Implementation of the Last Planner System in a Construction Company

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ABSTRACT

This project is focused on changing the traditional Ecuadorian manner of construction by implementing the last planner system in the building stage. Last planner system is a practical application of the methodology lean construction. First, a literature review will present the importance of changing the methodology and strategies of construction as this is one of the areas that contribute to the development of the country with its earnings. Also, to comprehend and analyse the current production process, seeking the activities that do not add value to the product, wastes, bottle necks, and the perception and attitude of workers with this traditional way of working. In this stage it is necessary to measure production times. Second, a literature review of Lean Construction`s methodology and its practical tool of last planner system will be done in order to have the key points of how to implement this new procedure. Furthermore, start implementing the practice. Analyze the reaction and attitude of workers during and after the change. Also, measure the new production times. Finally, there will be an analysis of the obtained data for comparing the production before and after the application of this innovative approach and also find the difference in worker`s perception and attitude.
ACKNOWLEDGMENTS AND DEDICATIONS

Dedication

Throughout my life, there have been persons that have always been there during happy but also difficult and trying times. I would like to dedicate this dissertation, effort, hard work and everything I did and keep doing to my family, love and friends that have been looking after me. Without their help and support I wouldn't be able to study abroad. During the master’s period all their love and supportive words made me feel comfortable and happy to know there will be always people with whom I can count. For those reasons, this project is dedicated to them.

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Furthermore, I would like to thank Trentino’s Construction Company for letting me work in the implementation of a new production system. This company supports the entire project, by giving data, opening, time and eager to learn how to improve their production. Without all this support this project wouldn’t have been able to conclude.
GLOSSARY / NOMENCLATURE

• GDP: Gross Domestic Product
• LCI: Lean Construction Institute
• LPS: Last Planner System
• PPC: is the percent plan complete.
• PU: production units
• WWP: Weekly work plan
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABSTRACT</td>
<td>ii</td>
</tr>
<tr>
<td>ACKNOWLEDGMENTS AND DEDICATION</td>
<td>iii</td>
</tr>
<tr>
<td>Dedication</td>
<td>iii</td>
</tr>
<tr>
<td>Acknowledgments</td>
<td>iii</td>
</tr>
<tr>
<td>GLOSSARY / NOMENCLATURE</td>
<td>iv</td>
</tr>
<tr>
<td>TABLE OF CONTENTS</td>
<td>v</td>
</tr>
<tr>
<td>LIST OF TABLES</td>
<td>i</td>
</tr>
<tr>
<td>TABLE OF FIGURES</td>
<td>i</td>
</tr>
<tr>
<td>TABLE OF APPENDIX</td>
<td>iii</td>
</tr>
<tr>
<td>STATEMENT OF ORIGINALITY</td>
<td>i</td>
</tr>
<tr>
<td>CHAPTER 1 – INTRODUCTION</td>
<td>1</td>
</tr>
<tr>
<td>Objectives</td>
<td>8</td>
</tr>
<tr>
<td>CHAPTER 2 - LITERATURE REVIEW</td>
<td>11</td>
</tr>
<tr>
<td>2.1. Last Planner System</td>
<td>11</td>
</tr>
<tr>
<td>2.2. Last Planner System Components</td>
<td>13</td>
</tr>
<tr>
<td>2.2.1. Master and Phase Plan</td>
<td>15</td>
</tr>
<tr>
<td>2.2.2. Look-ahead Plan</td>
<td>15</td>
</tr>
<tr>
<td>2.2.3. Weekly work Plan (WWP)</td>
<td>17</td>
</tr>
<tr>
<td>2.2.4. Percent Plan Complete (PPC)</td>
<td>17</td>
</tr>
<tr>
<td>2.2.5. Uncompleted activities analysis</td>
<td>18</td>
</tr>
<tr>
<td>2.2.6. Constraints analysis</td>
<td>20</td>
</tr>
<tr>
<td>Reliability of the Last Planner System</td>
<td>20</td>
</tr>
<tr>
<td>Benefits and Disadvantages of LPS</td>
<td>21</td>
</tr>
<tr>
<td>Relationship between LPS Implementation and Workers Attitude</td>
<td>24</td>
</tr>
<tr>
<td>CHAPTER 3 – METHODOLOGY</td>
<td>27</td>
</tr>
</tbody>
</table>
3.1.  Research strategies .................................................................27
  
3.1.1.  Action research .................................................................27
  
3.1.2.  Case study: ..........................................................................28
  
3.1.3.  Action case study: ...............................................................28
    
3.1.3.1.  Evaluation of the previous production system ......................31
  
3.1.3.2.  Training and education to employees about the Last Planner
  System. 32
  
3.1.3.3.  Implementation of the last planner system ............................37
  
3.1.3.4.  Evaluation of attitude and perception of workers within
  implementation of the last planner system ......................................44

CHAPTER 4 – RESULTS & ANALYSIS .........................................................46
  
4.1.  Previous Production System Results ............................................46
  
4.2.  Last Planner Results .................................................................48
  
4.3.  Results from the survey – questionnaire .....................................54
      
4.3.1.  Survey Number 1 (before the implementation of the new system) 54
      
4.3.2.  Survey Number 2 (during the implementation of the new system) 61
      
4.3.3.  Survey Number 3 (after the implementation of the new system) ...74

CHAPTER 5 – DISCUSSIONS AND CONCLUSIONS .................................89

CHAPTER 6 – RECOMMENDATIONS AND FUTURE WORK .......................93

REFERENCES .....................................................................................95

APPENDICES ......................................................................................95

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LIST OF TABLES

Table 1 Trentino´s Workforce .......................................................... 30
Table 2 Weekly Planning Cycle .......................................................... 37
Table 3 Reasons for Constraint ......................................................... 38
Table 4 Productive Time of Preliminary Work ........................................... 47
Table 5 PPC Results ........................................................................... 49
Table 6 Savings ............................................................................... 51
Table 7 Reason for Plan Failure .......................................................... 52
Table 8 Frequencies of Reasons for Plan Failure ........................................ 53

TABLE OF FIGURES

Figure 1 Labour market in the construction sector ......................................... 2
Figure 2 Ecuadorian External Investments 2008-2014 .................................... 3
Figure 3 Last Planning Process .................................................................. 14
Figure 4 Planning System ......................................................................... 16
Figure 5 Reasons for Plan Failures ............................................................ 19
Figure 6 Failures by Resources .................................................................. 20
Figure 7 Action Research Cycle .................................................................. 27
Figure 8 Action Case Study Steps ............................................................. 31
Figure 9 Logo of the LPS ....................................................................... 33
Figure 10 Triptych of the LPS .................................................................. 34
Figure 11 Results of LPS Tidiness, Labelling and Cleaning in the workplace ... 36
Figure 12 Format of Timetable Look-ahead Process ...................................... 41
Figure 13. PPC .................................................................................. 50
Figure 14 Frequencies of Reason for Plan Failure ........................................ 53
Figure 15 Results Question 1 - Survey 1 .................................................... 55
Figure 16 Results Question 2 - Survey 1 .................................................... 55
Figure 17 Results Question 3 - Survey 1 .................................................... 56
Figure 18 Results Question 4 - Survey 1 .................................................... 57
Figure 19 Results Question 5 - Survey 1 .................................................... 57
Figure 20 Results Question 6 - Survey 1 .................................................... 58
Figure 21 Results Question 7 - Survey 1 .................................................... 59
Figure 22 Results Question 8 - Survey 1 .................................................... 59
Figure 23 Results Question 9 - Survey 1 .................................................... 60
Figure 24 Results Question 10 - Survey 1 ................................................ 61
Figure 25 Results Question 1 - Survey 2 .................................................... 62
Figure 26 Results Question 2 - Survey 2 .................................................... 62
Figure 27 Results Question 3 - Survey 2 .................................................... 63
# TABLE OF APPENDIX

<table>
<thead>
<tr>
<th>Appendix</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>APPENDIX 1 BUDGET</td>
<td>104</td>
</tr>
<tr>
<td>APPENDIX 2 PERMISSION LETTER AND PARTICIPANT INFORMATION SHEET FOR RUNNING THE SURVEYS</td>
<td>107</td>
</tr>
<tr>
<td>APPENDIX 3 SURVEY 1</td>
<td>110</td>
</tr>
<tr>
<td>APPENDIX 4 SURVEY 2</td>
<td>112</td>
</tr>
<tr>
<td>APPENDIX 5 SURVEY 3</td>
<td>115</td>
</tr>
<tr>
<td>APPENDIX 6 WORKING ACTIVITIES</td>
<td>118</td>
</tr>
<tr>
<td>APPENDIX 7 PRELIMINARY WORK</td>
<td>122</td>
</tr>
<tr>
<td>APPENDIX 8 LOOK AHEAD PLAN</td>
<td>124</td>
</tr>
<tr>
<td>APPENDIX 9 WEEK PLAN</td>
<td>127</td>
</tr>
<tr>
<td>APPENDIX 10 CONSTRAINT ANALYSIS</td>
<td>135</td>
</tr>
<tr>
<td>APPENDIX 11 PPC</td>
<td>138</td>
</tr>
<tr>
<td>APPENDIX 12 RESULTS SURVEY 1</td>
<td>140</td>
</tr>
<tr>
<td>APPENDIX 13 RESULTS SURVEY 2</td>
<td>143</td>
</tr>
<tr>
<td>APPENDIX 14 RESULTS SURVEY 3</td>
<td>148</td>
</tr>
<tr>
<td>APPENDIX 15 PICTURES OF THE CONSTRUCTION</td>
<td>158</td>
</tr>
</tbody>
</table>
STATEMENT OF ORIGINALITY

Author’s declaration: I declare that the work in this dissertation was carried out in accordance with the requirements of the University’s Regulations and Code of Practice for Taught Programmes and that it has not been submitted for any other academic award. Except where indicated by specific reference in the text, this work is my own work. Work done in collaboration with, or with the assistance of others, is indicated as such. I have identified all material in this dissertation which is not my own work through appropriate referencing and acknowledgement. Where I have quoted or otherwise incorporated material which is the work of others, I have included the source in the references. Any views expressed in the dissertation, other than referenced material, are those of the author.

SIGNED: .......................... DATE: ..........................
CHAPTER 1 – INTRODUCTION

The economy of a country depends on several factors and its performance can be measured in terms of macro indicators such as firms’ outputs, households’ consumption, and government, among others (Khramov & Ridings Lee, 2013). The construction industry is an important and vital section of one of those macro indicators, reflecting a significant contribution to a country’s economy. Not surprisingly, many consider it as a real driving force behind the progress of society. Most citizens are consumers of this sector or of products of this industry, as it is necessary to live, perform activities, and develop industries or enterprises, among others. For example, people use roads, bridge and aqueducts, (civil engineering); and also they live in houses or apartments (domestic construction industry) that are the result of all the activities of those involved in this economic segment.

This industry is characterised by peculiar and complex factors that carry on inefficiency of operation, uncertainty and interdependence. This is caused by several reasons, begging by the nature of the operations. In the construction industry, the materials needed vary on the specifications of the project and they follow different degrees and kinds of processing in different areas, industries or places. The number of possible alternatives and permutations of those entities is enormous (Dubois & Gadde, 2002). Those are some of the reasons why it is said that construction projects are one of the most complexed (Winch, 1987). But also, they are to blame for inefficiency of operations (Cox & Thompson, 1997), endorsing sub-optimization and obstructing revolution and technical advances (Gann, 1996).

In Ecuador, the construction sector is one of the most dynamic economic activities. The Ecuadorian Central Bank ensures that it has beneficially contributed to the variation of the annual GDP. During the period 2014 -2015 there has been a variation of 1% while on 2013 -2014, it’s total variation was 3,51 % form which, 0,87 % come from the mines and oil sector, 0,68 % from
construction sector and 0.58% from professional and technical services (Banco Central del Ecuador, 2015).

The degree of linkage of the construction sector and other sectors in the Ecuadorian economy is very high and significant, as it directly influences the country's labor market, making it the fourth most important economic activity in the Ecuadorian dealing with 509,529 people, of which 492,155 are men and 17,374 are women (Pro-Ecuador, 2014). During 2015, the labour market grew in this sector, compared to that of 2014 by 0.2% (Banco Central del Ecuador, 2015).

**Figure 1 Labour market in the construction sector**

![Labor market in the construction sector](image)

Reference: (Calificadora de Riesgos Pacific Credit Rating S.A., 2014)

Furthermore, this sector has shown one of the most imperative foreign investment incomes, being in third place with respect to other economic activities. The investment overpasses the USD 217.4 million (Banco Central del Ecuador, 2015).
Based on the above, it is shown that this industry invests large amounts of money to undertake and cover almost all the building projects in the country, meaning that it implements, uses and consumes a significant amount of public and private resources. For those reasons, it is important to evaluate the construction industry and its importance in the national economy as it has a specific contribution to the Gross Domestic Product (GDP), and an outsized capacity to produce jobs, especially for unskilled labours.

However, the construction may be volatile. Its return is tied to the economic cycle and political variables. The economic crisis or political instability affecting the sector and the economic booms make it activates and energizes.

Also, despite the fact of being a key activity for the development of a country and its economy, the construction industry in South America has a low level of development and there has not been adequate research about how to manage it and how to become more productive (Serpell B, 2002). In Latin America, it has had a significant delay with respect to developed countries such as United States of America (Serpell B, 2002).

References: (Banco Central del Ecuador, 2015)
As with all the productions systems in the construction industry, the materials follow the sequence of transformation where all the resources, machinery, knowledge and labour join together to transform them into a more complex product. Nevertheless, for this specific sector the ways of increasing productivity, and managing materials and sources, has been little studied.

Even though this sector is very complex, people have tried without success to improve it through applying techniques that common industries have adopted such as, industrialization of manufacturing processes (Gann, 1996), just in time (Low & Mok, 1999), partnering with suppliers (Cox, 1996), and quality management (Shammas Toma, et al., 1998), among others.

