Optimization of Warehouse Operations for Logistics Company in the Philippines

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Abstract. The project aims to optimize the warehouse operations in one of the Logistics operations company in the Philippines by designing a warehouse facility layout, conducting time and motion study, and developing operational standards that will increase labor productivity. After a series of observations and interviews, this paper identified the factors affecting the low productivity of the operations in the Warehouse. The warehouse operations are composed of receiving, pick and pack, and the dispatch of items. Process and Layout designs were analyzed through the different Criterion: Economic, Health and Safety, Ergonomics, Environmental, and Productivity. The two designs were evaluated based on the Trade-Off analysis. The evaluation process of the design proposals summarizes the overall preference of the two designs, therefore satisfying the requirements of the client with the consideration of the different engineering standards. Designing the facility layout and process allows this study to observe, justify, and include provisions and standards to support the two alternative design proposals. This study recommends the use of the second design which is more economical, environmental friendly, and can contribute for a higher productivity.

Keywords: constraints, optimization, trade-off, warehouse facility layout, warehouse operations

1. INTRODUCTION

An effective facility layout provides comfort to employees and eliminates, if not eliminates delays in the operation. Hence, an effective facilities layout design is an integral part of an organization's success. It provides better control for the management and utilizes the available space efficiently.

Warehouse is a significant part of the supply chain as it provides a center for receiving, storing and distribution of goods. It acts as a buffer to ensure balance in the supply and demand of good to customers. Warehouse facilities layout design aims to optimize limited storage space and ensure productivity through smooth flow of the processes in the operation.

According to L. Agcaoili of Philippine Star (2015), Manila has the potential to become one of the major logistics hub as the size of the market is expected to hit 71 billion. Because of this opportunity, the competition between companies providing logistics solutions becomes tighter as companies continuously thrive to gain competitive advantages.

The client of this study is one of the leading logistics solution providers in the Philippines today. The company serves as a link between businesses, individuals and residents, the government and e-commerce and offer services such as air freight, sea freight, trucking, crating, door-to-door delivery and warehousing. These services are offer to various customer sectors like residents, businesses, the government and e-commerce. Its key activities involve enrollment in programs offered by the company's Academy of Developmental Logistics. This is to enhance proficiency in technical skills required to deliver their value propositions to their clients by earning a logistics management diploma. Their value proposition is to provide superior customer-driven quality service to its customers by providing time-definite, totally reliable and innovative pick-up, delivery, and logistics services.

2. PROJECT ANALYSIS

The operations officially started early in January 2015. The observed productivity rates were 60% for the receiving process, 53% for the pick and pack process, and 66% for the dispatch. The results of low productivity are due to the unavailability of operational standards. Hence, this paper was prompted to conduct the design project that will address the need to increase the productivity rate of the warehouse operations by at least 40%, 47%, and 34% respectively. The Root- cause analyses which were based on the study of D. Mahto, A. Kumar (2008) were utilized in order to breakdown and identify the main cause of low productivity. Each warehouse process was then analyzed through Pareto chart to further the analysis of the problem, receiving and pick and pack process yielded the highest average time to complete one sales order. Receiving process yielded 6.99 or 7 hours to complete 1 sales order, while pick and pack process requires 8.82 hours to complete 1 sales order, which supports the observed low productivity, and therefore prompted the study to focus and investigate on the two processes.

