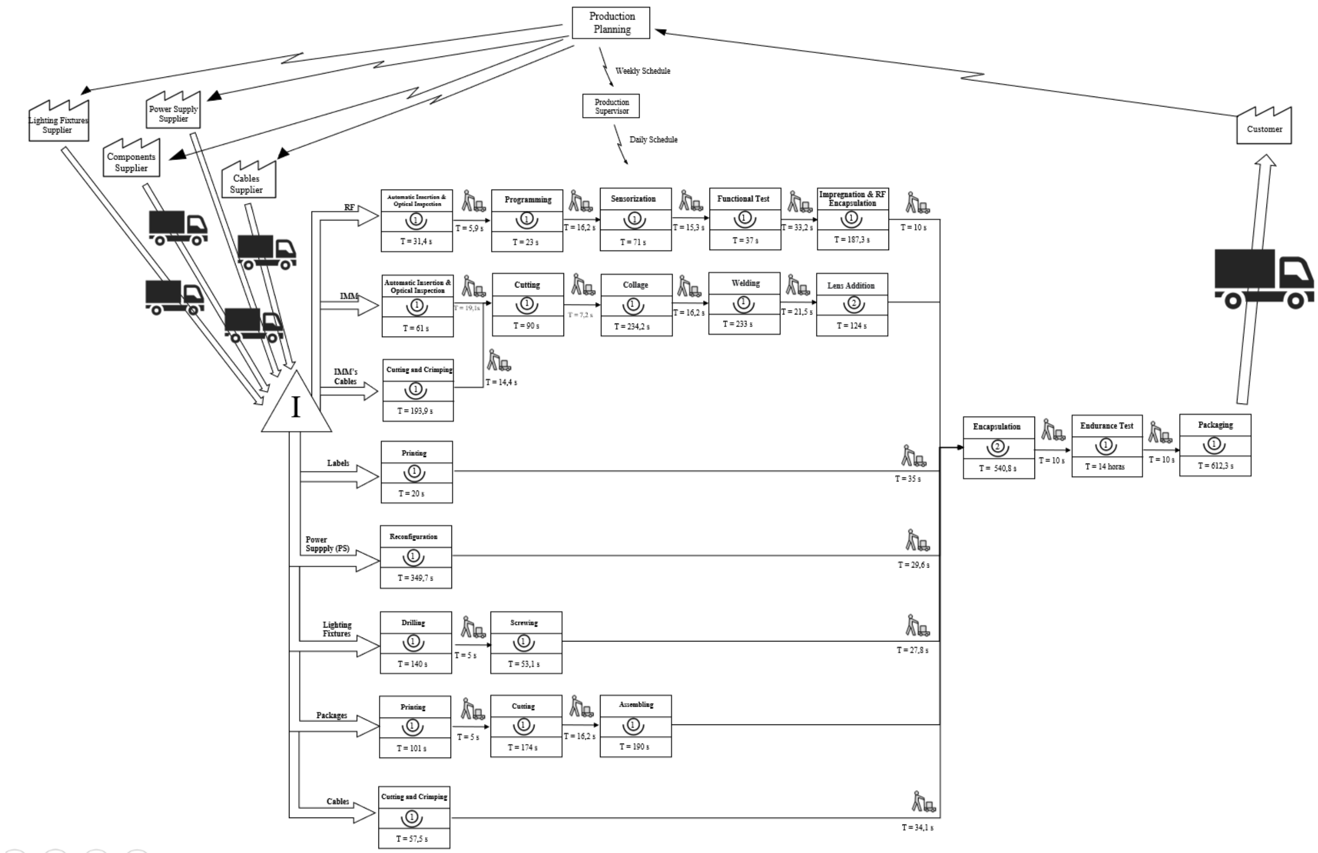

Figure 12 - IE Family VSM: As-Is Model.