Supply chain management, specifically the material management for this industry has an important role since it is permanent and applicable in all the building stages. The degree of success of any project is largely dependent on the supply of materials, equipment and all the necessary elements with the entire requirement of quality and in the specified time. This means that an appropriated and correct control could help to improve the productivity and to reduce costs.

Moreover, the productivity losses in this area depend on the administration of the activities with a range of 50 to 55%, design contributes to 20-25%, and 10-15% corresponds to the labour and work force. As shown, properly managing the supply chain will help to improve more than a half of the actual productivity (Undurraga Montes, 1999).

The administration of production as shown above is the most important aspect of the supply chain and that is why there have been studies of how to improve the production system that is included in the organization management and organization strategy as the ones conducted by Ballard, 2000, Diekman, et al., 2004, Alsehaimi, et al., 2009, and Banawi, 2013, among others. If the construction sector wants to replicate the improvements of other business sectors, the supply chain management and lean criteria and techniques should be applied (Cain, 2004).
Changing the way of production and improving it will help the country’s economy as well as the net incomes of each company. Techniques such as lean construction have now been applied to specific corporations, some of which has being adopted successfully.

Lean Construction is a manufacturing management created method to project delivery (Lean Construction Institute, 2015). It aims to change the way labour is completed, maximize value, and minimize waste (Koskela, et al., 2002). This means that this methodology sets similar objectives as lean production (Gao & Pheng, 2014).

The accomplishment of lean principles in industrial process and the welfares ascending from its usage is one of the principal incentives for adopting lean principles in construction. A few years after Lean Manufacturing gained total acceptance in western industrial processes, Lean construction and its principles appeared (Gao & Pheng, 2014).

There are different methods and techniques to apply Lean Construction depending in which area it is going to be executed. In many companies the implementation takes various steps and it is much easier to adopt a culture in an area and then pass this sustained culture to the other departments of the company rather than trying to implement by imploring the whole company to adopt it.

The best known practical application of this methodology is the last planner system which concerns the planning and management of the construction process (Ballard & Howell, 1998). This tactic is a manufacturing control technique which helps to perform activities in a productive way and reducing the time and wastes that the process could have. The production control involves a work flow control and production unit control. On one hand, the work flow control is necessary to use the look-ahead process. The production unit control, on the other hand, must be achieved by a weekly work plan (Last planner system) (MSU, 2008).

These last ones consist of weekly construction tasks, structured depending on the ability to complete them and not only based on what is needed to be done.
The number of completed assignments is measured as a ratio of the entire number of tasks. With this way of measurement, it can be determined by the commitment and effectiveness of the production system (Abdelhamid, 2004). The plan percent complete (PPC) is the quantitative value that shows this result (MSU, 2008).

In the UK, various studies and techniques have been implemented, because the construction industry is an important economic sector. For this reason, the Lean Construction Institute (LCI) was founded in August 1997 (McGeorge, et al., 1997). LCI appeared as a partnership between Gregory A. Howell and Glenn Ballard (Ballard, 2000). This organization aims to research, design, and develop new practical methods of lean construction and to share information and data concerning the administration and supervision of production on civil-engineering/construction/architectural projects (Lean Construction Institute, 2015).

The Egan report has popularized the lean methodology between construction industries and professionals (Green & May, 2005). In 1998, the UK Rethinking Construction Egan report revealed the importance of the Last Planner and stated that it was one of the few tools for the management of construction production. Currently, there are many advocates of the Last Planner System including BAA, the UK Airport operator, Waitrose in UK and Sutter Health, UHS and others in the US (Mossman, 2013).

The Last Planner System has reported benefits for all the construction projects that have been applied (Alsehaimi, et al., 2009; Mossman, 2013). For instance, the production rate, productivity, percentage of completed activities and efficacy increased, while wasting times, bottlenecks, waste, and risk decrease (Ballard, 2000; Bristow, 2007; Dixit, et al., 2010; Mossman, 2013). However, there are some challenges and issues of this technique. Those are considered to be the partial or incorrect implementation (Fernández-Solis, 2007); the insurance that suppliers and subcontractors properly adopt this technique (Dixit, et al., 2010); the necessity of daily score of delays, productivity, and percentage of completion of activities (Fuemana, et al., 2013); the time, attendance, and concentration required for meetings to analyze the reason for failures (Shahwe,
et al., 2013); the struggle to make every worker participate or get involved (Bristow, 2007) and the cost of implementation (Alsehaimi, et al., 2009), among others.

Furthermore, in the UK some companies that help with the application of this technique have been formed. For example, 6ix Consulting is an organization that intends to apply lean thinking in the construction sector and that is constantly designing, sustaining and teaching this philosophy. This organization offers training courses and consultancy (6ixConsulting, 2015). Another example is the Construction Lean Improvement Programme (CLIP) created by BRE in 2003. The main objective of it is to support the UK construction companies to improve their products, financial performance, services, customer contact, and productivity, among others.

The LPS has been extensively used in the US and around the world. Much research has been conducted in the US after the UK has shown their results with the use of this technique, and they have been applying it in to the US construction industries. At the moment, there is still more research going on, trying to improve the PPC efficiency and some other benefits of this tool (as the reduction of operational risks) (Ballard, 2012).

The LPS is suitable for both big and small projects. Large scale companies have adopted this technique and some projects such as London Heathrow Terminal 5 or the North Staffordshire Hospital PFI were done applying this tool (Peter, 2009). For this kind of projects it is necessary to use generic and specific software such as MS Excel, Project flow (SPS), or OurPlan. But also, small projects can use this technique requiring just some office materials as coloured post-it notes, paper, pencils, pens, markers, eraser, and photocopier, among others (Mossman, 2013).

In Ecuador, where the project takes place, this tool hasn’t been fully applied. There is just one case study made by Fiallo and Revelo (2001) in which this tool was adopted in a residential construction project of the Fideicomiso Mercantile. That is why this project intends to successfully implement and sustain in “Trentino’s” Construction company this culture.
Objectives

This project has as its objectives to implement the methodology of the Last Planner System in Trentino’s residential construction project. The work consists in 34 one-family units’ houses, covering a land surface of more or less 75,000 square feet, with a budget of around two million dollars, 650 thousand were spent in the acquisition of the land. This project will implement this technique during a stage of the construction process in order to compare the difference in the performance, productivity rates, and efficacy as well as the changes in the attitude of workers while adopting this culture.

The main objectives of this project are:

- Review and analyse the conventional method of construction in Ecuador. This means making a literature review of the normal process of construction, identifying the main problems and discussing which can be optimised using the last planner system. Also in this phase all the critical points, bottle necks, safety issues and attitudes of people will be identified. This is an important step to realize because it will help to understand the necessity of changing the way of production in such a difficult process. The construction industry is a very complex entity, because it is not a stable production, it change with every project, the need of workers as well as the educational level varies depending on the step of production. Most of the time, the level of education of workers is not require, what matters is the expertise and the techniques teacher and learn during the day to day activities. With this it is meant that physical strength is required than intellectual knowledge.

Furthermore, people may not worry about the productivity rates because they are paid weekly and as soon as they finish their activities there is a change of working team to start new and specific actions, this means that for them it is better to spend more time performing activities than doing them faster, as they want to spend more time working and having an income.

All those aspects have to be considered, listed and explained in order to understand and look the changes that the new methodology of production will benefit to the company.
• Analyse and implement the new method of Last Planner System over a 5 month period within the company.

In this stage of the project, it is necessary to make a literature review of the methodology Last Planner System, understand the way of implementation and choose the best alternative to adopt the culture in Trentinos` construction company.

Moreover, in this period, it is important to have contact with the company and the workers. Teaching sessions and lectures about the culture, the expectations and the needed support will be running. To achieve this goal it is important to have a strong commitment of both the company that made the implementation as well as the head of the project. In addition, weekly measures of the productivity, and a comparison of the will and did actions is required.

• Analyse the attitude and perception of workers within the implementation.

The implementation of a new working methodology will produce some changes at different levels of the company.

From the perspective of organizations, change includes difference in the functional and operational methodology, staff working form and leadership, and resources management, among others (Huber, et al., 1993). From the point of view of organizational development, change is “a set of behavioural science-based theories, values, strategies, and techniques aimed at the planned change of the organizational work setting for the purpose of enhancing individual development and improving organizational performance, through the alteration of organizational members’ on-the-job behaviours (Porras & Robertson, 1992)”.

The information mentioned above suggests that there may be changes in the attitude of the workers. For this reason, it is necessary to analyse and measure those changes.
In this step of the project the aim is to determine the changes shown during the adoption of the new culture. Surveys before, during and after the implementation will take place.

- Compare and analyse the obtained results and draw some appropriate conclusions.

Finally, it is important to evaluate and analyse the changes after the implementation. A comparison of the productivity and all the data will be presented; graphical results and conclusions will be shown in order to see the efficacy of the chosen methodology.
CHAPTER 2 - LITERATURE REVIEW

2.1. Last Planner System

Last Planner System (LPS) is a philosophy that helps building companies to proactively manage their production process using an immediate development planning scheme (Fiallo & Revelo, 2002; Abdelhamid, 2004). Last planner system was created after analysing that only about half of all the tasks planned for a week were completed (Ballard & Howell, 1997; Ballard, 2012). This technique is suitable for design production control, as it take away the ineffective and invaluable jobs that are done during production as well as the traditional planning techniques such as control through after detection of variances or detailed front end planning (Cox & Thompson, 1997; Ballard, 2000). One of the most important aspects of this tool is that it generates a valuable design (Ballard, 2000). On the other hand, one of the most highlighted challenges of it is the committee, and time consuming required from workers to implement and carry on the system (Chen, et al., 2009). Additionally, the methodology has been considered to be a tool of lean methodology, which has been largely used in the manufacturing sector (Ballard, 2000). As Green & May (2005) and Ballard (2012) assert that this term in certain circumstances is even be used as a synonymous for lean though this is just a tool or part of this great system. In fact, the LPS is consider to be the best known, and the most powerful planning and control system of the lean construction technique (Ballard & Howell, 1998; Christoffersen, et al., 2001; Kenley & Seppänen, 2010). Thus, it has been proved as the most reliable and useful tool for the administration of the building process and the incessant monitoring of scheduling efficiency (Ballard & Howell, 1997; Christoffersen, et al., 2001), even thought, some as Alarcon, et al. (2008) and Banawi (2013); consideres that the implementation of all the Lean Construction’s techniques makes a better work in those mentioned aspects. Furthermore, this generates noteworthy improvements in project and program productivity, security, predictability, delivery times, revenue and feelings of comfort and sense of belonging among
project staff (Mossman, 2013; Armenakis & Bedeian, 1993; Cain, 2004; Fiallo & Revelo, 2002). Green & May (2005) confirm this statement by considering the LPS as a “set of techniques, a discourse, a ‘socio-technical paradigm’ or even a cultural commodity” (p.503)

Moreover, LPS has a vital connection among construction assembly and logistics teams (Mossman, 2013). Therefore, activities in a company cannot be seen as unitary operations, as they require information, materials, and resources from others. This can be an enormous challenge for companies as it is necessary to have an alignment of systems with suppliers and subcontractors for obtaining better results (Cain, 2004). Additionally, some different systems such as project management do not consider all this parameters making them be less effective than this one as them have a global or overall view (SixConsulting, 2015). LPS should as a system involve the alignment and communication between all departments of a company (Lean Construction Institute, 2015; Undurraga Montes, 1999) since this is an important aspect when an organizational change or adaption of a new system occurs (Olesen & Myers, 1999). Managing this level of complexity involves a high level of commitment, collaboration, and communication; a failure in one of those aspects can invalidate and make the LPS stop working properly or at all. Consequently, it is crucial to endorses dialogues between managers and trade foremen before problems become too critical which helps to increase the understanding of issues in human relationships and production slowdowns (Mossman, 2013). Strategies and a well organizing program need to be carried on to make the system be able to overcome. Establishment of importance in building involves the change of resources. To converge at the workforce to allow building process to flow, there are seven streams required. Those streams are: people, information, equipment, materials, prior work, safe external conditions and safe space. If any one of the seven is broken up, sequence value cannot be formed (Mossman, 2013).

As in all the productions systems, there must always be a person responsible for carrying the systems on; in the case of the LPS, the last planners are them. The need for the last planners was inclined by the ostensible lacking of
knowledge of weekly and short period planning for building locations with the development in project planning software packages (Harris & McCaffer, 2006; Koskela, et al., 2010). “Last Planner System provides the last planners, trade foremen and design-team leaders, with the authority, information and physical & social space they need to make decisions collaboratively about the use of resources to deliver the project (Mossman, 2013).” Thus last planners support value, flow and transformation because their main responsibilities are to determinate the specific and physical works to be performed in a specific day or week, making them develop working strategies (Winch, 1987) (Ballard & Howell, 1998). Kenley & Seppänen (2010) asserts that the last planner is the most suitable person for production planning process as he or she is the one that has more contact with crews and employees. In contrast, project managers have a global view of the process but are not properly involved with it (Cain, 2004). For most of the companies, the necessity of having a last planner means hiring new employees or promoting existing workers. These are workers whom the company has to invest, train and spend time and money on, which is a disadvantage (Bascand, 2011).

2.2. Last Planner System Components

LPS classifies their activities, to some extent to all the executable project task, in four main groups; and has named them as SHOULD, CAN, WILL, and DID (Shang & Pheng, 2014; Ballard, 1997; Fiallo & Revelo, 2002; Gann, 1996)
On one hand, the WILL be done activities are the outcome of a scheduling procedure that “best matches WILL with SHOULd within the constraints of CAN (Ballard, 2000)”. The job of the supervisors in these cases is to control and keep pressure on their employees to perform their activities in the best possible way, to increase their proactivity, efficiency, and productivity rates, despite all the obstacles that can be presented during it (Ballard, 2000; Abdelhamid, 2004; Gao & Pheng, 2014). On the other hand, the CAN activities are all the task that employees are able to complete as they have all the resources, tools, materials and capacity that they need (Dubois & Gadde, 2002; Fiallo & Revelo, 2002; Harris & McCaffer, 2006). While, the SHOULD be done activities are those that the company needs to do but they cannot be performed because of constraints. All assignments require critical and quality characteristics. This means that they must be well defined, have an exact sequence, and check the availability of workforce, tools, machinery, capacity, amount, etc (Ballard, 2000).