2.1 Design 1

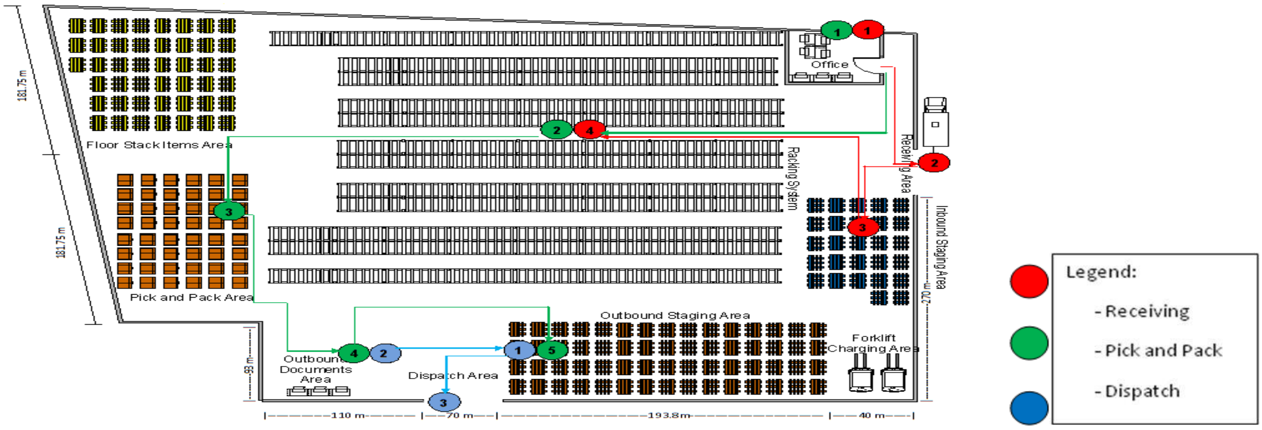


Figure 1. Warehouse Facility Design 1

2.2 Design 2

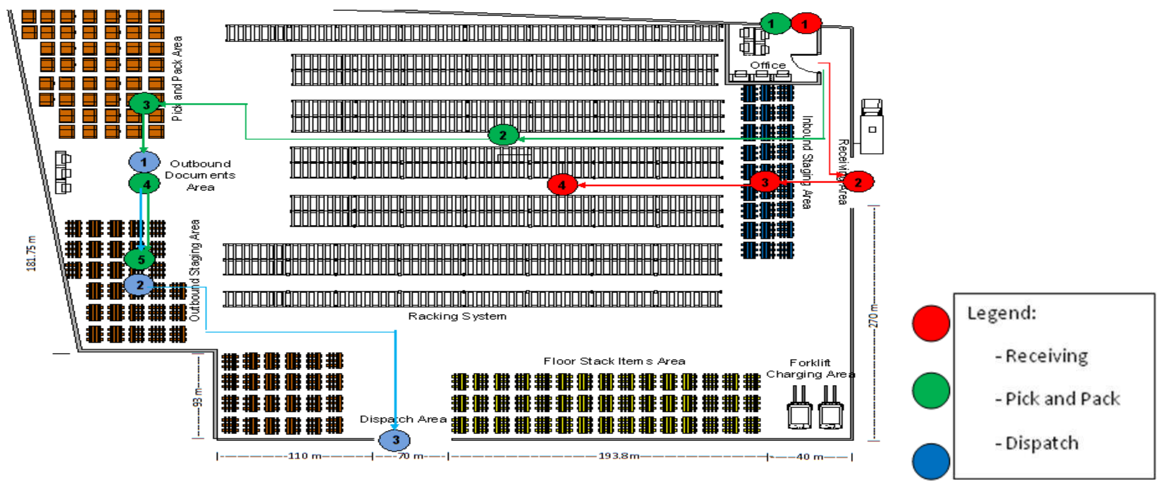


Figure 1. Warehouse Facility Design 2

The general objective of this project is to optimize the warehouse operations in receiving process, pick and pack process, and the dispatch process, specifically, this study aims to develop process standards using time and motion study, which was based on the study sample came from A. Freivalds, and B. Niebel (2009), design warehouse layout with the aid of Pro-Model Simulation to validate the different designs, determine the best layout to achieve an improved productivity rate of the processes, Stellar (2014) and evaluate the best design with considerations of the applicable constraints such as: Economic, Health and Safety, Ergonomics, Environment, and Productivity.

3. APPLICABLE CONSTRAINTS AND STANDARDS

Multiple constraints were utilized in this study to determine the most efficient way to implement the design, in consideration with its primary objectives and its cost efficiency. It is primarily the basis in the decision phase to identify the best design. The constraints involved in this study were economic, health and safety, ergonomics, environmental, and productivity. In addition to the constraints that were utilized in this study, applicable standards were also applied. These standards were based on the International Organization for Standardization (ISO), and Occupational, Safety and Health (OSHA) Standards.

3.1 ECONOMIC

This study used the different components, such as the life cycle cost of the forklift equipment and proposed lighting material, operations cost, and the project implementation cost. Cost analysis of each design including the current (existing) design was analyzed in order to meet this criterion. It was given a rate of 5 (highest) in terms of its importance mainly because it contributes to the profitability of the company, and since it determines the design in the most cost effective manner.