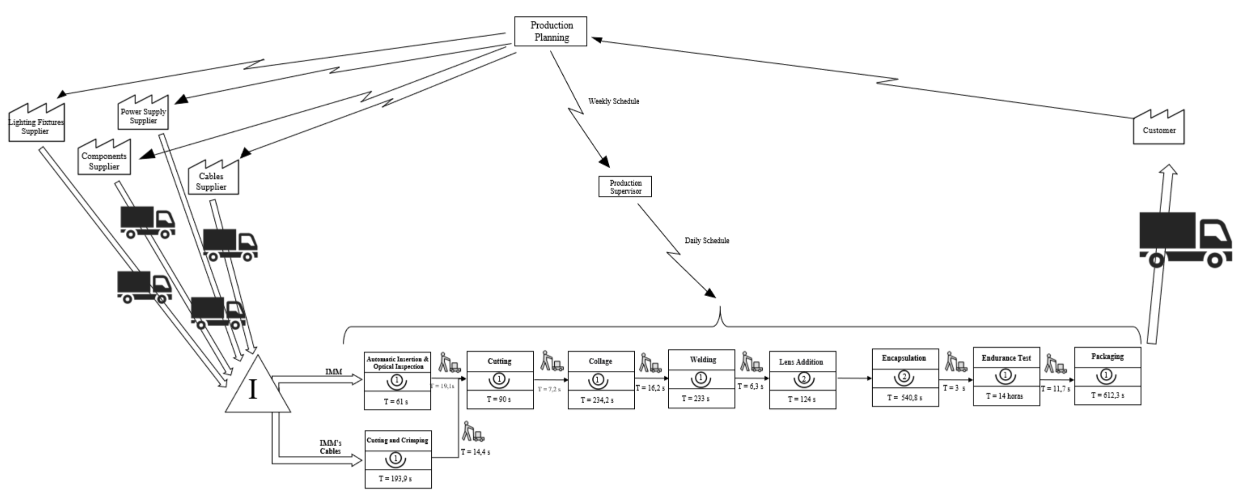

Figure 13 - IE Family VSM: To-Be Model.