Moreover, LPS uses a four-level hierarchy of timetables and scheduling tools which are the master and pull phase plans, the look-ahead plan, and the weekly work plan (Ballard, 2000; Kenley & Seppänen, 2010; Ballard, 2012). Additionally, it implements a tool which determines the percentage of completes activities of the plan PPC and reasons for incomplete assignments. Ballard and
Howell (2003) allude that when all those mentioned tools are systematically executed, they provide major reimbursements to construction planning.

2.2.1. Master and Phase Plan

The master plan is the global project agenda, which is established from the design principles and keeps in mind the objectives which will satisfy the clients. It involves indicators and objects with extended principal times. Landmark days are determined by means of “pull” procedure from successor milestones (Ballard, 2000). The plan is established by a group of people including those responsible for the construction in conjunction with subcontractors (Kenley & Seppänen, 2010). The process exposes the tasks to be performed to discharge labour for production (Gao & Pheng, 2014). As it can be seen this master and phase plan are very or almost equal to the project management were all the aspects of production are evaluated and the global view is considered.

2.2.2. Look-ahead Plan

The look-ahead plan aims to proactively produce a better flow of work through construction units (Armenakis, et al., 1993; Ballard & Howell, 1998). Consequently, it attempts to achieve the best possible rates and sequence of work by organizing the flow of design and supply depending on the production units that are planned (Winch, 1987; Bady, 2001; Ballard, 2012). Additionally, these functions are accomplished through several detailed procedures, including the definition of activities, analysis of constraints, pulling work from upstream production units, and matching load and capacity (Ballard, 2000; Cain, 2004; Kenley & Seppänen, 2010). This mentioned fact makes the look-ahead plan a very complex and time consuming work (Diekman, et al., 2004). The number of weeks over which a look-ahead process is covered depends on the dependability of the scheduling structure, the characteristics of each project, and the main times for obtaining materials, equipment, data and labour (Ballard & Howell, 1997; Alarcon, et al., 2008; Alsehaimi, et al., 2009). The look-ahead determines the activities to be done in detail on weekly work
plans in which each one has a list of multiple specific assignments. The basic functions of it are the creation of a plan work flow order and rate; match capacity with work flow; decompose master schedule activities into work packages and operations; generate detailed methods for executing work; keep a backlog of complete tasks and update and review advanced level timetables. This makes the last planner have a difference compare to other systems since it prepare work to be ready just in time is needed (Formoso & Moura, 2009; Friblick, et al., 2009; Ballard, 2000). The planner should be sure of the real activities that can be completed each week (Court, et al., 2009; Fernández-Solis, 2007). If an activity demands more time he should move the frame work for that activity to another week.

The look-ahead process has the sequence as it can be seen in the graph bellow:

**Figure 4 Planning System**

Reference: (Ballard, 2000)
2.2.3. **Weekly work Plan (WWP)**

It is an assignment-level schedule, grounded on the LPS’ mechanisms (Hamzeh, 2009; Khanzode, et al., 2008). It objective is to convert what SHOULD be finished into what CAN be completed, thus creating a record of arranged work (Kim & Jang, 2005; Ballard, 2000). A representative weekly labour scheduling technique proposed by Ballard and Howell (1997) suggests that WWC should include definition, reliability, categorization, size and knowledge.

2.2.4. **Percent Plan Complete (PPC)**

The effectiveness of the last planner system can be determined by the percent plan complete (PPC) (Ballard & Howell, 1998; Friblick, et al., 2009; Khanzode, et al., 2008). This parameter reveals the quantity of planned activities completed divided by the total number of planned activities, expressed as a percentage (Ballard, 1997; Winch, 1987; Chen, et al., 2009)

\[
PPC = \frac{Completed \text{ planned tasks}}{Planned \text{ activities}} \times \%
\]

PPC not only show the efficiency of a team, but also it measures the extent to which supervisor's commitment was comprehended (Ballard, 1997; Green & May, 2005). As well as the PPC, another way of measuring the effectiveness of LPS is to determine the Performance Factor (PF) (Gao & Pheng, 2014; Formoso & Moura, 2009). This is consider a secondary index to define the ratio to estimated efficiency, obtained by dividing actual hours by earned labour hours or vice versa (Abdelhamid, 2004; Green & May, 2005). Those two parameters are some of the aspects that also mark a difference between LPS and other systems (Koskela, et al., 2010). Moreover, this last factor helps to determine quantity of working hours required finalizing the activities in time and it associates them with the budget of each assignment (Gao, 2013). Consequently, a bad result for the PF is obtained when the scheduled time is lower than the labour hours required to accomplish an exact job. On the other
hand, a bigger planned time compared with the labour hours result in a good PF ratio (Jesus & Leong, 2000).

2.2.5. **Uncompleted activities analysis**

During the performance of activities, some issues can come out. Variation of importance to activities execution is one of them (Alsehaimi, et al., 2009). For instance, in some occasions it is possible that workers are reassigned tasks as a result of delays (Ballard & Howell, 1997). Another problem determined by Ballard & Howell (1997), was the vendor or design errors meaning that the specifications of the clients change and the activities have to be rescheduled (Ballard & Howell, 1997). Additionally, a not ready prerequisite for work is other factors (Johansen & Wilson, 2006). All tasks depend on resources and materials and most of the time failures are an effect of the lack of those important aspects (Friblick, et al., 2009). As the LPS was formed upstream of weekly labour scheduling to regulate proactivity and work flow a good design of the data collector is needed. When this information is missing, the activities are commonly not performed as expected (Lehman, et al., 2002; Hamzeh, 2009). This comes in conjunction with a bad design of the needs as well as a deficiency in monitoring or control (Gann, 1996). To continue, misunderstand of the quality criteria to jobs is also consider as an issue (Ballard, 2012). For example, planners may not comprehend that some activities must take more time if they want to have a good result of the final product, so the amount of work is excessively scheduled (Cain, 2004; Court, et al., 2009). Alarcon, et al. (2008) also mentions that shared resources that are not well coordinated, can be one of the main issues experimented during the application of the LPS systems. For example, some tools, printers, computers, plotters, mixers and cutters, among others (Ballard, 2000). Finally the last factor that determines the efficiency of the LPS is defectiveness direction and data (Ballard & Howell, 1998; Ballard, 2000). This means that the system carry on by the company to collect information indicated incorrectly that all the prerequisites, resources and materials were able (Ballard, 2000; Dubois & Gadde, 2002; Ballard, 2012).
Several of the reasons for failures related with bad directives are shown in the chart below.

**Figure 5 Reasons for Plan Failures**

- Misunderstanding of criteria for deliverable
- Misunderstanding of the requested
- Misunderstanding of the applicable requirements
- Redefinition of criteria during the week
- Incorrect directives
  - Misspecifications of prerequisites
  - Misspecifications of resources
  - Misspecifications of processes
  - Misspecifications of output

**Needed Changes in directives**

**Person responsible for changes**

- Why criteria change?
- What to do to avoid plan changes?
- Reasons for misunderstanding of needs
  - What will prevent repetition

**Reference** (Ballard, 2000)

Additionally, a chart detailing the reasons for failure considering the resources is shown below.
2.2.6. **Constraints analysis**

A constraint analysis is needed as soon as the assignments are recognised (Kim & Jang, 2005; Wambeke, et al., 2012). Each task has their own constraints, creating the necessity to determine them for knowing their disposition to be executed or not during an exact week (Armenakis, et al., 1993; Alarcon, et al., 2008). In this step, it is mandatory that suppliers of goods and services accomplish with their deadlines, since it has been researched that most of the times the delays on this is the main reason for tardiness (Christoffersen, et al., 2001; Abdelhamid, 2004; Fiallo & Revelo, 2002). Therefore, they have to dynamically manage their manufacturing, and delivery (Fernández-Solis, 2007). Also, they must warn the planner with sufficient lead time about problems so a rescheduling can be done (Dubois & Gadde, 2002).

**Reliability of the Last Planner System**
The plan dependability increases by loyalty to the last planner system rules (Jesus & Leong, 2000); wide education (Gao, 2013); self-inspection involvement of members (Johansen & Porter, 2003); joint supplier-customer inspection and the use of techniques such as: make ready activities, protecting manufacture from doubt through selection of quality tasks, job explosion, examination of restrictions, identification and action taking over uncompleted allocated jobs (Zou, et al., 2007). All those factors help to reduce defects, complete activities through empowerment of the workers themselves, as their work is been constantly been inspected (Cain, 2004). However those aspects are also hard to generate, develop and to maintain (Johansen & Wilson, 2006).

Furthermore, by identifying the critical requirement for the supplier’s and customer's process, it is supposed to establish selection objectives and arrange an agreement on working/executing directives for only those assignments that release on outdoor workers (Bady, 2001; Cain, 2004; Ballard, 2012). This aim to make suppliers and customers feel responsible for their activities (Cain, 2004).

**Benefits and Disadvantages of LPS**

One of the benefits of the LPS is that it has had a fast expansion which has made it win recognition from experts worldwide. According to Nieto-Morote & Ruz-Vila (2011) more than two hundred projects had applied LPS all around the world, including the UK (Johansen & Porter, 2003), the US (Jesus & Leong, 2000), Ecuador (Fiallo & Revelo, 2002), Korea (Kim & Jang, 2005) and the Middle East (Alsehaimi, et al., 2009), among others. All those projects vary in size (small, medium and large scale companies), type of construction system (civil construction and residential construction), cultural conditions, and number of workers, among others (Nieto-Morote & Ruz-Vila, 2011; Fernández-Solis, 2007; Zou, et al., 2007; Banawi, 2013). Despite those mentioned facts, all of them have reported that the use of LPS is beneficial since it resulted in reductions in workflow deviation, and urgent procurement requests (Liu, et al., 2010; Johansen & Porter, 2003); adoption of hierarchical structure (Jesus & Leong, 2000); enhancement of process plan structure and reliability (Fiallo & Revelo, 2002); improvement of managerial control and thus aided to advance
labour efficiency (Kim & Jang, 2005; Alsehaimi, et al., 2009), reduction of cost and duration (Seppänen, et al., 2010; Wambeke, et al., 2012)

Additionally, this system helps to organise more competently, refining manufacture by plummeting delays, getting the work done in the best constructability sequence, match available work with manpower, synchronising various dependent activities (Fiallo & Revelo, 2002; Bady, 2001). Some other advantages of this system include the safety and faster delivery of projects (Liu, et al., 2010); predictable production programs (Fernández-Solis, 2007); reduction of stress on project management staff as well as on the construction sites, firefighting or fewer day to day problems, waiting time and amount of required personnel (Liu, et al., 2010; Nieto-Morote & Ruz-Vila, 2011; Gao, 2013); improvement of the supply chain integration, communication among project participants, knowledge among project teams and quality of work practice at construction site (Lehman, et al., 2002; Khanzode, et al., 2008; Koskela, et al., 2010); stabilized project based production systems (Ballard, 2000); proactive control and decentralized decision making (Jesus & Leong, 2000; Lehman, et al., 2002; Fiallo & Revelo, 2002).

LPS split labour structure up to crumble the project into extensive and feasible tasks at the operative level. The difference, that makes LPS better than other methods such as project management (PMI), lies in who should perform the most important role in project plans. PMI (2008) does not openly outline who should be in charge for project scheduling. Moreover, LPS inspires a bottom-up system to involve the last planner or foreman to take proprietorship of preparations and regulations, and it also discusses that, since last planners are nearer to the production location, it is more suitable that they arrange for inputting into weekly plans. LPS already includes quality, risk, and procurement management (Shen & Song, 1998; Zeng, et al., 2003; Zou, et al., 2007).

Also, even though there are new and existing techniques for continual improvement and better managing procedures, such as agile manufacturing, Lean has recently been applied in the construction sector (Friblick, et al., 2009; Green & May, 2005). It is important to remember that agile manufacturing was
developed from lean manufacturing. The implementation of lean tools requires high level of strategies and procedures (Cox, 1996). Not surprisingly, companies struggle in accomplishing this activity as it requires the complementation of several sub methodologies like supply change, logistics, 5s, Kanban and project management, among others, making this a big challenge for most of the companies (Armenakis, et al., 1993; Alarcon, et al., 2008; Court, et al., 2009; Ballard, 2012). LPS shifts the focus of control from the employees to the flow of work by including a set of procedures, tools and rules (Ballard, 2000).

However as this is a system, it also present disadvantages. Bristow (2007) maintains that in certain occasions when there is no a well-structured method and the delivery has the highest priority, there can be rushes and quality compromising. Also Fuemana, et al., (2013), show that an incorrect or partial incorrect implementation produces a system malfunction, creating more problems and wastes to the company. The whole implementation of LPS means that all areas, including suppliers and subcontractors must be aligned with it. Heidemann & Gehbaurer (2010) presented that there is a high range of difficulty in achieving this, because in some cases it is required more effort, time and money in educating all the areas rather than just managing it. Furthermore, the LPS involves the scoring and measurement of PPC and productivity, analysis of constrains and reasons for failures; which are extra activities that workers do not want to perform (Porwal, et al., 2010).