Table 1: Economic Constraint

Economic (Cost)	Level of Importance	Design 1	Design 2
Total Cost (Pesos)	5	1,183,882	638,583

As what was shown on the table above, the design 2 has the least cost of Php638, 583 compared to the design 1 which has a total cost of Php1, 183,882. The total cost was composed of the monthly operations cost (electric consumption, labor costs, forklift consumption, and the maintenance cost), and the total implementation cost of each design proposal, such as the labor cost, material and training cost, rearrangement of the racking system, additional production, energy consumption savings, and the movement costs of the fire extinguishers and first aid kits based on the proposed evacuation plans of each design.

3.2HEALTH AND SAFETY (*Probability of Injury Occurrence)*

This study analyzed the importance of health and safety constraint under the parameters of material handling component. Probability of injury occurrence depending on the level of severity (minor, major, and fatal) was based on the conducted survey in the warehouse, with the consideration of the designed process, layout and design standards based on ISO and OSHA. This constraint was given a rate of 5 (highest) since safety is always in high priority of companies in the different industries, and employees are the most important asset of the company, health and safety should be one of the top priorities / importance.

Table 2: Health and Safety Constraint

Health and Safety	Design 1 (Occurrence) (14.75%)			Design 2 (Occurrence) (23.45%)		
	Minor	Major	Fatal	Minor	Major	Fatal
Injury Occurrence	10.72	4.03	0	18.56	4.89	0
Total	14.75			23.45		
Average (%)	4.92			7.82		

The probability of accidents for the first and second design was based on the survey conducted in the warehouse; it was manually answered by the administrative and the personnel that are personally working hand in hand in the warehouse processes (receiving, pick and pack, and dispatch). The first design, as what was shown in Table 2 obtained 10.72% occurrence for minor injury, 4.03% for major injury, and 0% of occurrence for fatal injury, for a total of 14.75%, and an average of 4.92% injury occurrence. The second design obtained 18.56% occurrence for minor injury, 4.89% for major injury, and 0% of occurrence for fatal injury, for a total of 23.45%, and an average of 7.82% injury occurrence.

3.3 ERGONOMICS

This paper considered the value of lighting, and its effect to the performance of the workers during the operating hours. The illuminance of the lighting source was computed for each of the proposed design. It was given a rank of 5 (highest) since it highly affects the performance of the workers. The illuminance was computed based on the luminous flux of each proposed lighting source for designs 1 and 2. Table 3 shows the computed amount of luminous flux for design 1 (LED), which has 291.78 lux and design 2 (Fluorescent), which has 171.31 lux.

Table 3: Ergonomics Constraint

Ergonomics Constraint	Level of Importance	Design 1 (LED	Design 2 (FLUORESCEN)
Illuminance (in Lux)	5	291.78	171.31

3.4 ENVIRONMENTAL

This paper analyzed and compared the importance of environmental constraint with the consideration of carbon being emitted by the forklift equipment. This constraint was given a rate of 3 since the nature of the company chosen by this paper is not directly affecting the environment or its surroundings, but should be taken into consideration for the better realization of each design proposal. Table 4 shows that the first design proposal (LPG-operated forklift equipment) has a total of 403.2kgCO2 per year based on the study of Duran Ganesen M, 2009 and while the second design (electric operated forklift) got 0 carbon emission.

Table 4: Environmental Constraint

Carbon Emission (kgCO2/year)	
Design 1 (LPG Operated Forklift)	Design 2 (Electric Forklift)
403.2	0

3.5 PRODUCTIVITY

This paper analyzed the labor productivity (%) from the current design, the first design, and the second design proposal through the utilization of time and motion study. It was given a rate of 5 (highest) in terms of its importance because, relative to the economic constraint, it affects the profitability of the company (Farrel M.J, 1957) and it evaluates the efficiency of the workers pertaining to its facility layout and process design. The projected productivity was based on the observed time and motion study that was conducted to the first month of operation, and was projected based on the proposed layout. As what is shown in Table 4, the design 1 got 133% labor productivity, while design 2 got 135% of labor productivity.