Appendix B: Ic VSM - As-Is and To-Be Models

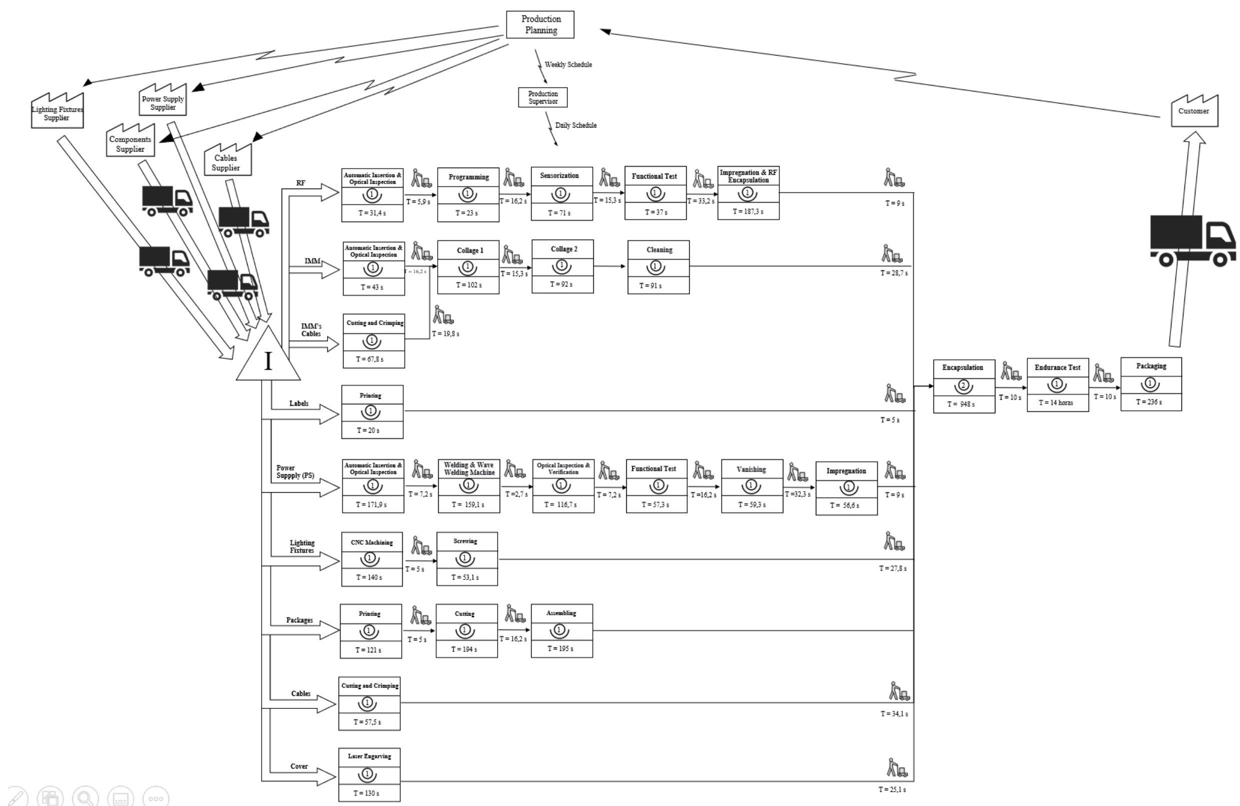

Figure 14 - Ic Family VSM: As-Is Model.

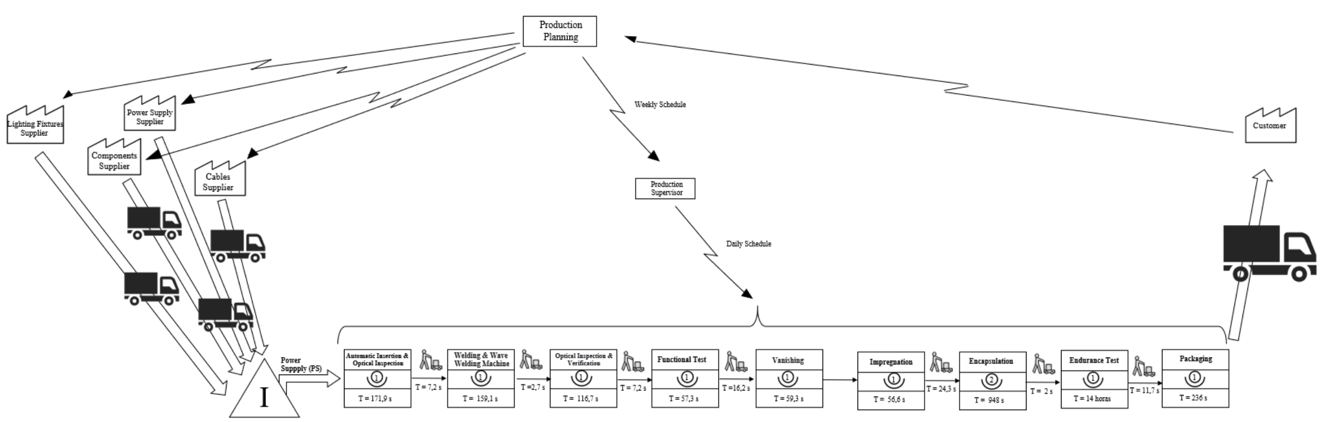

Figure 15 - Ic Family VSM: To-Be Model.