Additionally, apart from the disadvantages of the LPS, there are also some challenges that companies have to face while implementing it as lack of training (Hamzeh, 2009), stakeholder support (Alarcon, et al., 2008), lack of leadership (Alsehaimi, et al., 2009), low levels of commitment (Koskela, et al., 2010), attitude of workers, legal and contracting issues (Koskenvesa & Koskela, 2005), extra resources (Alsehaimi, et al., 2009), and physical integration, among others. Companies have to carefully take care and manage properly those factors in order to successfully implement the system (Porwal, et al., 2010).
Relationship between LPS Implementation and Workers Attitude

Apart from respectable planning skills, labour force plays the most important role in contributing to the implementation of new production systems that will generate an on-time job delivery (Gao & Pheng, 2014; Russell, et al., 2015). The implementation of new systems are considered as organisational changes, which are processes of transformation that include the migration from an existing condition to a desired upcoming state, including how change occurs (Todnem, 2005; Khoja & Maranville, 2010; Russell, et al., 2015). Change must always be set up on operational as well as strategic levels as they are part of the organisational life (Sternberg & Lubart, 1995; Todnem, 2005). Each organisation can choose which type of change it wants to face as there are several kinds of them, fluctuating from culture change to restructuring and downsizing (Armenakis, et al., 1993). In this case the last planner system is considered as a culture change. Those changes do not only affect financial and economic areas, but they also inspire to conception and distribution of information within organizations (Khoja & Maranville, 2010; Gao & Pheng, 2014). Culture change has focus its attention in the analysis of the previous long term status of how work was done within a company, to then search for the best way of how to implement a sustainable change of how things should be done (Porter & Parker, 1992; Russell, et al., 2015).

One of the most important aspects that contribute to effectiveness during an organizational change is behaviour patterns of workers, as they are the ones that will accept or refuse to change (Eagly & Chaiken, 1993; Barnes-Farrell & Ratz, 1997; Robson, 2002). Companies have been using different techniques such as empowerment of employees in decision making, motivating them to accomplish desired performance, and training them to be more sensitive to diversity and changing environments (Smith, 2002; Todnem, 2005). “Learning is the basis for improvement that helps the team avoid repeating mistakes and working more effectively together as new problems emerge (Mossman, 2013)”. Additionally for developing a positive attitude in workers is needed to clarify the mission, objectives and goals of this changing process (Lehman, et al., 2002).
By attitude, it is meant to “the neural or mental state of willingness, ordered through knowledge, exerting an instruction or dynamic influence on the individual’s response to all objects and situations to which it is related” (Pickens, 2005). The implementation of LPS is a social process including debate with site workers and also planning to guarantee that work is not waiting on staff, and that employees are not waiting on work (Shang & Pheng, 2014). Arguably, the construction industry is occupied with uneducated workers, yet some are hard-working and enthusiastic to follow their supervisors’ instructions in order to get a slithered timetable back on the correct path as fast as conceivable (Kotter & Cohen, 2002; Garvin & Roberto, 2005). LPS needs commitment in completing tasks that were promised for the upcoming week, while having commitment in workplace but missing a positive attitude will straightforwardly change the commitment into an unfilled promise (Armenakis, et al., 1993; Beer & Nohria, 2000; Huber, et al., 1993; Garvin & Roberto, 2005). In contrast, in some cases, even though assignments tumble behind the original scheme, overtime work and strong effort would rapidly place the project back onto the precise path, but people’s attitude would transform that fact into a workable one (Johansen & Wilson, 2006; Russell, et al., 2015).

Piderit (2000) has shown that the attitude of employees is not an unidimensional measure as it implies three dimensions (tripartite) known as cognitive, emotional, and intentional. Furthermore, generating and sustaining satisfactory perceptions, beliefs and attitudes among workers is vital for an effective application of organizational variation initiatives (Lindsay & Norman, 1977; Dubois & Gadde, 2002; Garvin & Roberto, 2005). Beer & Nohria (2000) establish that perceptions and attitudes generate an effect over productivity, job satisfaction, employee’s self-esteem, and rates of absenteeism. It becomes indispensable for companies to satisfactorily manage emotional responses of workers, as structural variations can be a particularly demanding event for them (Cox, 1996; Beer & Nohria, 2000; Johansen & Porter, 2003). As shown above the most important aspect is readiness for change. It is focus on organizational members’ attitudes and beliefs, but also to what extent they trust the changes to be required and the companies’ capacity to effectively implement changes (Armenakis & Bedeian, 1993; Khanzode, et al., 2008).
Furthermore, during every change, it is important that supervisors and employees are on board, to keep resistance at a minimum level and achieve a successful transformation process (Armenakis, et al., 1993; Christoffersen, et al., 2001; Garvin & Roberto, 2005). Some researchers have shown that resistance to changes is reduced and commitment is increased when employees have been included in the planning and implementation of this process (Weber & Weber, 2001; Khoja & Maranville, 2010).

With the purpose of getting employees of a company prepared for conversion, the main tool is the communication process in which its message should include the reason for changing and how the process is going to be managed as well as who can be affected by it (Armenakis, et al., 1993; Johansen & Porter, 2003). Applying the correct technique for communication is indispensable for increasing the probability of effective change (Dubois & Gadde, 2002). Organizational changes can be challenging since many people are unenthusiastic to modify their habits. People believe that what normally functioned in the past is the best way to do things (Armenakis & Bedeian, 1993; Dubois & Gadde, 2002). They enter in a comfort zone where they will keep doing what they have always done because they do not want to be forced to change, or to be challenged to find new methods (Garvin & Roberto, 2005). The most common reasons why workers struggle to accept changes comprise a lack of belief in the change; confusion of the transformation and its consequences (positive or negatives ones); fear of losing their valuable things, and high resistance (Kotter & Cohen, 2002; Bristow, 2007; Formoso & Moura, 2009).
CHAPTER 3 – METHODOLOGY

3.1. Research strategies

In this project it was necessary to consider a mixed method approach; the first one is the action research, the second one is case study and the last one is surveys (Liaw & Yen, 2002). The combination of them is called action case study that was the technique applied for researching (Tseng & Yen, 2002). To have a better understanding of the reasons for selecting this method it is presented a quick introduction of the main purpose of them.

3.1.1. Action research can be defined as any study into practice assumed by those involved in those activities, with an intention to transform and develop it (Yen, et al., 2002).

Action research is a methodology which has evidenced to be predominantly attractive to practitioners since it is problem-solving and practical. Practitioners get directly involved in the research and it is directed towards a general and greater comprehension of the system to try to improvement it over a period of time (Liaw & Yen, 2002). It is a cycle that includes:

**Figure 7 Action Research Cycle**
In the Trentino’s construction it was necessary as a practitioner to get involve with the production process and work with the company in the implementation process to understand the necessities, obstacles, aptitude and perception of employers and the overall system to first determine if it is possible to apply a new production methodology and then implement it.

3.1.2. **Case study:** is an empirical investigation within its real life context. Collection of evidence is the way of measurement of effectiveness of this method (Robson, 2002). Some proposed that case studies must be conceived as a type of experiment, having similar methodological rules (Campbell & Stanley, 2015). Also this strategy fits when there is some knowledge about the subject either the production control or the design of management (Yin, 2014).

Studies focusing on user, designer, product and product manufacturers can be helpful in understanding the reasons for changes in design practice (Chin, et al., 2001). Moreover, Patton assures that “case studies are particularly valuable when the evaluation aims to capture individual differences or unique variations from one program setting to another, or from one program experience to another” (1990: 54). This is the main reason why a case study was also considered as a proper research strategy for this project.

3.1.3. **Action case study:** The usage of action research in conjunction to case study is a more complete methodology and fills the gap between them. It does not only focus on the prevailing procedures or model, but also it intends to change it with new phenomena (Tseng & Yen, 2002).

This strategy has been successfully applied by numerous studies (Hughes & Wood-Happer, 1999; Stenmark, 2000). Action case consists of a mix of understanding and involvement. It comprises components of action research which replicates the impending for examination to modify companies resulting in changes and case study which shows the requirement of pondering understanding obtained from the outcomes.
intended to equilibrate the trade-offs between being either a practitioner that creates changes in the design of processes and a researcher that makes analysis and interpretations of data and theory to design (Hsu, et al., 2001). In these circumstances, researchers work as practitioners or collaborate with them in reviewing and changing the information investigated from the design data into practice (Liaw & Yen, 2002).

As mentioned before, in this research, the strategy selected was action case study. This strategy was established to implement the Last Planner System in Trentino`s construction company. For data collection it was used observation, production measurements, as well as surveys. This last ones where used because they are useful to collect information either specific or limited depending on the necessity of the research (Yin, 2014). The data is obtained from a selected group of people (Armenakis, et al., 1993; Campbell & Stanley, 2015). This method includes selection of the population, pre-testing tools, definition of delivery means, validation and examination of results (PennState, 2006). In this project surveys where used to determine the attitude and perception of workers within the changes in the production system.

This action case study implemented the methodology of the Last Planner System in the residential construction project Trentino. This housing project takes place in Tumbaco, Ecuador. The project consists in 34 one-family units' houses, covering a land surface of more or less 75 000 square feet. With a budget of around three million dollars from which 650 thousand were spend in the acquisition of the land. The budget is detailed in Appendix 1. Trentino’s Construction Company is a small scale and family-industry that began their operations in 2006 with small projects and has grown steadily both in capital, earnings, human resources and assets. Currently, Trentino has two main investors/owners and their participation in investment varies by 70 and 30%. Their workforce is made up of:
Table 1 Trentino’s Workforce

<table>
<thead>
<tr>
<th>WORKING POSITION</th>
<th>NUMBER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manager</td>
<td>1</td>
</tr>
<tr>
<td>Architect (supervisor)</td>
<td>1</td>
</tr>
<tr>
<td>Planner / Programmer</td>
<td>1</td>
</tr>
<tr>
<td>Designer</td>
<td>1</td>
</tr>
<tr>
<td>Civil Engineer</td>
<td>1</td>
</tr>
<tr>
<td>Hydraulic Engineer</td>
<td>1</td>
</tr>
<tr>
<td>Electric Engineer</td>
<td>1</td>
</tr>
<tr>
<td>Electric Technicians</td>
<td>2</td>
</tr>
<tr>
<td>Plumbing Technicians</td>
<td>2</td>
</tr>
<tr>
<td>Painters</td>
<td>5</td>
</tr>
<tr>
<td>Carpenters</td>
<td>3</td>
</tr>
<tr>
<td>Ceramic installers</td>
<td>2</td>
</tr>
<tr>
<td>Shop Floor</td>
<td></td>
</tr>
<tr>
<td>Master builders</td>
<td>5</td>
</tr>
<tr>
<td>Operators</td>
<td>15</td>
</tr>
<tr>
<td>Peon</td>
<td>20</td>
</tr>
</tbody>
</table>

The actual construction project of the company is the one mentioned and it has decided to build the 34 houses in difference stages, due to different factors as the economic situation of the country, the numbers of members of the crew, and the required investment, among others. The first stage consists of 8 houses, the second stage of 14 and the last stage 12. The last Planner system is been implemented in the first stage of this construction project.

There were several steps that were followed for putting in practice this action case study shown below:
3.1.3.1. Evaluation of the previous production system

In this step, the production was measured by the amount of work that was done every week during the first two months of 2016 (January and February). During the first half of the month, me as observer and project executor attended the workshop during the 8 hours labor day. With the help of the architect responsible for the supervision and management of the project, the progress in activities and amount of work was measured. After those first weeks, the architect carries on measuring this factor and
reported it to me via skype and emails. The architect asks operators to perform certain activity that was planned during the week.

In this building company, the payment to employees is made at the end of each week so before ending the last working day of the week, they have a meeting were every employee shows the activities they have done. After that they are payed and then they can leave the project. The architect then lists the tasks. The analysis of these activities was done by measuring the time needed to complete an activity and also by determining the advance in the master plan that was expected.

Also a budget and a list of all the operations for this project were done. When measuring the initial production time, it was in the stage known as preliminary work.

For the analysis of the production, no interaction or intervention was done in order to let the process follow the way it commonly is done. Therefore, the technique used to identify problems was observation. Also in this stage, a survey of the aptitude and perception of employees was applied. All the employees (thirty persons) were given a survey that consists of ten quantitative closed questions. Those in general include how they feel with the company, how they think it should be, and if they consider that a change would help to improve production, among others.

3.1.3.2. *Training and education to employees about the Last Planner System.*

The execution of the system initiated with classroom training. The employees were divided into three groups to attend a lecture of one hour, where it was explained what was going to be done, why is important to change the production system and how the project is going to be executed. The lecture took place on Friday 8th of January, 2016 and he lecturer was the executor of the Project (Daniela Armas). The reason for giving these lectures in separate groups was because people commonly get distracted when there are in large groups, but also
to avoid reducing the productivity. Each crew that attended the lecture interrupted their activities for one hour, so the planner schedules the lecture for each crew when they finish an activity so in between the change of activities they were asked to participate in the training. A registration form for this training was filled and signed by all the participants. Personnel first learned about the system and the expectations regarding their roles and responsibilities within it after coming to the site. Not astoundingly, some were more proficient, skilled, involved and enthusiastic about contributing to this change than others. Subsequently introducing and working with this system employees became apparent and more active involvement was shown.

Furthermore, every week the supervisor, gave a ten minutes talk about the project, the expectations and how they are managing the operations. This talk was done during the first month that the last planner system was applied, in order to remember employees about the new system. To motivate people, a logo of better production was done as show in Figure 9.

Figure 9 Logo of the LPS

![Figure 9 Logo of the LPS](image)

In addition, triptychs with tips were given to employees to persuade people to keep with this new system (the triptychs were done in Spanish as this is the worker’s mother tongue). Those triptychs were given in the weekly talk. An example of them is shown bellow
Figure 10 Triptych of the LPS

Mejorando tu desempeño ayudas a crecer a esta familia de trabajo.
Siempre da lo mejor de ti.

Improving your performance helps to grow this work family.
Always do your best.

SISTEMA DE PLANIFICACIÓN
LAST PLANNER SYSTEM

Vamos por la mejora continua
Let’s go keep improving
Last Planner System

- The planning system helps distribute the work through analysis of constraints.
- All activity is previously analyzed so it can be accomplished in a given period of time.
- The percentage of fulfilled at the end of each week's activities is measured and the causes of the failures are analyzed.