Table 5: Productivity Constraint

Process	Design 1 Labor Productivity	Design 2 Labor Productivity
Total	133%	135%

3.6 STANDARDS

The two design proposals conform to the following codes and standards:

1. OSHA 1075.01 : Illumination
2. OSHA 1075.03 : Artificial Lighting: Quality
3. ISO 6780:2003 : Flat pallets for intercontinental materials handling - Principal dimensions and tolerances
4. OSHA 1926.250(a)(2) : Safe Loading Rule
5. OSHA 1926.250(a)(3) ; Aisles and Passage ways
6. OSHA 1926.250(c) : Housekeeping Rule
7. OSHA 3077 : Personal Protective Equipment
8. OSHA 2236 : Materials Handling and Storage
9. OSHA 3125 : Ergonomics – The Study of Work
10. OSHA 3088 : Planning for Workplace Emergencies and Evacuations

4. TRADE-OFFS

The constraint evaluations are summarized and ranked according to the level of importance using a formula from the Model on Trade-Off Strategies in Engineering Design (Otto K.N and Antonsson E.K, 1991) for the quantitative scaling of constraints. The importance of each criterion (on a scale of 0 to 5, as 5 being the highest importance) was assigned, and each design methodology's ability to satisfy the criterion (on a scale of 0 to 5, as 5 being the highest ability to satisfy the criterion) was also tabulated. On the other hand, this study set the governing rank for each criterion involved and was based on the initial research and analysis made for the design.

The computation of ranking ability to satisfy the criteria of the design proposal is as follows

$$\%Difference = \frac{Highest\ Value - Lowest\ Value}{Lowest\ Value} \quad (1)$$

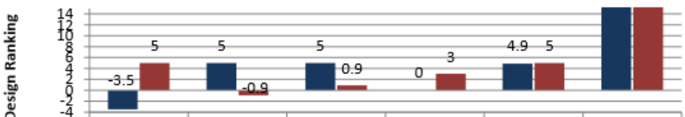
$$Subordinate\ Ranking = Governing\ Rank - (\%Difference * 10) \quad (2)$$

The governing rank is the subjective choice of this study. Assigning the value for each criterion's importance was also based on the subjective judgment. The subordinate rank (Equation 2) is a variable that corresponds to its percentage (%) distance from the governing rank along the ranking scale. In testing the ability to satisfy a criterion, the governing trade-off in terms of which design yielded the lowest value (depending on the criteria) will be subjectively ranked the same as the criterion's level of importance, for which criteria it belongs, while the subordinate rank of the other design with higher values (depending on the criteria) will be computed in accordance to Equation 1 and 2.

Table 6: Decision Criteria

Constraints	Level of Importance	Design 1	Design 2
A. Economic (in Php)	5	-3.5	5
B. Occupational Health and Safety	5	5	-0.9
C. Ergonomics (Illuminance in lux)	5	5	0.9
D. Environmental (CO2 Emissions)	3	0	3
E. Productivity (%Labor Productivity)	5	4.9	5
Over-all rank	**23**	**57**	**59**

The table above shows the trade-offs (decision criteria), that have been utilized in order to compare the first design to the second design proposal. The design that has the highest score using the equation of Otto and Antonsson, will be considered as the best design as it is measured using the applicable constraints, shown in the table above. The first design proposal yielded 57, while the second design yielded 59.



	Economic	Health and Safety	Ergonomics	Environmental	Productivity	Total
Design 1	-3.5	5	5	0	4.9	57
Design 2	5	-0.9	0.9	3	5	59

Fig. 3. Decision Criteria Summary

5. CONCLUSIONS AND RECOMMENDATIONS

The figure shown above is the summary of all the computed rankings of the applicable constraints. The final decision is based on the computed ranking. Graphical comparison of the over-all rank of both designs is shown in the figure above. Based on the analysis of the trade-offs and the over-all ranking of the two designs based on the applicable constraints which are Economic, Occupational Health and Safety, Ergonomics, Environmental and Productivity, this paper therefore choose the second alternative design or the Design 2. The chosen design yielded a rank of 5 in the Economic constraint, -0.9 in the Occupational Health and Safety constraint, 0.9 in the Ergonomic constraint, 3 in the Environmental constraint and 5 in the Productivity constraint.

Based on observations and results of the study, this project recommends the following:

- Application of the second warehouse layout alternative in the Warehouse
- Installation LED for warehouse lighting
- Utilization of electric forklift in the warehouse operations
- Application of the developed operations standards
- Perform training and seminar for the warehouse safety aligned with the OSHA Standards
- Monitoring of the operations for continuous improvement

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