Appendix C: L VSM - As-Is and To-Be Models

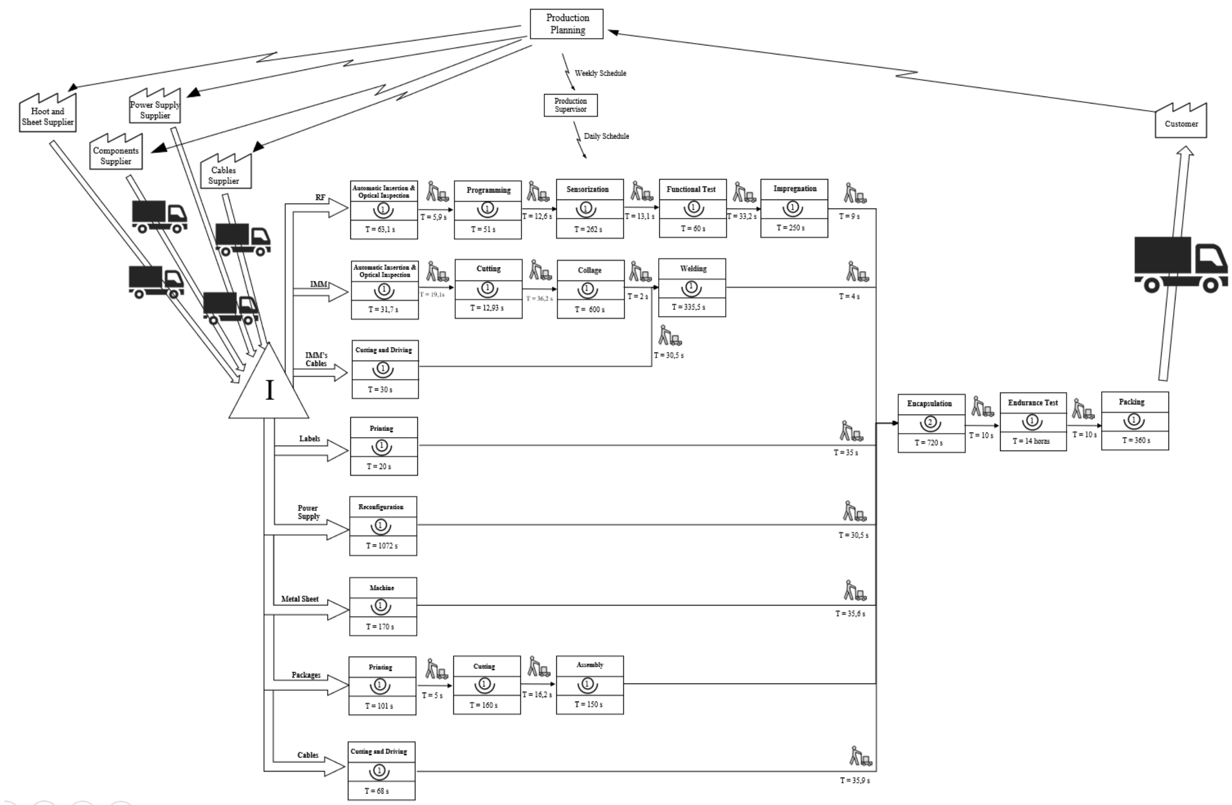

Figure 16 - L Family VSM: As-Is Model.

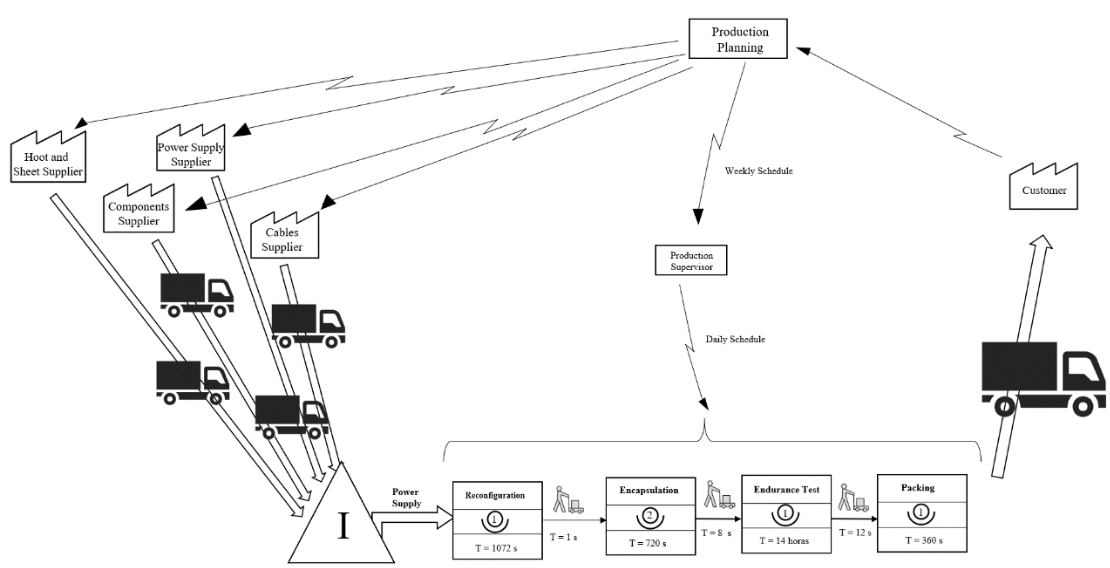

Figure 17 - L Family VSM: To-Be Model.