TIPS

- Before starting an activity, verify the weekly plan and the availability of resources and materials.
- Keep your supervisor informed of any changes or difficulties arise during the completion of tasks.
- Encourage your team to continue and finish all planned activities.
- Make an analysis at the end of the day of your performance, and suggest areas of improvement for your crew.
- Keep clean and tidy your work place. Remember to keep only the necessary tools at hand.

Trentino
In this stage it was also done a campaign to apply rules of tidiness, labelling and cleaning after finishing each workday. This was done as a result of seen that most of the operators spend lots of time searching for tools that they should keep during their labour day as them are crucial resources. For this reason, tool holder boxes were replaced with tool holder cars and they were labelled and signpost. Only necessary tools are kept in this area and each crew has a tool holder. Also tools that were damage or not working properly were replaced. The change can be seen in the figure above.

Figure 11 Results of LPS Tidiness, Labelling and Cleaning in the workplace
3.1.3.3. **Implementation of the last planner system**

The implementation of the last planner system consists of a series of activities that match together to obtain the desired result. First of all, responsibilities and tasks are divided for all the members of the working team. The most important activities are described below considering its executer.

3.1.3.3.1. *Last Planner’s Tasks*

In this project the case study was managed by a weekly planning cycle as shown in Table 2. These specified the activities that the last planner had to perform during each week.

**Table 2 Weekly Planning Cycle**

<table>
<thead>
<tr>
<th>DATE</th>
<th>ACTIVITIES</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Collect information of completed</strong></td>
</tr>
<tr>
<td></td>
<td>activities</td>
</tr>
<tr>
<td>Friday</td>
<td><strong>Collect information of production</strong></td>
</tr>
<tr>
<td></td>
<td>needs</td>
</tr>
<tr>
<td></td>
<td><strong>Confirm the availability of</strong></td>
</tr>
<tr>
<td></td>
<td>materials, resources and capacity</td>
</tr>
<tr>
<td></td>
<td><strong>Produce last version of timetable</strong></td>
</tr>
<tr>
<td>Afternoon</td>
<td><strong>Ask supervisors to review the schedule</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Produce last version of timetable</strong></td>
</tr>
<tr>
<td>Morning</td>
<td><strong>Assign activities to each employee or</strong></td>
</tr>
<tr>
<td></td>
<td>crew taking care of the workload</td>
</tr>
<tr>
<td>Monday</td>
<td><strong>Receive tools and materials needed for</strong></td>
</tr>
<tr>
<td></td>
<td>work</td>
</tr>
<tr>
<td>Afternoon</td>
<td><strong>Determinate the completed activities</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Ask for materials that will be needed</strong></td>
</tr>
<tr>
<td></td>
<td><strong>next day</strong></td>
</tr>
<tr>
<td>Morning</td>
<td><strong>Reschedule uncompleted</strong></td>
</tr>
<tr>
<td></td>
<td>activities</td>
</tr>
<tr>
<td>Tuesday</td>
<td><strong>Assign activities to each employee or</strong></td>
</tr>
<tr>
<td></td>
<td>crew taking care of the workload</td>
</tr>
<tr>
<td></td>
<td><strong>Receive tools and materials needed for</strong></td>
</tr>
<tr>
<td></td>
<td><strong>work</strong></td>
</tr>
<tr>
<td>Afternoon</td>
<td><strong>Determinate the completed activities</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Ask for materials that will be needed</strong></td>
</tr>
<tr>
<td></td>
<td><strong>next day</strong></td>
</tr>
</tbody>
</table>
The last planner has to produce a timetable of the activities to be performed each week. The first schedule to implement LPS was done considering just the availability of material, labour, workload, capacity and resources. The capacity of each process is defined by highest time of a sub-activity of it (bottle neck). Then, plans were done considering all the constraints seen in previous weeks and the accessibility to all job’s requirements. The plan and its control were done by analysing the possible constraints as well as by determining the accomplishment of scheduled activities. The intention of this analysis was to focus attention and take all the possible actions of making scheduled tasks ready by removing their constraints but also to determine the causes of failure. The status of those activities is registered in a form as shown below.

Table 3 Reasons for Constraint

<table>
<thead>
<tr>
<th>ACTIVITY</th>
<th>START</th>
<th>LABOR MATERIALS</th>
<th>RESOURCES</th>
<th>EQUIPMENT</th>
<th>PREREQUISITE DESIGN</th>
<th>SPACE</th>
<th>CONTRACT</th>
<th>SUBMITTALS</th>
<th>OTHERS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land clearing</td>
<td>07/03/16</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stakeout and grading</td>
<td>12/03/16</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

After that, assignments that meet quality criteria, size, sequence and that had already passed by the analysis of constraints have to be selected to form part of the plan for each week.

Once the last planner has a previous plan draft, he calls for a meeting involving the supervisor, administrator, purchasing personnel and trade crew leaders. In this meeting, the team revised the preceding week’s work plan and reported whether or not each task was completed. In addition, if any modification in the preliminary duration or time had befallen, the magnitude and origin reason of that deviation was documented. Also in this meeting, the crew leaders were asked to give
the list of look-ahead activities and their possible duration in order to continue with the planning process. The best promising duration for each activity given by the crew leader was founded on the experience of workers, optimum productivity rates and scope and complexity of each task. Then the last planner gave a 15% of uncertainty extra for the plan in case something happen with the crew as manpower can vary depending on different aspect such as fatigue. Work plan forms were used and all the resources, materials, and labour among others were specified. After re-planning and considering all the aspects detected during the weekly meeting, the last planner asked the supervisor (architect) to carefully check the week plan and to make any changes if necessary. Then the final plan is published to be followed.

For having a better overview of the system, the last planner must create a master program that consists of a four to five week look-ahead schedule. The look-ahead activities are specified by the crew leaders. The last planner follows the steps listed below to implement the look-ahead plan.

- List only those the activities that meet all the quality control standards and that can be completed within the next few weeks.
- Determine the feasibility of tasks by asking the foremen and checking the existence and stock of the appropriate. Include additional works, such as adjusting framework and organizing the usage of extra resources (equipment or special tools).
- Recognize and take away any task that cannot be finalized in time by examining the remaining weeks in the look-ahead. Each week, every team of workers will be given assignments each that must be completed.
- Identify all the activities that cannot be completed by checking the accessibility of supplies, components and materials. Also, make sure that all the tools are ready to be used and authenticate the phase of the project.
- Divide look-ahead into projects by putting together interdependent activities that still need to be planned. Classify all the tasks to be accomplished at the same time.
- Estimate the amount of labour-hours required or quantify the total work contained in the look-ahead program and relate it with job’s necessities.
- List the activities that must be finished previous to the performance of other assignments.

The last planner for doing these plans has to match load to capacity within a production system. Two important factors are needed for this. First, the one of the most important facts is the productivity (rate of finished units) of the system. Second, the system cycle time is also essential, as it is the time necessary to move from one end to the begging of another (Lottaz, et al., 1999). By matching capacity and load, it can be seen that pull techniques are apply. This is also shown by the introduction of quality criteria, materials, and information with capacity, as assignments are planned to be ready in the look-ahead process. Consequently, Last Planner is a type of pull system (Lottaz, et al., 1999). Additionally, the look-ahead process is supposed to maintain a backlog of workable tasks for each PU. Load and capacity are determined and the planner must make some adjustments. In this case, workforce is keep stable (avoiding frequent changes), so some possible actions can be taken to match load and capacity as listed below:

- Change of load to match capacity by retarding or accelerating work flow.
- Modification of capacity to match load by reducing or increasing resources.
- Alteration of load and capacity (Low & Mok, 1999)

Moreover, the last planner for creating the programs had schedule rules that allows it to have a successful system.
• Keep programmed jobs in the master plan except if it is totally known that the activity should not or cannot be accomplished when arranged.
• Consent booked actions to continue in the look-ahead window only if the planner is sure that the activity can be executed.
• Remove all constraints in order to allow activities to be scheduled.

Moreover, the look-ahead schedule was organized with the table below, where all the activities to be done by day/week and all the requirements for this work are specified.

**Figure 12 Format of Timetable Look-ahead Process**

<table>
<thead>
<tr>
<th>PROJECT:</th>
<th>01-03-16</th>
<th>14-03-16</th>
<th>21-03-16</th>
<th>28-03-16</th>
<th>NUMBER OF</th>
<th>NEEDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>No.</td>
<td>ACTIVITY</td>
<td>M T W T F</td>
<td>M T W T F</td>
<td>M T W T F</td>
<td>M T W T F</td>
<td></td>
</tr>
</tbody>
</table>

Furthermore, for each week it was displayed a detailed timetable in which all the needs were identified and asked to be ready. This was made in order to make the purchasing department able to request and acquire all the materials and resources but also hire processes that are carried out by specialist companies. But also to have the necessary time to examine all the restrictions of the month and little by little eliminate them.
3.1.3.3.2. Supervisors` tasks

The supervisor, which in this specific case is the architect, is the responsible of the production control. She has to ask the operators to perform the planned activities and make sure that all of them are well comprehended. Moreover, she has to check the advance and the quality of each day work in order to make sure workers are performing in an efficient and effective manner.

Each week, the supervisor calculates the percent of the plan completed (PPC) and reasons for not completing a planned task were identified. Employees were encourage and motivated to keep improving and to learn from their experience. They were not beat for plan failure, but a more careful supervision was done.

At the end of a month, the strategy of the 5 why’s were applied to determinate the worst and the most frequent reasons for failure. Solutions were given and it was designated a person in order to make the improvement suggested.

Regarding subcontractor`s work, the supervisor was in constant contact to coordinate, make sure and insist that all tasks be deliver in the agreed day, as they are part of the plan or are constraints of it. Moreover, it was necessary to ask subcontractors to make a weekly work plans and look ahead schedules in order to manage their production in the same way as the company is doing, so it is easier for them to inform the company their status. Similarly with this activity, employees can see that all the activities are done in time and that all the system is been carried in a reciprocal way. Furthermore, penalties for delays were applied. Those penalties were stablished and specified in a contract in which both parts involved sign before starting the activities.

After those activities were finished, the status of the schedule was weekly updated on a data base. This information is important to calculate and determine the range of improvement obtained.
3.1.3.3.3. Crew leaders tasks

The crew leaders perform an important activity during the planning process. They are the ones responsible of the development of the look-ahead activities list. They select activities on the master program that can be included in the forthcoming weekly plans. Also they were directly involved in the decision making of task durations. The main reason for delegating that task to the crew leaders is that they are closer to the real building process. Not even the supervisors or managers on a project are as close to the actual work compared with crew leaders and thus are recognized as a treasured source of information related with project.

Furthermore, they were precisely request to define the best feasible length of time for each activity presuming there was no concern about probable variations or improbability in the tasks.

3.1.3.3.4. Project Executor / observer

Daniela Armas was the responsible of the execution, implementation and observation of this action case study. During the first half of the month of the project (Preliminary work), an observation process was carried out, in which throughout the 8 labour hours the activities performed by the crew were measured. At this point it was necessary to show the architect how to measure it in order to she carry on with this activity for the rest of the two first months of the year. Also during this period, the first survey was completed by the crew.

Additionally, a one hour lecture about the LPS was given the 8th of January to all the members of the crew involved in the current construction project.

Furthermore, meetings with the planner and architect were carried on to provide training of how to implement the system. At this point, all the formats for analysis of constraints, planning tables, PPC sheet registration, timetable look-ahead process, and logo was done and
delivered to them ready for using. Those documents were uploaded to Google Drive to be modified and for me to directly have access to it. Also, the activities for each member were determined, and explained to the architect and planner.

Moreover, a second period of observation was carried out during the 13th of June to the 4th of July 2016, in which it was necessary to attend the work shop during labour hours and measure the PPC, taking part of the weekly meeting for analysis of plan failure and to take the last survey from the crew.

3.1.3.4. Evaluation of attitude and perception of workers within implementation of the last planner system

In this project the attitude and perception of people within the organizational change was measure by applying three surveys in each stage of the implementation of this new system. The research strategy remained inspired and relatively grounded on comparable studies piloted by Jones et al. (2008) and Martin et al. (2006). The centre of attention in this research was the workers that were directly involved in the construction process. Therefore, they are the ones that were involved in this analysis. The number of workers participation is thirty. The three different surveys where taken in different times, the first one was taken by the executer of the project Daniela Armas on Monday 4th of January 2016, the second one was taken by the architect on Wednesday 13th of April 2016 and the last survey was taken again by Daniela Armas on Monday 20th of June 2016. All the crew members reply completely to it.

For data collection, they were asked to answer three quantitative structured questionnaires – surveys which were applied in the mother tongue of workers (Spanish) and then translated to English to show the results in this project. One of the principal reasons for choosing quantitative questions was the number of surveys to manage and also the facility for survey takers
to answer and to measure it (Orellana, 2001). The participants were first informed about the reasons for the survey, the possible consequences when replying to it, the time that it would take and the way to respond to it, among other data. They were given a participant information sheet and requested to read all of it and ask for clarifications if there were any inquires. They were also allowed to refuse or withdraw taking it.

The first survey consisted of ten questions which aim was to analyse the previous production system, as mentioned in the evaluation of the production system. The scale of measurement for all the surveys applied were Likert scale which makes the rating and evaluation easiness for respondents and researcher. The numeric reporting scale was customized with a scale of 1 to 7, that demanded contestants to designate their degree of agreement or disagreement with a series of statements; 1 been strongly disagree and 7 strongly agree.

The second survey questionnaire was administered to evaluate the attitude of staff during the LPS implementation. Changes can be hard as people does not like to go out from their comfort zone, so this survey aimed to understand how the process of changing was impacting in people’s attitude. This survey was made up of nineteen questions graded with the same Likert scale as the previous survey.

The last survey was applied at the end of the implementation of the LPS. The key objective of it was to let contributors to self-report the benefits achieved, barriers and in general what how they found LPS implementation in the production system. The questionnaire contained also nineteen questions expressed using also a seven-point Likert scale. The takers were given an appropriate time to read and understand the questionnaire, contemplate it and inquire any queries they desired. All participants answered in a group session in company of the supervisor and/or the first author. The purpose of that was to be able to explain the questions, provided clarifications and to make sure that participants reply correctly to it.
CHAPTER 4 – RESULTS & ANALYSIS

4.1. Previous Production System Results

The previous production system was evaluated by determining the time that it took to finish the activities during the first two months of the Project. In this research period, the building process was in the stage of preliminary work. Commonly this stage takes one month to be finished (information obtained and known of previous projects performed by the company). In this case the master production scheduling showed that the preliminary work must be finished in the first five weeks of the year beginning the 04/01/2016 and ending the 05/02/2016; meaning that there were 25 working days and 200 working hours. This master plan was not successfully fulfilled by the crew during this expected time and it was necessary 120 extra working hours (3 more weeks). The master plan during these 200 hours was completed in a 50% considering that there were 16 main activities to be performed and they were finished just 8 of them. The last activity performed when completed the 200 hours was “move and re-plant trees that will remain”. The time of each activity performed was registered as shown in the table bellow.
<table>
<thead>
<tr>
<th>Activities</th>
<th>M²</th>
<th>Productive hours</th>
<th>Time required by M²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clear the ground of obstacles for the stakeout (marking)</td>
<td>90</td>
<td>16</td>
<td>5.6</td>
</tr>
<tr>
<td>Mark the position of the posts according to plans (distance shown between the poles)</td>
<td>90</td>
<td>3</td>
<td>30.0</td>
</tr>
<tr>
<td>Mark the surface of each foundation using stakes to indicate the depth.</td>
<td>90</td>
<td>2</td>
<td>45.0</td>
</tr>
<tr>
<td>Excavation of foundation mark out by posts</td>
<td>90</td>
<td>136</td>
<td>0.7</td>
</tr>
<tr>
<td>Lay concrete foundation and place the post leveled evenly</td>
<td>30</td>
<td>8</td>
<td>3.8</td>
</tr>
<tr>
<td>Place blocks or bricks connecting to each other using cement</td>
<td>30</td>
<td>27</td>
<td>1.1</td>
</tr>
<tr>
<td>1. Mark the area that will be cleaned and stripped</td>
<td>50</td>
<td>2</td>
<td>25.0</td>
</tr>
<tr>
<td>Move and re-plant trees that will remain</td>
<td>35</td>
<td>5</td>
<td>7.0</td>
</tr>
<tr>
<td>Cut unnecessary trees</td>
<td>20</td>
<td>3</td>
<td>6.7</td>
</tr>
<tr>
<td>Remove the topsoil or black soil and roots with the help of a backhoe</td>
<td>6878</td>
<td>32</td>
<td>214.9</td>
</tr>
<tr>
<td>Determine the reference level</td>
<td>15</td>
<td>2</td>
<td>7.5</td>
</tr>
<tr>
<td>Pass levels with the hose</td>
<td>90</td>
<td>6</td>
<td>15.0</td>
</tr>
<tr>
<td>Determine cut and fill areas</td>
<td>45</td>
<td>2</td>
<td>22.5</td>
</tr>
<tr>
<td>Excavation</td>
<td>6878</td>
<td>40</td>
<td>172.0</td>
</tr>
<tr>
<td>Fill areas with the extracted earth from the excavation process</td>
<td>2060</td>
<td>20</td>
<td>103.0</td>
</tr>
<tr>
<td>Building of drains</td>
<td>30</td>
<td>16</td>
<td>1.9</td>
</tr>
<tr>
<td>TOTAL</td>
<td>320</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Some of the reasons for not completing the master plan during this period were mainly that the planner does not consider all the necessities and constraints that those activities have. Specifically, there were problems with materials and labour.

In the case of materials, suppliers not all the time delivered on time, especially during the first month of the year suppliers have low stock of materials and they did not, or operators did not ask on time the requirement of materials before all of it is finished. On the other hand, the main problems related with labour, is the attendance rate. During the first week the percentage of absenteeism was the highest recorded in the overall duration of the project.

4.2. Last Planner Results

McNeill (1989); Ballard (2000) and Fiallo (2002) suggested that there are three key points while talking about the analysis of data. Those are validity, representativeness and reliability. This last one in the LPS is measured by PPC. As Alarcon, et al. (2008) considered, an exertion with this is that PPC only cares about effectiveness but does not directly measure plan quality. To begin, completeness and success or incompleteness and failure of tasks, consignations or assignments are probably a result either of execution, materials, work load, productivity or quality of the assignment. Since the Last Planner System predominantly challenges to increase plan quality, execution failures and therefore PPC may not vary with its effectiveness. Another difficulty with the LPS plans can be the ambiguity of task completion especially when they are not completely clear or well defined. To some extent safeguard against this problematic, all assignments must be formerly checked and review for adequate definition, that is why the supervisor and the last planner has to constantly talk and meet.

In this project several kinds of data were collected including working plan, PPC and reasons for not completion of activities, look-ahead plan, and week plans, among others. PPC and non-compliance reasons data was collected, tracked
and published each week between March 2016 to July 2016 (5 months) consisting of 22 weeks. Table 5 shows the data collection of the PPC, in which it was counted the number of planned action and compared with the number of completed action to obtain the PPC.

**Table 5 PPC Results**

<table>
<thead>
<tr>
<th>Week No.</th>
<th>Dates From</th>
<th>To</th>
<th>Tasks Completed</th>
<th>Tasks Planned</th>
<th>PPC</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>29-02-16</td>
<td>04-03-16</td>
<td>12</td>
<td>20</td>
<td>60</td>
</tr>
<tr>
<td>2</td>
<td>07-03-16</td>
<td>11-03-16</td>
<td>17</td>
<td>24</td>
<td>70.8333333</td>
</tr>
<tr>
<td>3</td>
<td>14-03-16</td>
<td>18-03-16</td>
<td>14</td>
<td>16</td>
<td>87.5</td>
</tr>
<tr>
<td>4</td>
<td>21-03-16</td>
<td>25-03-16</td>
<td>35</td>
<td>42</td>
<td>83.3333333</td>
</tr>
<tr>
<td>5</td>
<td>28-03-16</td>
<td>01-04-16</td>
<td>40</td>
<td>53</td>
<td>75.471698</td>
</tr>
<tr>
<td>6</td>
<td>04-04-16</td>
<td>08-04-16</td>
<td>53</td>
<td>60</td>
<td>88.3333333</td>
</tr>
<tr>
<td>7</td>
<td>11-04-16</td>
<td>15-04-16</td>
<td>60</td>
<td>75</td>
<td>80</td>
</tr>
<tr>
<td>8</td>
<td>18-04-16</td>
<td>22-04-16</td>
<td>38</td>
<td>40</td>
<td>95</td>
</tr>
<tr>
<td>9</td>
<td>25-04-16</td>
<td>29-04-16</td>
<td>45</td>
<td>45</td>
<td>100</td>
</tr>
<tr>
<td>10</td>
<td>02-05-16</td>
<td>06-05-16</td>
<td>44</td>
<td>45</td>
<td>97.777778</td>
</tr>
<tr>
<td>11</td>
<td>09-05-16</td>
<td>13-05-16</td>
<td>48</td>
<td>52</td>
<td>92.307692</td>
</tr>
<tr>
<td>12</td>
<td>16-05-16</td>
<td>20-05-16</td>
<td>50</td>
<td>58</td>
<td>86.206897</td>
</tr>
<tr>
<td>13</td>
<td>23-05-16</td>
<td>27-05-16</td>
<td>60</td>
<td>65</td>
<td>92.307692</td>
</tr>
<tr>
<td>14</td>
<td>30-05-16</td>
<td>03-06-16</td>
<td>27</td>
<td>30</td>
<td>90</td>
</tr>
<tr>
<td>15</td>
<td>06-06-16</td>
<td>10-06-16</td>
<td>30</td>
<td>38</td>
<td>78.947368</td>
</tr>
<tr>
<td>16</td>
<td>13-06-16</td>
<td>17-06-16</td>
<td>40</td>
<td>42</td>
<td>95.238095</td>
</tr>
<tr>
<td>17</td>
<td>20-06-16</td>
<td>24-06-16</td>
<td>8</td>
<td>10</td>
<td>80</td>
</tr>
<tr>
<td>18</td>
<td>27-06-16</td>
<td>01-07-16</td>
<td>10</td>
<td>14</td>
<td>71.428571</td>
</tr>
<tr>
<td>19</td>
<td>04-07-16</td>
<td>08-07-16</td>
<td>39</td>
<td>48</td>
<td>81.25</td>
</tr>
<tr>
<td>20</td>
<td>11-07-16</td>
<td>15-07-16</td>
<td>47</td>
<td>50</td>
<td>94</td>
</tr>
<tr>
<td>21</td>
<td>18-07-16</td>
<td>22-07-16</td>
<td>55</td>
<td>60</td>
<td>91.666667</td>
</tr>
<tr>
<td>22</td>
<td>25-07-16</td>
<td>29-07-16</td>
<td>58</td>
<td>60</td>
<td>96.666667</td>
</tr>
<tr>
<td>Media</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>85.830415</strong></td>
</tr>
</tbody>
</table>

Furthermore, a bar chart was produced to have a better visualization of the variation of the PPC during the weeks. The PPC was measured starting in week 1 the 29 of February as shown in Figure 13. PPC, ranging from an initial measurement of 60% to 90% in the week 14. During the entire project, it was shown a variation or fluctuation during the weeks but initially the completion of
week plan was low, but during the following weeks the rate increased due to a better planning, more guidance/supervision and more commitment of employees. PPC could be conserved constantly at a level around 85% - 86% (which is the mean) through motivation, development, nurturing and encouragement of teamwork and the subsequent team application of norms and rules.

Figure 13. PPC

The data obtained with the PPC has a standard deviation of approximately 10 meanings that the completion of the activities varied every week and do not keep a linear or normal distribution. This must be increase or at least keep stable higher than the mean as this represent the efficiency and productiveness.

Comparing with the previous productive methodology, LPS increased productivity in a 35%. This has reduced the master plan schedule in 29 working days, thus there were 5.8 week less than the projected and budgeted. This means that it was saved the payment of the crew during these weeks which represents an amount of $13,514 as shown in the table below.
Table 6 Savings

<table>
<thead>
<tr>
<th>Crew Members</th>
<th>Number of workers</th>
<th>Salary per Week</th>
<th>Payment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master operator</td>
<td>1</td>
<td>$120.00</td>
<td>$120.00</td>
</tr>
<tr>
<td>Operator</td>
<td>9</td>
<td>$90.00</td>
<td>$810.00</td>
</tr>
<tr>
<td>Junior Operators</td>
<td>20</td>
<td>$70.00</td>
<td>$1,400.00</td>
</tr>
<tr>
<td>Total Labour payment per week</td>
<td></td>
<td></td>
<td>$2,330.00</td>
</tr>
<tr>
<td>Saving due to the 5.6 Week of reduction from the master plan</td>
<td></td>
<td></td>
<td>$13,514.00</td>
</tr>
</tbody>
</table>

For determining the saved amount, just the labour was considered in this project, since number of workers varies depending on each project meanwhile the engineering department remains equal in each of them.

Additionally, non-compliance reasons or plan failure was registered. The team met every Friday for twenty minutes before finishing the workday and they analyse the reason for failure to root causes by applying the method of questioning “Why?” up to five times in sequence. Then the reasons were categorized in labour, material, equipment, prerequisite, supplier, weather, and others. A table which collects the information was done and the frequencies of the repetition of each event were determined. The following tables show in detail the results.
<table>
<thead>
<tr>
<th>WEEK</th>
<th>FROM</th>
<th>TO</th>
<th>LABOR</th>
<th>MATERIALS</th>
<th>EQUIPMENT</th>
<th>PREREQUISITE</th>
<th>SUPPLIER</th>
<th>WEATHER</th>
<th>DETAIL</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>29-02-16</td>
<td>04-03-16</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td>Stakes and iron missing (the supplier didn’t gave all the materials needed)</td>
</tr>
<tr>
<td>2</td>
<td>07-03-16</td>
<td>11-03-16</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td>Crew has to complete the activities from the previous week. Also the productivity was low due to weather conditions (rain)</td>
</tr>
<tr>
<td>3</td>
<td>14-03-16</td>
<td>18-03-16</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Missing to assemble two columns to complete the 2 houses per week</td>
</tr>
<tr>
<td>4</td>
<td>21-03-16</td>
<td>25-03-16</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>The attendance rate on Monday was 80%. Stakeout of the last house wasn’t done due to waiting for finishing the previous activity</td>
</tr>
<tr>
<td>5</td>
<td>28-03-16</td>
<td>01-04-16</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Less people than asked before planning</td>
</tr>
<tr>
<td>6</td>
<td>04-04-16</td>
<td>08-04-16</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Less material than required. Raw material was able, operators didn’t formulate the enough quantity of concrete needed</td>
</tr>
<tr>
<td>7</td>
<td>11-04-16</td>
<td>15-04-16</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Less people than asked before planning</td>
</tr>
<tr>
<td>8</td>
<td>18-04-16</td>
<td>22-04-16</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td>Concrete didn’t dry in some columns</td>
</tr>
<tr>
<td>9</td>
<td>25-04-16</td>
<td>29-04-16</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>02-05-16</td>
<td>06-05-16</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>09-05-16</td>
<td>13-05-16</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Missing stone to fill the base of the chain</td>
</tr>
<tr>
<td>12</td>
<td>16-05-16</td>
<td>20-05-16</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td>Lack of concrete and iron to produce the chains</td>
</tr>
<tr>
<td>13</td>
<td>23-05-16</td>
<td>27-05-16</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td>Many activities planned with few people able to work. Delays in production of previous activities</td>
</tr>
<tr>
<td>14</td>
<td>30-05-16</td>
<td>03-06-16</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td>Waiting time for concrete dry was longer than the expected due to weather conditions</td>
</tr>
<tr>
<td>15</td>
<td>06-06-16</td>
<td>10-06-16</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td>Framework was not possible to remove, concrete was not dry enough (quality of material and weather condition)</td>
</tr>
<tr>
<td>16</td>
<td>13-06-16</td>
<td>17-06-16</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Not all the framework was removed due to production labor rate lower than expected</td>
</tr>
<tr>
<td>17</td>
<td>20-06-16</td>
<td>24-06-16</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Production rate lower due to misunderstanding of activities</td>
</tr>
<tr>
<td>18</td>
<td>27-06-16</td>
<td>01-07-16</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td>Iron didn’t arrive on time. Problems with the supplier, it was offered to be deliver on Monday at 7 am just when the work was supposed to start.</td>
</tr>
<tr>
<td>19</td>
<td>04-07-16</td>
<td>08-07-16</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td>Low production rate due to less people than expected, rate of absenteeism high</td>
</tr>
<tr>
<td>20</td>
<td>11-07-16</td>
<td>15-07-16</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td>Missing wood for formworking</td>
</tr>
<tr>
<td>21</td>
<td>18-07-16</td>
<td>22-07-16</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Workers lost pins, that are necessary for the process</td>
</tr>
<tr>
<td>22</td>
<td>25-07-16</td>
<td>29-07-16</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Delay on previous activities (Bottle neck)</td>
</tr>
</tbody>
</table>

**Table 7 Reason for Plan Failure**

*Note: The table shows the reasons for plan failure during certain weeks, including labor shortages, material issues, equipment problems, prerequisite completion issues, supplier delays, and weather conditions.*
From the results obtained with the determination of reasons for plan failure, it is shown that the three main problems that the company is dealing with is labour, materials and planning (prerequisite). Analyses revealed that attendance, and productivity was the most common cause of the labour reason. Meanwhile, quality and quantity of material or resources were the main issue in this area.
With respect to prerequisites, the central problem is planning the material and labour needed.

4.3. Results from the survey – questionnaire

As specified previously, the survey answers from participants were structured on a seven-point Likert scale, in which the choices were: strongly disagree, disagree, somewhat disagree, neither agrees nor disagrees, somewhat agree, agree, and strongly agree. In this segment, conversely, the scales were summarized in shorter groups corresponding to: generally disagree that includes the answers of strongly disagree, disagree, and somewhat disagree. The same criteria was applied for answers of strongly agree, agree, and somewhat agree, which procedures the class generally agree. The responses neither agree nor disagree remained equal, unaltered. The purpose of doing this shortening was to permit readers to keep a clearer and overall idea and view of the contributors’ attitudes in the different stages of the production change, although each question is reinforced with a character, diagram or figure covering the full detail of the outcomes. Additionally, all the results will be shown in Appendices.

It is important to consider that surveys were translated to English as they were applied in Spanish (the mother tongue of workers). Moreover, the result only shows the frequency of answers.

4.3.1. Survey Number 1 (before the implementation of the new system)

4.3.1.1. I feel that the company has a good way of production
Figure 15 Results Question 1 - Survey 1

Figure 15 Results Question 1 - Survey 1 demonstrates that workers were generally in agreement that the company used to have a good system of production (previous the application of the new methodology), with 70% of members mostly supporting the statement. Only 13.3% of participants generally disagreed, and 16.7% neither agreed nor disagreed.

4.3.1.2. I feel like I can give advice about the way of performing the activities

Figure 16 Results Question 2 - Survey 1
When asked if they can give an opinion of the manner to execute activities, 93.3% generally agree and only 6.7% disagree as shown in Figure 16 Results Question 2 - Survey 1. This means that workers are able to talk, ask and give ideas to their superiors without fearing been not listen or slighted.

4.3.1.3. I believe that a change in the productive process will positively influence relations between me and my co-workers.

![Figure 17 Results Question 3 - Survey 1](image)

A fully successful replied (100% generally agree) was shown when asking if workers think that a change in the production system will help to have a better relationship with co-workers. This shows that people want to improve not only the production process but also the working environment.

4.3.1.4. I believe this company cares about my-self and my colleagues
Furthermore, Figure 18 Results Question 4 - Survey 1 shows that employees generally agree (76.7%) that the company cares about their staff, while 13.3% do not believe that the statement is true and 10% are impartial with it.

4.3.1.5. I think that a change is not necessary
In this question, participants were asked if there is no necessity to change the production system, in which the majority of them (83.3%) generally disagree, and only 16.7% generally agree. This indicates that almost all the population thinks that a change in the production system of the company is needed. Moreover, this statement also supports the respond of question 3.

4.3.1.6. The production system is slow, there are many factors that affect the performance of my activities

![Bar chart showing responses to survey question 6](image)

**Figure 20 Results Question 6 - Survey 1**

In addition, employees were asked if their performance was stocked by different factors that as a consequence generate a decrease in the production rate, in which 60% generally agree that this statement is a fact. A 13.3% are impartial with it, while a 26.7% generally disagree.

4.3.1.7. I feel that I am not listened.
With respect to the feeling of being listened to while giving opinions or while talking with their superiors, half of the employees agree that this fact is true, while 26.7% generally disagree and 23.3% neither agree nor disagree.

4.3.1.8. I feel that this company satisfies all the necessities that I have either professionally and personally

![Figure 21 Results Question 7 - Survey 1](image)

![Figure 22 Results Question 8 - Survey 1](image)
When questioned on the subject of satisfaction of employee's necessities by the company, 66.7% generally consider their selves satisfied. Meanwhile, 30% disagree and 3.3% remain impartial.

4.3.1.9. I care about production (rates, resources, time, etc.)

![Graph showing the percentage of employees agreeing or disagreeing with the statement.]

**Figure 23 Results Question 9 - Survey 1**

Additionally an 86.7% of workers care about their production system, meanwhile an equal average (6.7%) keep neutral and do not look after it.

4.3.1.10. I believe this company will give me the opportunity to develop more
Figure 24 Results Question 10 - Survey 1

As shown in Figure 24 Results Question 10 - Survey 1, 73.3% of workers generally agree that they will be given the chance to grow professionally if they continue working for the firm. In contrast, just the 10% believe that the statement mentioned is not real, and the 16.7% neither agreed nor disagreed with it.

4.3.2. Survey Number 2 (during the implementation of the new system)

4.3.2.1. I feel there is no reason for changing the system
When asked if employees felt that there were no reasons for changing the production system, most of them (80%) were generally in disagreement with that statement. Moreover, Figure 25 Results Question 1 - Survey 2 shows that 14% agree that there were reasons for having a change and just the 3% persist unbiased. Overall though, participants were generally in agreement on the matter that conversion was essential at the company.

4.3.2.2. The change process is affecting work relationships in a positive way
Figure 26 Results Question 2 - Survey 2 presents that 76% of workers consider that during the productive change to the LPS system, they have had better relationships with co-workers, partners, mates and all the staff of the company. In contrast, just the 7% of the disagreed and 17% neither agreed nor disagreed with that fact.

4.3.2.3. I think that this change in this organization, in general, tend to work well

![Pie chart showing responses to the question](image)

**Figure 27 Results Question 3 - Survey 2**

While asking if the change in the company is working properly, an 80% of the population generally agreed. Meanwhile a 13% in general disagreed and 7% neither agreed nor disagreed. This means that during the implementation process of the LPS people feel that there is a good way of production and that probably things will be better with the new system.

4.3.2.4. Changes seem to create more problems than they solve
Figure 28 Results Question 4 - Survey 2

Figure 28 Results Question 4 - Survey 2 demonstrates that 66.7% of workers considered that the change of production system to the LPS does not create more problems than they solve. In contrast, 20% agreed with this fact and 13.3% maintains impartial. This means that people consider that the implementation of LPS system is helpful.

4.3.2.5. I fear that the change might affect my position in a negative way

Figure 29 Results Question 5 - Survey 2
With respect to the feeling of workers in respect with the affection of their working place due to the transformation, 63.3% in general do not consider there is going to be any problem with their job in comparison to a 30% that fear to have it and a 6.7% that do not know or have not consider that possibility.

4.3.2.6. I think the change might cause uncertainty about work-roles in the company

![Figure 30 Results Question 6 - Survey 2](image)

70% of the staff does not consider that the implementation of the LPS causes ambiguity about work roles, while a 20% agreed with this statement and 10% kept neutral with it.

4.3.2.7. I think the change will increase conflict within the company
Figure 31 Results Question 7 - Survey 2

Figure 31 Results Question 7 - Survey 2 show that 70% of workers do not consider there will be problems or conflicts in the company due to the implementation of the LPS. Only 20% agreed and 10% neither agreed nor disagreed with this fact.

4.3.2.8. I am confident that I will be able to influence the extent to which the changes will affect my job

Figure 32 Results Question 8 - Survey 2
As seen in Figure 32 Results Question 8 - Survey 2, 90% of the population is in harmony that they are able to impact the amount of affection of their job caused by the implementation of LPS. Just 3.3% disagreed and 6.7% does not care about this fact.

4.3.2.9. I feel like I am being included in the change process

![Pie Chart]

**Figure 33 Results Question 9 - Survey 2**

86.7% of workers considered that during the implementation of LPS process they were involved. This statement shows the same correlation with the previous question, since people can be part of the process and they can directly act over it. Moreover, a 10% and a 3.3% disagreed and neither agreed nor disagreed respectively with this fact.

4.3.2.10. I feel like I have a voice when it comes to the change process
This question also tried to understand and analyse the range of participation of workers within the changing process. In this case, it was asked if they had the opportunity to express what they thought, believed and felt about this procedure, in which 80% agreed, 6.7% disagreed and 13.3% neither agreed nor disagreed with this declaration.

4.3.2.11. I believe that the change fits well with the overall company culture
When asked if the people perceived that the change was adequate for the company culture, 86.7% agreed; 3.3% disagreed and 10% kept impartial.

4.3.2.12. The implications of the change have been clearly communicated to me by my superiors.

![Pie chart showing responses to the question about communication of change implications.](image)

**Figure 36 Results Question 12 - Survey 2**

Furthermore, 80% of the staff considered that there was a good and clear communication system about the implementation of LPS provided by their supervisor. Meanwhile 16, 7% generally disagreed and 3.3% remain neutral with this proclamation.

4.3.2.13. I am concerned about implementation issues related to the change process.
More than the half of the crew (60%) is in general worried about the execution problems related to the LPS implementation, while 30% do not care and 10% persist unprejudiced.

4.3.2.14. I actively participate in the decision-making in matters that affect me at work

During this process of changing the production system to the LPS, 70% of the employees ensured that they enthusiastically took part in
the decision making in subjects that could affect their labor. 23.3% and 6.7% keep neutral and didn’t participated correspondently.

4.3.2.15. It is really not possible to change things in the company

![Pie Chart](image)

**Figure 39 Results Question 15 - Survey 2**

On one hand, 83.3% of employees think that changes in the company are handballed and achievable. This fact is in harmony with the previous question, in which the majority of the staff considered that the implementation process has been well performed. On the other hand, just 10% did not consider a change was possible and 6.7% did not know about the subject in question.

4.3.2.16. My superiors have been supportive throughout the process (they explain the activities to be performed, reasons for changing, and the methodology to follow)
The mainstream consideration of supportiveness by supervisors during the production change, was confirmed by the 73.3% of the population, while 13.3 % contrasts it and an equal value stayed unbiased.

4.3.2.17. I am pleased with the way the change process has been handled.
The same pattern of the question before was shown in this one; in which 73.3% of the participants in general are delighted with the technique applied in the enactment of LPS. Meanwhile, a 13.3% are not happy with it and do not care about it.

4.3.2.18. The change process has made it easier for me to solve certain tasks

![Pie chart showing the results of Question 18 - Survey 2](image)

**Figure 42 Results Question 18 - Survey 2**

When asked if the changing of the production system has help staff to perform in an easiest manner their activities and problems, most of them (83.3%) agreed, 10% disagreed and 6.7% were unprejudiced.

4.3.2.19. I feel that the new method takes more time and makes work difficult
Finally, during the implementation process of the LPS, there is a big range of dispersion in the way workers perceived the functionality and workability of the new system with respect to the time and scale of difficulty of work. 56.7% consider that it did not take more time and make work more difficult than it used to be. Meanwhile, 33.3% consider that it take more time and make it difficult to them to complete their activities. This can be understood as some workers are directly involved in the implementation system, and a more precise and managerial work, including paperwork, is needed.

4.3.3. **Survey Number 3 (after the implementation of the new system)**

4.3.3.1. I feel there was no reason for changing the system
As seen in Figure 44, the 90% of workers consider that they are generally in disagreement with the fact that there was not necessity to have a change of the production system to the LPS. In other words, workers consider that the change was important and things are better with this new method of production. Comparing with the previous stage, during the implementation of the LPS, workers were a 10% less in concordance with this fact, they may have not understand all the benefit of having this change than they have at the end of the project. Some of the people 6.7% do not like to have changes making them consider that a change was not necessary, while some others (3.3%) did not notice the change between the old and new system.

### 4.3.3.2. I feel that the change was necessary
A similar rate of response comparing with the previous question was obtained while asking if workers feel that the change was necessary. This question was done to have a better understanding of the thinking of workers as soon as they were asked the same question but with a different context. The results show that a 93.3% consider that the change was necessary. This means a 3.3% more than the question above. This can be interpreted as one of the workers is unsure of the degree of benefits of this change.

4.3.3.3. I think the change in this organization is working properly
Workers at the end of the project considered that the LPS is working properly in a 83.3%. There has been seen an increase of 3.3% with respect of the previous stage (implementation 80% of agreement). This can mean that while the process of changing of production system, there could be a range of things that can cause a non-well-functioning of the production system that will change as soon as it is perfected.

4.3.3.4. This change has created a good working environment

![Bar chart showing results of survey question 4 regarding working environment.]

**Figure 47 Results Question 4 - Survey 3**

While asking about the working environment, 73.3 % of participants generally agreed that the LPS form a better atmosphere, a 16.7% neither agreed nor disagreed with this fact and a 10% deliberated that it produces a bad environment. This question is mainly related to the attitude of employees while working, because they are the ones that are involved in the implementation and changing process, so they would produce a good or bad environment depending on the way they see the process. Some may fear about having problems with their job, making them have a bad attitude within the change, some others will face the change as an opportunity to have a better
development or less restrictions while working; making them have a better attitude.

4.3.3.5. The change in the production system has solved many problems (lack of resources, time lost, understanding of activities, etc)

![Figure 48 Results Question 5 - Survey 3](image)

A 90% of workers generally deliberated that many production issues have been solved after applying the LPS. This can be produced because a more care planning system is been carried on and also because the attitude of employees have ameliorated. People used to get angry, inpatient, and less productive when there used to be lack of materials, wrong planning, and fewer personnel than the needed, among others.

4.3.3.6. The production plan is properly managed since the workload is the ideal (no stress is generated, or overworks).
As shown in Figure 49, 83.3% of the crew agreed that the production schedule was carry on in an appropriate way since the workload was the perfect one. Meanwhile a 13.3% believed that the workload was not ideal (so they can think that work was over or unloaded) and a 3.3% remain neutral with this fact.

4.3.3.7. I think the change caused uncertainty about work-roles in the company

As shown in Figure 50, 40.0% of the crew agreed that the production plan is properly managed since the workload is the ideal (no stress is generated, or overwork).
On the one hand, 73.3% of the population believe that work-roles 'uncertainty is not produced with the LPS. On the other hand, a 16.7% considers that work-roles are not well defined, producing ambiguity. This can be solved creating a well-defined structured and communicating it to all employees. They must have access to it, in case they do not remember their responsibilities.

4.3.3.8. I think the change increased conflict in the company

![Figure 51 Results Question 8 - Survey 3](image)

This question has a link or relation with the previous question. There is a relationship between work-roles uncertainty and conflict, in the sense that not well defined responsibilities may produce conflict between employees. Commonly people do not like to perform what others are supposed to do. But this is just one of the reasons why conflict can be produced. Other reasons can be the lack of understanding of the system or its benefits. 63.3% of employees disagreed with the fact that LPS increased conflict in the company, while 20% agreed and 16.7% remain impartial with this fact.

4.3.3.9. I was able to influence the extent to which the changes affected my job
As shown in Figure 52, 80% of workers generally agreed that they were able to influence the magnitude of affection of their job. This means that they were able to talk with their supervisors and to actively participate in the system. This fact is true, since meetings were constantly done to understand the reasons for non-completed activities, in which employees were not only able to search for the main causes of uncompleted tasks, but also they were able to express their feelings about the system and about their job.

4.3.3.10. I feel like I have been included in the change process
When asking to employees if they generally agreed that they were included in the process of changing to the LPS, the success of response were an 86.7%, while the unsuccessful was of 3.3% and the impartibility of 10%

4.3.3.11. I believe that the change fits well with the overall company culture

![Bar chart showing the percentage of employees' agreement](image)

**Figure 54 Results Question 11 - Survey 3**

Furthermore, it was asked if the change to the LPS productive system is suitable for the global company culture having as a result an 80% of agreement, meaning that this change will probably be successfully implemented and accepted by other workers of other projects of the same company. On the other hand, just a 10% did not agree and remain neutral with this statement.

4.3.3.12. I think this change helps to have continuous improvement as it encourages to seek for them
The change of production system has generated a positive attitude in most of workers encouraging them to search for new ways of improving their work and to help the company to be better. This has been verified by the response to this statement in which 86.7 % of participants generally agreed that this changing process has helped them in trying to find new ways of doing things.

One of the most important factors that make this statement be positive is the amount of participation that people has had during the implementation of this new system. As was shown in the results of the previous survey, during the implementation process people felt that they were included and that they could give their opinion and that makes people wanted to try to improve the process in which they are working for.

4.3.3.13. The implications of the change were clearly communicated to me by my superiors
Figure 56 Results Question 13 - Survey 3

Moreover, in every company the communication process is very important in order to avoid misunderstandings and to have a clear idea of what is or will happen. During the whole project, a 70% of the employees generally believe that there was a good communications method; while 16.7 % disagreed and a 13.3 % neither agreed nor disagreed with this fact. Those results, shows that the communication process need to be improve as failure to many other change can happen due to this essential aspect.

4.3.3.14. After this change I feel confident in my ability to deal with planed changes
One of the most denotable facts of attitude of people within the change is the confidence they gained with the completion of this process. In fact, 93.3% of employees feel that after this change, they are able to deal with other possible improvement changes if they are handled in the same or better manner than this project. These rate of successful response, may believe that workers have and will have a positive point of view when having organizational changes.

4.3.3.15. A better managerial and leadership style is carried out
In addition, 90% of workers consider that a better leadership and managerial style is carried out since the application of the LPS. This is due to the fact that the last planner is constantly reviewing the production program, as well as a better and more rigid supervision has been carried out. Employees are not only asked to finish their activities but also they need to perform them in such a way that the final product has the standard quality that the company offers to their customers.

4.3.3.16. I feel that the change generated a positive impact

![Bar chart showing the results of Question 16 - Survey 3]

**Figure 59 Results Question 16 - Survey 3**

Most of the staff (86.7%) has the perception that the change to the LPS has generated a positive impact in all the company not only economically but also in the working environment, attitude of workers, leadership method, managerial performance, quality of work, efficiency, and productivity, among other factors. Just a 3.3% of the population disagreed with this statement.

4.3.3.17. I feel that the change has been successful
Moreover, an 86.7% of participants agreed that the change to LPS has been successful. This was made possible by all the collaboration, participation and positive attitude of most of the workers of this project. In this company most of the tasks are team work so a success in a project is group achievement.

4.3.3.18. Resistance to change was managed correctly, incentives and stimulus were given
As shown in Figure 61 Results Question 18 - Survey 3, a 66.7% of the employees believed that the correct way of avoiding resistance was managed, because incentives, motivation and stimulus. As it can be seen this is not a high rate, as employees are not paid extra (economical compensation) for performing in the best way their activities. They are motivated by denoting the crew how achieved the highest rate of PPC. The response of this questions, in fact indicates that probably a better way of stimulating and compensate employees is needed to have better results.

4.3.3.19. In my opinion, the change will stay in place for a long time as long as workers are motivated to continue with the new methodology

![In my opinion, the change will stay in place for a long time as long as workers are motivated to continue with the new methodology](image)

**Figure 62 Results Question 19 - Survey 3**

While asking if employees consider that LPS will be durable, 83.3% of them agreed with this fact. Meanwhile, a 10% of them believe that it will not continuously be kept. This high rate of agreement makes believe that people feel identified and wanted to stay with this new system (having a positive attitude). The durability of this process will need to be measured in subsequent investigations as an evaluation of the maintenance of it, and the advantages and disadvantages since the implementation of the system.
CHAPTER 5 – DISCUSSIONS AND CONCLUSIONS

The Last Planner System is identified as a construction planning system designed to create expectable and consistent workflow, however it has not been much implemented and analysed in the context of the Ecuadorian construction industry. There was just a previous research applied in this country by Fiallo & Revelo, (2002), which showed a successful implementation of the LPS in a large scale construction company in the city of Quito. This paper is one of the pioneering studies that have successfully implemented LPS for the production and planning system in a small size construction company in Ecuador. This agrees with the statement made by Mossman (2013) in which was mentioned that LPS can be applied in any size and type of construction companies.

By reviewing the current production and planning system of construction companies in Ecuador it was able to determine that the actual way of producing have certain issues that need to be change in order to have a better performance as also exposed by Serpell (2002). In this research, it was shown that an increase in the productivity is possible by implementing managerial systems as the LPS.

Having strategies and a better control over the suppliers by applying contract rules, penalties, selection processes, and quality control of materials, among others, is crucial for developing and increasing the productivity of company. This means that all the areas, including suppliers and subcontractors need to implement the system. Fuemana, et al., (2013) asserted that an incorrect or partial implementation of the LPS is one of the challenges of this system, factor that is consider truth as in this research around 30% of the reasons for plan failure was caused by delays of suppliers and subcontractors.

Moreover, planning process must care not only in determining the working necessities and creating a master plan, but it also has to look for little details that can interrupt the productivity and have waste. In this case, LPS pay
attention more in detail to all the constraints, requirements, suppliers, materials, and labour, among others to make activities ready for just perform them. Those are some of the advantages that match the results obtained in this study, as well as the studies conducted by Johansen & Porter (2003), Jesus & Leong (2000), Fiallo & Revelo (2002), Kim & Jang (2005), Alsehaimi, et al. (2009), and Liu, et al. (2010). Therefore, LPS has a more detailed perspective of how and when to perform activities. This last fact mentioned make the last planner system have a big difference with the conventional project management methods, as well as including the stakeholders in the planning process, make activities reliable, been a pulling process instead of a pushing one, and to immediately take action over activities that could not be completed by mitigating and avoiding those facts and constraints to be repeated for a better development of future activities.

The managerial way of controlling production is similar to the actual one, though; several vital elements of Last Planner System are used, like PPC, look-ahead plans and analysis of constraints; which in particular were not regularly seen in Ecuador.

Moreover apart from the technical and procedural features, the most substantial modification appears to lie in little factors. For instance, LPS consider all the supply chain. Additionally, it empowers foremen to take control, commitment and ownership of critical analysis and participation in the project planning process as they are the ones directly involved with these procedures. This fact is one of the main considerations that Bady (2001), Cain (2004), and Ballard (2012) highlight about this system. As well, Huber, et al. (1993) in their research mentioned that an organizational change is possible when commitment, empowerment and a good leadership method is conducted. In this project, those factors were shown not only by the increase of productivity, and PPC but also from the results obtained in the surveys.

From the surveys applied, it was able to determine the aptitude and perception of people before, during and after this transformation process. First survey revealed that, the majorities of workers care about the production system
demonstrating that most of them feel a sense of belonging with the company, but the commitment to perform all the activities was low, as the production rate and the efficacy was half of the expected one (50%). Not only labour was one of the factors related with this low rate but also problems with the planning system, suppliers and communication between areas were the major aspects that affect the productivity. Moreover, employees strongly agree that a change in the production system will help to have a better working environment as well as higher production rate. This statement became true as a 35% in the productivity was increased after applying this system.

In addition, the surveys applied during and after the implementation of the LPS, exposed that workers perceive that a better production method is been care on. People feel more involved with the company, and they consider that previous problems that used to stock the production are been diminished. Employees also present a better commitment in finishing their activities, and feel free to present their ideas to continuously improve the production system as there are weekly meetings to analyse reasons for constraints. Moreover, people feel motivated to continue working with all their effort trying to increase the production rate and avoiding wastes.

In general, the changing of production system of a company is a complex work, because it does not only deal with the work procedures but also with the culture of the company and workers mentality. This was one of the factors which it was necessary to deal and put more effort and attention, as people need to be convinced of the necessity of the change to avoid resistance to it. Therefore it was necessary to motivate people and keep them involved with the system. Applying communication and leadership techniques helped to overcome some of the problems and encourage people to continue working on this project.

Furthermore, from the results obtained with the evaluation of reasons for plan failure, it was seen that the planner has to be continuously reviewing the plan, necessities and constraints to make sure that all the prearranged activities are ready to be perform. Those are the basic elements that Ballard (2000), Fernández-Solis (2007) and Alsehaimi, et al., (2009) mention to cautiously pay
attention on. Also it is necessary to have a carefully attendance control to avoid low productivity as this job directly depends on people’s performance (being this the bottle neck).

For this company, in concordance with the fact ensured by Heidemann & Gehbaurer (2010), the implementation of the LPS is time consuming and costly. It is necessary to constantly have meetings, reviews and evaluations to assure the effective and proper work of the LPS. However, the revenue obtained after the implementation of the LPS is higher than producing without it.

With this case study, it was shown that last system is a technique that will help Ecuadorian small and medium size construction companies to increase their productivity as well as to have a better working environment. The system is applicable, but it is necessary to have the commitment of all employees to have a successful implementation and to make it perdurable.
CHAPTER 6 – RECOMMENDATIONS AND FUTURE WORK

The company must continue applying the techniques learned with the Last Planner System to keep improving the completion of the activities and to have a better efficiency. In this case, planner needs to carefully review all the details, necessities, and in general all the constraints to allow the process flow in a natural way.

Furthermore, motivation and leadership techniques are needed to keep employees working in a proper manner, to keep commitment and to avoid bad aptitudes that can stop the implementation process. It is recommended to all companies that will adapt this system to their realities to take care and analyse the better strategy related with human resources as employees in construction companies are the main resource that make possible complete the required tasks.

Additionally, for further studies it will be a good option to track in a longer period of time the results of the LPS to see if the changes presented during the first months of the implementation are been kept or if there is an continual improvement. Being the second option the ideal one, due to the hardworking of analysis of reasons for plan failure and the working criterial to avoid repetition of those reasons.

Moreover, another consideration to have an integrated work will be to ask suppliers, and subcontractors to apply the LPS in their production system with a communication system in between companies to avoid problems with them, to improve their time deliver, and product quality. This will be successful as planner can verify if their materials, equipment and task can be delivered in time, and to have a better planning of the activities. With this it is meant to try to push the production system to become a virtual system where many companies
join together and give their best qualities to produce a product that satisfies all the costumer’s requirements.

Furthermore, it is recommended to search for training and better computerized systems to track the development of activities and remind workers to take action in all the activities that are making the process get stocked.

In addition, to understand better the aptitude and perception of workers with this kind of changes it will be useful to collect qualitative data, by interviewing workers from different working levels. That will give a more complex and complete information of the changes.
REFERENCES


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